

# 2018-2023 Colorado Hazard Mitigation Plan

Prepared by  
Division of Homeland Security  
and Emergency Management

Colorado Department of Public  
Safety

Pursuant to

Disaster Mitigation Act 2000 &  
Section 409, PL 93-288

9195 E. Mineral Avenue  
Suite 200

Centennial, CO 80112  
720-852-6600  
DHSEM.STATE.CO.US

# EXECUTIVE SUMMARY

Hazard mitigation helps to reduce or eliminate potential losses from future disasters. Hazard mitigation planning helps to establish and maintain a process that leads to the implementation of hazard mitigation actions. The State of Colorado is intimately familiar with the impacts of hazards on its residents, visitors, infrastructure, and economy. This 2018 update to the State's Hazard Mitigation Plan (State Plan) again re-affirms the state's commitment to continual improvements to its statewide mitigation strategy and program.

*The State Plan is the demonstration of Colorado's commitment to reduce risks from hazards and serves as a guide for state decision makers as they commit resources to reducing the effects of hazards.*

The hazard mitigation planning process began with the identification of a broad-reaching State Hazard Mitigation Team (SHMT), which helped to guide the development of the State Plan. The next steps involved a detailed identification of all natural, technological, and human-caused hazards that can impact Colorado and an assessment of the vulnerability, and ultimately the

risk, presented by those hazards. The next stage included a thorough evaluation of the state's current mitigation capabilities, followed by an update to the state's mitigation strategy. This strategy identified eight overarching Mitigation Goals, and related Mitigation Objectives, that define Colorado's path forward to implementing hazard mitigation.

## Mitigation Goals

- Minimize the loss of life and personal injuries from all-hazard events
- Reduce losses and damages to state, tribal, and local governments, as well as special districts and private assets, and support similar local efforts
- Reduce federal, state, tribal, local, and private costs of disaster response and recovery
- Support mitigation initiatives and policies that promote disaster resiliency, nature-based solutions, cultural resources and historic preservation, and climate adaptation strategies
- Minimize interruption of essential services and activities
- Incorporate equity considerations into all mitigation strategies
- Support improved coordination of risk mitigation between and among the public, private, and non-profit sectors
- Create awareness and demand for mitigation as a standard of practice

*The Enhanced State Mitigation Plan must demonstrate that a state has developed a comprehensive mitigation program, that the state effectively uses available mitigation funding, and that it is capable of managing the increased funding (44 CFR § 201.5(a)).*

These goals helped the SHMT to identify new and on-going mitigation actions that specific state agencies plan to

implement over the next five years. The final and most important piece of the State Plan is defining the path forward. Through the planning process a clear process for implementation and maintenance has been defined.

The State Plan addresses each required element of 44 CFR § 201.4 and also includes information required in 44 CFR § 201.5 to meet the Federal Emergency Management Agency's (FEMA) "Enhanced" plan criteria. Pending approval of the "Enhanced" plan elements, Colorado will become eligible for increased federal funding for state and local mitigation projects.

# FORMAL ADOPTION BY THE STATE

The State of Colorado Hazard Mitigation Plan was adopted by the Office of the Governor on November 15, 2018.



**COLORADO**  
Gov. John Hickenlooper

November 15, 2018

Lee dePalo, Regional Administrator  
Federal Emergency Management Agency  
Region VIII  
P.O. Box 25267  
Denver, CO 80225-0267

Dear Mr. dePalo:

Pursuant to the authority vested in the Office of the Governor of the State of Colorado, and pursuant to the relevant portions of the Colorado Disaster Emergency Act of 1992, §24-33.5701 *et seq.*, C.R.S. as amended and made effective on August 8, 2018 by House Bill 18-1394 to address all phases of emergency management, I, John W. Hickenlooper, Governor of the State of Colorado, hereby approve the 2018 Colorado State Hazard Mitigation Plan (SHMP) and all supporting documents.

As a result of this approval, the Colorado State Hazard Mitigation Plan is adopted and serves as a Supporting Annex to the State of Colorado Emergency Operations Plan.

This plan reflects the efforts and dedication of departments and agencies within state and local governments to mitigation, preparedness, prevention, response, and recovery activities. I support the goals and actions identified in the plan and encourage its continued implementation. Thank you.

Sincerely,

A handwritten signature in black ink that reads "John W. Hickenlooper".

John W. Hickenlooper  
Governor

136 State Capitol, Denver, CO 80203 | P 303.866.2471 | F 303.866.2003 | [www.colorado.gov/governor](http://www.colorado.gov/governor)



# ASSURANCES OF CONTINUED COMPLIANCE WITH FEDERAL REQUIREMENTS

The Colorado State Hazard Mitigation Plan (SHMP) was prepared pursuant to the requirements of the Disaster Mitigation Act of 2000 (DMA or DMA 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 §201.4 and §201.5) and finalized on October 31, 2007. (Hereafter, these requirements and regulations will be referred to collectively as the Disaster Mitigation Act.)

While the Act emphasizes the need for mitigation plans and coordinated mitigation planning and implementation efforts, the regulations established requirements that hazard mitigation plans must meet in order for a state jurisdiction to be eligible for certain federal disaster assistance and hazard mitigation funding under the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Public Law 93-288).

The Colorado SHMP falls under assurances proclaimed in this Plan. The State of Colorado assures that it will comply with all applicable federal statutes and regulations in effect with respect to the periods for which it receives grant funding in compliance with 44 CFR Part 13.11(c). The state will amend the SHMP whenever necessary to reflect changes in state or federal laws and statutes, as required in 44 CFR Part 13.11(d). The adoption of this SHMP demonstrates the State of Colorado's commitment to fulfilling the mitigation objectives in the SHMP and authorizes the agencies identified in the SHMP to execute their responsibilities.

# CONTENTS

Section 1. Introduction/Plan Process .....	1-1
Section 2. Colorado Overview .....	2-1
Section 3. Hazard Identification and Risk Assessment.....	3-1
Section 4. Capabilities.....	4-1
Section 5. Mitigation Strategy.....	5-1
Section 6. Local Planning.....	6-1
Section 7. Plan Maintenance .....	7-1
Section 8. Enhanced Plan .....	8-1
Section 9. Appendices .....	9-1
Appendix A: State and Local Government Mitigation Responsibility Analysis .....	A-1
Appendix B: State Referral Process.....	B-1
Appendix C: Current Building Code Conditions in Colorado .....	C-1
Appendix D: Tools .....	D-1
Appendix E: E1.1 Full Planning Process Schedule .....	E-1
Appendix F: FEMA Review tool .....	F-1

# SECTION 1. INTRODUCTION/PLAN PROCESS

# SECTION 1. INTRODUCTION/PLAN PROCESS

## CONTENTS

Section 1. Introduction/Plan Process.....	1-2
Introduction.....	1-3
Planning Teams.....	1-3
1. Core Planning Team.....	1-3
2. State Hazard Mitigation Team (SHMT).....	1-4
3. Technical Assistance Partnerships.....	1-10
Planning Process.....	1-12
1. Planning Schedule.....	1-13
2. Meetings and Coordination.....	1-17
3. Public Involvement.....	1-31
Significant Changes in the State Plan from 2013.....	1-31

## LIST OF TABLES

Table 1-1 Core Planning Team Members.....	1-4
Table 1-2 State Hazard Mitigation Team – State Agency Partners.....	1-6
Table 1-3 State Hazard Mitigation Team – Summary.....	1-10
Table 1-4 Drought Mitigation and Response Planning Committee (DMRPC) Agency Participation.....	1-11
Table 1-5 Flood Technical Assistance Partnership Agency Participation.....	1-12

## LIST OF FIGURES

Figure 1-1 E1.1 Planning Schedule.....	1-14
Figure 1-2 Road Map Recommendations Polling Results.....	1-19
Figure 1-3 Top Hazards Polling Results.....	1-19
Figure 1-4 Mitigation Activities Polling Results.....	1-20
Figure 1-5 SHMT Workshop #1.....	1-21
Figure 1-6 SHMT Workshop #2.....	1-24

# INTRODUCTION

Colorado's 2018 State Hazard Mitigation Plan Update (SHMP or State Plan) builds on the original Colorado State Hazard Mitigation Plan of 2001 and subsequent updates, most recently the 2013 Colorado Natural Hazards Mitigation Plan. In addition to ensuring that all requirements outlined in 44 CFR § 201.4 are met, sections of the State Plan were updated, expanded, newly developed, and consolidated to provide a more concise picture of statewide mitigation. In addition to meeting all required 'standard' plan elements, the 2018 State Plan was developed to also meet all required 'enhanced' plan elements as defined by FEMA. The State of Colorado recognizes the importance of the increased mitigation funding that comes with being an enhanced state. By doing so, the State Plan indicates an integrated and capable state mitigation program and demonstrated success in managing mitigation funding.

## PLANNING TEAMS

The State has three separate yet integrated state-level hazard mitigation plans, including this State Plan and two hazard-specific annex plans for flood and drought. The SHMP encompasses all natural, human-caused, and technological hazards. The hazard-specific Colorado Flood Hazard Mitigation Plan (Flood Plan) and the Colorado Drought Mitigation and Response Plan (Drought Plan) are legacy documents that address in more detail two of Colorado's most significant hazards. All three plans have been on the same update cycle of the SHMP in 2010, 2013, and 2018.

There were several planning teams involved in each of the three integrated mitigation planning efforts. The planning teams for the SHMP included both a Core Planning Team and the State Hazard Mitigation Team (SHMT). The Flood Plan planning team consisted of the Flood Technical Assistance Partnership (TAP) made up of diverse stakeholders involved in flood mitigation planning across the state. The Drought Plan planning team consisted of the Drought Mitigation and Response Planning Committee (DMRPC) comprised of diverse stakeholders involved in drought mitigation planning across the state. Additionally, overlap existed between members of the Core Planning Team, SHMT, the TAP, and the DMRPC creating a defined integrated planning process. The following sections provide details about the various state planning teams that contributed to these mitigation planning efforts.

### 1. CORE PLANNING TEAM

The Core Planning Team was made up of DHSEM staff and a consultant team of Michael Baker International (Michael Baker) and Wood Environment & Infrastructure Solutions, Inc. (Wood). The Core Planning Team was tasked with day-to-day responsibilities for developing the SHMP update. Additionally, the Core Planning Team was responsible for coordination and communication amongst the SHMT and other key stakeholders. The Core Planning Team members are listed in Table 1-1 below.

TABLE 1-1 CORE PLANNING TEAM MEMBERS

Organization	Title	Name	SHMT Member?	Flood TAP Member?	Drought DMRPC Member?
DHSEM	State & Local Hazard Mitigation Planning Program Manager	Patricia Gavelda	Yes	Yes	Yes
DHSEM	State Hazard Mitigation Officer	Steven Board	Yes		
DHSEM	Mitigation Planning Specialist	Mark Thompson	Yes	Yes	
DHSEM	Deputy State Hazard Mitigation Officer	Scott Baldwin	Yes	Yes	
Michael Baker	Project Manager	Mike Garner			
Wood	Hazard Mitigation Lead/Senior Associate	Jeff Brislawn		Yes	Yes
Wood	Senior Emergency Management Specialist	Scott Field			

## 2. STATE HAZARD MITIGATION TEAM (SHMT)

The SHMT is comprised of a broad group of state agency partners and natural hazard Subject Matter Experts (SMEs) that encompasses a whole community approach. These state agency partners and other stakeholders, listed in Table 1-3 and summarized in Table 1-3, contributed to Colorado’s mitigation program and integrated planning process through a variety of means including their defined capabilities, ownership of critical facilities, provision of data and information for the risk assessment, participation in the planning process, and their ongoing review and comment on plan drafts throughout the update.

The 2018 SHMT membership was based on: involvement in the 2013 SHMP update, collaboration in the 2018 Flood and Drought Plans update process, state agencies and organizations with a hazard mitigation component to include additional sectors as defined by FEMA and identified in the Phase I Road Map, and additional Subject Matter Experts (SMEs) and stakeholders throughout the state. Invitations to participate as part of the SHMT and become involved in the 2018 Plan update process originated from DHSEM’s Director and the State & Local Hazard Mitigation Planning Program Manager by e-mail and direct phone call discussions.

The SHMT has its origin in an Executive Order signed by Governor Romer in March of 1989 establishing the Colorado Natural Hazards Mitigation Council (CNHMC). The Council was a public/private organization with various subcommittees that focused on vulnerabilities and potential mitigation projects for specific hazards. Over the years since the CNHMC has evolved into the SHMT, the ongoing agency and SME coordination contributed to an initial 2001

Colorado Natural Hazards Mitigation Plan and the present-day SHMT. The SHMT continues to exist in present form and participates cooperatively in good faith in order to maintain a FEMA-approved SHMP as required for the benefit of all of Colorado.

TABLE 1-2 STATE HAZARD MITIGATION TEAM – STATE AGENCY PARTNERS

Agency	Acronym	Contact Person	Title	Flood TAP Member?	Drought DMRPC Member?
Colorado Climate Center	CCC	Peter Goble and	CCC - Weather & Climate EM Data Gap Assessment		Yes
		Dr. Russ Schumacher	State Climatologist		
Colorado Department of Agriculture, Animal Health Division	CDA	Nick Striegel (Maggie Baldwin)	Assistant State Veterinarian (EM Planning)		
Colorado Department of Local Affairs, Colorado Resiliency Office	DOLA/ CRO	Marilyn Gally	Senior Advisor/Special Projects	Yes	
Colorado Department of Local Affairs, Colorado Resiliency Office	DOLA/ CRO	Iain Hyde	Director, CRO	Yes	
Colorado Department of Local Affairs, Colorado Resiliency Office	DOLA/ CRO	Rob Pressly	Resiliency Program Coordinator	Yes	
Colorado Department of Local Affairs, Community Development Office	DOLA/ CDO	Andy Hill	CDO Program Manager		
Colorado Department of Local Affairs, Community Development Office	DOLA/ CDO	Anne Miller	Senior Planner	Yes	Yes
Colorado Department of Local Affairs, Community Development Office	DOLA/ CDO	Logan Sand	Recovery and Resilience Planner	Yes	Yes
Colorado Department of Local Affairs, Division of Housing	DOLA/ DOH	Maulid Miskell	Program Manager, Housing Technology & Standards Section		

Agency	Acronym	Contact Person	Title	Flood TAP Member?	Drought DMRPC Member?
Colorado Department of Local Affairs, State Demography Office	DOLA	Elizabeth Garner	State Demographer		
		Heather Champeau	Estimates Demographer		
Colorado Department of Natural Resources, Avalanche Information Center	DNR/CAIC	Ethan Greene	Director, CIAC		
Colorado Department of Natural Resources, Colorado Water Conservation Board	DNR/CWCB	Taryn Finessey	Senior Climate Change Specialist		Yes
Colorado Department of Natural Resources, Division of Water Resources	DNR/DWR	Bill McCormick	Chief, Dam Safety	Yes	
Colorado Department of Natural Resources, Water Conservation Board	DNR/CWCB	Kevin Houck	Section Chief	Yes	
Colorado Department of Natural Resources/Water Conservation Board	DNR/CWCB	Stephanie DiBetitto	Community Assistance Program Coordinator	Yes	
Department of Natural Resources, Colorado Water Conservation Board	DNR/CWCB	Thuy Patton	Colorado Hazard Mapping Program Coordinator	Yes	
Colorado Department of Public Health & Environment	CDPHE	Greg Stasinos	Preparedness Branch Manager	Yes	
Colorado Department of Transportation	CDOT	Elbert Hunt	Homeland Security Coordinator	Yes	
Colorado Department of Transportation, Office of Emergency Management	CDOT	Kerry Kimble	Planning Section Chief		
Colorado Division of Homeland Security & Emergency Management	DHSEM	Scott Baldwin	Deputy State Hazard Mitigation Officer	Yes	

Agency	Acronym	Contact Person	Title	Flood TAP Member?	Drought DMRPC Member?
Colorado Division of Homeland Security & Emergency Management	DHSEM	Steve Board	State Hazard Mitigation Officer		
Colorado Division of Homeland Security & Emergency Management	DHSEM	Electra Bustle	Chief of Staff		
Colorado Division of Homeland Security & Emergency Management	DHSEM	Patricia Gavelda	State & Local Mitigation Program Planning Manager	Yes	Yes
Colorado Division of Homeland Security & Emergency Management	DHSEM	Jody Horn	Contingency Planner		
Colorado Division of Homeland Security & Emergency Management	DHSEM	Kevin Klein	Division Director		
Colorado Division of Homeland Security & Emergency Management	DHSEM	Irene Merrifield	Recovery Specialist		
Colorado Division of Homeland Security & Emergency Management	DHSEM	Don Moore	Recovery Specialist and Planner		
Colorado Division of Homeland Security & Emergency Management	DHSEM	Sean Settle	Colorado IMT Program Manager/SPR THIRA Representative		
Colorado Division of Homeland Security & Emergency Management	DHSEM	Mark Thompson	Mitigation Planning Specialist	Yes	
Colorado Division of Homeland Security & Emergency Management	DHSEM	Micki Trost	Strategic Communications Director		

Agency	Acronym	Contact Person	Title	Flood TAP Member?	Drought DMRPC Member?
<b>Colorado Division of Homeland Security &amp; Emergency Management</b>	DHSEM	Ethan Williams	SEOC Planning Section Chief		
<b>Colorado Division of Homeland Security &amp; Emergency Management</b>	DHSEM	Mike Willis	DHSEM Director		
<b>Colorado Geological Survey</b>	CGS	Karen Berry	State Geologist/ Director, CGS		
<b>Colorado State Forest Service</b>	CSFS	Kristin Garrison	Assistant Division Supervisor/ Fire Fuels Management Forest Management Division		
<b>Federal Emergency Management Agency</b>	FEMA	Nicole Aimone	Senior Community Planner	Yes	
<b>Federal Emergency Management Agency</b>	FEMA	Margaret Doherty	RiskMAP/ (Community Planner)		
<b>Federal Emergency Management Agency</b>	FEMA	Richard Hansen	HMA Specialist		
<b>Federal Emergency Management Agency</b>	FEMA	Ryan Pietramali	Risk Analysis Branch Chief		
<b>History Colorado</b>	HC	Todd McMahon	OAHP Librarian/ GIS Survey Archaeologist		
<b>History Colorado</b>	HC	Joseph Saldibar	Architectural Services Manager		

TABLE 1-3 STATE HAZARD MITIGATION TEAM – SUMMARY

Department / Agency	Division or Program Area
<b>Agriculture</b>	Animal Health Division
<b>Higher Education</b>	Colorado Climate Center (UNC) Colorado Geological Survey (School of Mines)
<b>Local Affairs</b>	Colorado Resiliency Office Community Development Office Division of Housing State Demography Office
<b>Natural Resources</b>	Colorado Avalanche Information Center Colorado Water Conservation Board Division of Water Resources
<b>Public Health and Environment</b>	CDPHE, Emergency Preparedness and Response
<b>Public Safety</b>	Division of Homeland Security & Emergency Management
<b>Transportation</b>	Colorado Department of Transportation, Office of Emergency Management
<b>Other Partners</b>	Colorado State Forest Service Federal Emergency Management Agency History Colorado

### 3. TECHNICAL ASSISTANCE PARTNERSHIPS

The Colorado Division of Homeland Security & Emergency Management (DHSEM) and other state agencies have historically organized hazard-specific working groups to address all aspects of disaster preparedness, including mitigation. These working groups are defined as Technical Assistance Partnerships (TAPs), and participation is based on a whole community concept as appropriate, with evolving membership. Since the 2013 State Plan was updated, the Drought and Flood partnerships have continued to be active and contributed to the respective 2018 updates of the Colorado Drought Mitigation and Response Plan (Drought Plan) and Colorado Flood Mitigation Plan (Table 1-4 and Table 1-5). The Drought Mitigation and Response Planning Committee (DMRPC) includes state agencies that contributed to the integrated planning process for Colorado’s Drought Plan (see the Drought Plan for more details). Both the flood and drought planning teams incorporated one or more agency that was also involved in the SHMP update as a SHMT member or Core Planning Team member. This allowed for enhanced coordination across recent state mitigation planning efforts.

**TABLE 1-4 DROUGHT MITIGATION AND RESPONSE PLANNING COMMITTEE (DMRPC)  
AGENCY PARTICIPATION**

<b>DMRPC Agency</b>	<b>Flood TAP Member?</b>	<b>SHMT Member?</b>	<b>Core Planning Team Member?</b>
<b>Colorado Water Conservation Board</b>	Yes	Yes	
<b>Colorado Division of Water Resources</b>	Yes	Yes	
<b>Colorado Division of Homeland Security &amp; Emergency Management</b>	Yes	Yes	Yes
<b>Colorado Department of Local Affairs - Community Development Office</b>	Yes	Yes	
<b>Colorado Department of Local Affairs - Colorado Resiliency Office</b>	Yes	Yes	
<b>Colorado Parks and Wildlife</b>		Yes	
<b>Colorado Department of Corrections</b>			
<b>Colorado Public Utilities Commission – Department of Regulatory Affairs</b>			
<b>State Land Board</b>			
<b>Colorado Department of Public Health &amp; Environment</b>	Yes	Yes	
<b>Colorado Climate Center</b>		Yes	
<b>National Weather Service</b>			
<b>National Oceanic &amp; Atmospheric Administration – National Integrated Drought Information System</b>	Yes		
<b>Natural Resources Conservation Service</b>			
<b>National Drought Mitigation Center</b>			
<b>US Geological Survey</b>			
<b>US Bureau of Land Management</b>			
<b>US Department of Agriculture - Natural Resources Conservation Service</b>			
<b>US Bureau of Reclamation</b>			
<b>Colorado Tourism Office</b>			
<b>University of Colorado – Western Water Assessment</b>			
<b>Local water providers (Denver Water, Colorado Springs Utilities, Northern Water Conservancy District, Aurora, Thornton)</b>			
<b>The Nature Conservancy</b>			

TABLE 1-5 FLOOD TECHNICAL ASSISTANCE PARTNERSHIP AGENCY PARTICIPATION

Flood TAP Agency	DMRPC Member?	SHMT Member?	Core Planning Team Member?
Colorado Water Conservation Board	Yes	Yes	
Colorado Division of Water Resources - Dam Safety Branch	Yes	Yes	
Colorado Department of Local Affairs - Community Development Office	Yes	Yes	
Colorado Department of Local Affairs - Colorado Resiliency Office	Yes	Yes	
City of Fort Collins			
Urban Drainage & Flood Control District			
Colorado Association of State Floodplain and Stormwater Managers			
FEMA			
Colorado Division of Homeland Security & Emergency Management	Yes	Yes	Yes
City and County of Denver - Office of Emergency Management and Homeland Security			
Colorado Department of Transportation		Yes	
Colorado Department of Public Health & Environment	Yes		
US Army Corp of Engineers / Silver Jackets			

## PLANNING PROCESS

The Division of Homeland Security & Emergency Management (DHSEM) is the state entity responsible for maintaining ownership and leading development of the State Plan. The planning process for the 2018 State Plan update began in 2015 with development and completion of the *Colorado Enhanced Mitigation Plan: Phase I Road Map (September 2016)*. A gap analysis process allowing for creation of the Road Map was undertaken to evaluate whether it was feasible, and the state could in fact achieve enhanced plan status. It also provided future guidance should Colorado decide to request enhanced plan status from FEMA.

The 2018 State Plan update process began in October 2017 with intent to develop a standard and eventual enhanced plan. An expert planning consultant team led by Michael Baker International (Michael Baker) was hired to help facilitate development of the updated State Plan.

During the update to the State Plan, Colorado was concurrently updating its Drought Mitigation and Response Plan, and Flood Mitigation Plan. These efforts were led by the Colorado Water Conservation Board and supported by their consultant, Wood. In 2018, a decision was made that the State Plan would summarize content from the Drought and Flood Plans, similar to

previous State Plan versions, and more explicitly link the three plans by integrating the mitigation strategies.

The 2018 planning process leveraged an expanded SHMT and focused on integration across all other state planning efforts. The existing SHMT members were continually asked throughout the process to invite any other relevant stakeholders to participate along with the planning team.

## **1. PLANNING SCHEDULE**

A detailed DHSEM planning schedule was used to ensure a timely completion of the State Plan. The planning schedule reduced each major task into subtasks with associated end dates. Additionally, a more robust planning schedule (E1.1) was developed by Michael Baker in conjunction with the Core Planning Team and followed very closely throughout the planning process. Observing the detailed E1.1 schedule helped facilitate the planning process, provided for timely ongoing draft section reviews by DHSEM and the SHMT and associated comment integration, and made sharing task deadlines amongst the different planning teams more seamless. The detailed E1.1 planning schedule can be found in Appendix E. Figure 1-1 shows a timeline for each task within the schedule.







## 2. MEETINGS AND COORDINATION

Meetings and coordination were an integral part of the planning process for continued progress on the State Plan update. A variety of coordination was conducted amongst the Core Planning Team, the SHMT, key stakeholders, and with the Flood and Drought Plans. Each effort is described in more detail in the following sections.

### **2.1 CORE PLANNING TEAM MEETINGS**

The Core Planning Team began the planning process with an in-person kickoff meeting on October 12, 2017. The kickoff meeting discussed the high-level strategy for each phase of the planning process, with more focus on methodology and data needs for the Hazard Identification and Risk Assessment (HIRA). Following the kickoff meeting, the Core Planning Team met weekly throughout the planning process and beyond, utilizing conference calls and webinars as well as several in-person meetings. During these weekly meetings topics such as progress updates, data needs/requests, project timelines, et cetera were discussed for each phase of the planning process. These phases correspond with the phases identified in the planning schedule and E1.1 for an organized structure. Action items were determined for the Core Planning Team members during these meetings, and discussions were summarized and e-mailed to the Team every week. Follow-up between weekly meetings was conducted via e-mail or phone. The weekly Core Planning Team meetings were critical in continually advancing the planning process and allowing for consistent communication regarding Plan progress and needs. Members of the Core Planning Team are also members of the SHMT and Flood and Drought TAPs, and served as a point of contact for ensuring communication and coordination regarding the SHMP across the different teams.

### **2.2 STATE HAZARD MITIGATION TEAM (SHMT) MEETINGS**

A total of three SHMT workshops were conducted over the course of the eight-month planning process, in addition to a number of individual meetings and calls with SHMT members and individual SMEs. DHSEM Core Planning Team members lead all SHMT communications, utilizing email as the primary communication tool, followed by individual meetings and phone calls with key stakeholders as needed (see Additional Key Stakeholder Involvement subsection).

#### **SHMT Workshop #1**

The first SHMT workshop was held on February 13, 2018. At this time in the planning process, the SHMT had an opportunity to review and comment on the first drafts of natural hazard profiles for the Hazard Identification & Risk Assessment (HIRA). A robust representation attended the workshop, with a large majority of participants attending in person and a few members utilizing a webinar and conference call capability. The following agencies and organizations listed below were represented at the initial workshop. Full meeting sign-in sheets and notes are on file at DHSEM.

- Colorado Division of Homeland Security & Emergency Management (DHSEM)

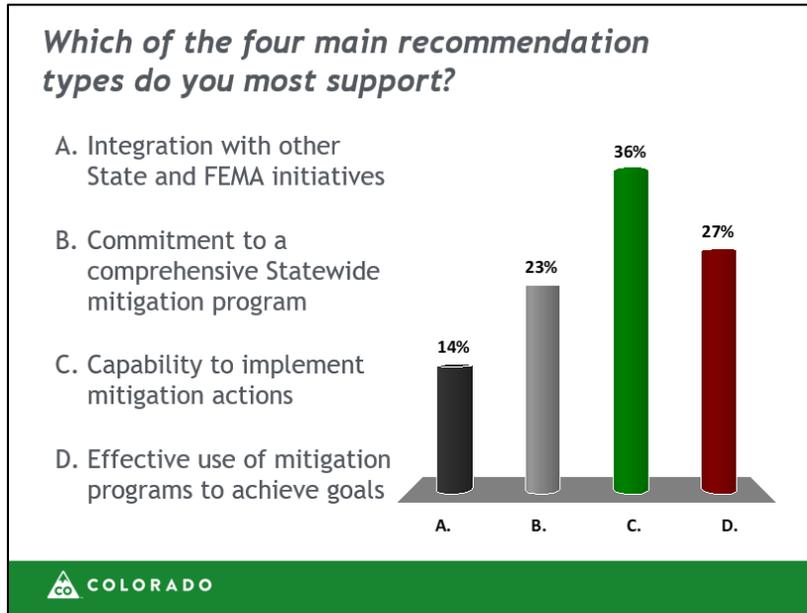
- Colorado Geological Survey (CGS)
- Colorado Water Conservation Board (CWCB)
- Colorado Resiliency Office (CRO)
- Colorado State Forest Service (CSFS)
- Colorado Avalanche Information Center (CAIC)
- Colorado Department of Transportation (CDOT)
- History Colorado
- Community Development Office (CDO)
- Division of Housing (DOH)
- Colorado Climate Center (CCC)
- Colorado Department of Agriculture (CDA)
- State Demography Office

The workshop’s agenda focused on the following topics:

- Introductions
- Why an Enhanced State Hazard Mitigation Plan (E-SHMP)?
- Where are we now? How did we get here?
- What is the planning process?
- Hazard Identification & Risk Assessment
- Mitigation Strategy Review
- Other E-SHMP Efforts
- Next Steps/Questions/Open Discussion

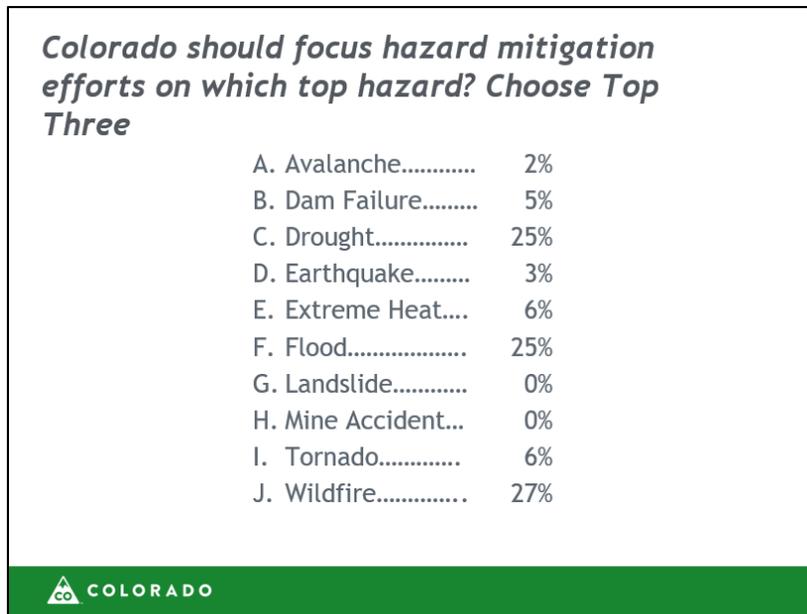
The goal of this workshop was largely informative, aiming to educate the SHMT on the importance of an Enhanced Plan and the efforts required by the SHMT to reach Enhanced Plan status. The workshop included a PowerPoint presentation led by the Core Planning Team. Turning Point software was used in conjunction with PowerPoint to poll the SHMT for input on several items. The first polling question directed to the SHMT was to determine who participated in the 2013 SHMP planning process. The results indicated 46 percent of the current SHMT did participate and 54 percent did not. The large amount of new SHMT members allowed for a fresh perspective on hazard mitigation planning and a robust representation of agencies and organizations throughout the state. Next, the presentation discussed the importance of Enhanced Plan status and implications for the State of Colorado. The presentation then reviewed the Phase I Road Map recommendations for the state to attain Enhanced Plan status. The next poll was conducted to determine which recommendation from the four main types outlined by the Road Map the SHMT supported. Figure 1-22 shows the results of the polling. “Capability to implement mitigation actions” received the highest support from the SHMT.

FIGURE 1-2 ROAD MAP RECOMMENDATIONS POLLING RESULTS



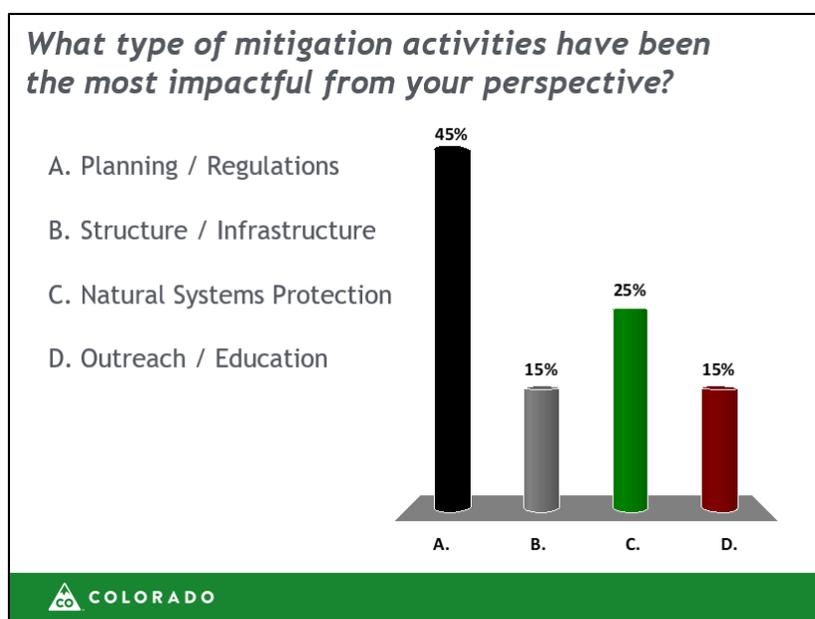
Next, the presentation reviewed steps of the planning process and went on to discuss the HIRA. The third polling question asked the SHMT on which three hazards they would like to see Colorado focus their efforts. The full results are shown in Figure 1-33 below. Overall, the top three hazards were wildfire, flood, and drought, which aligns with the results of the HIRA as three of Colorado’s top hazards.

FIGURE 1-3 TOP HAZARDS POLLING RESULTS



The presentation then moved on to a review of the 2013 mitigation strategy. The 2013 mitigation goals and objectives were reviewed, as well as 2013 mitigation action types. The goal was to prompt the SHMT to start thinking of meaningful mitigation actions for the 2018 SHMP. Turning Point was used to poll the SHMT whether or not they thought the state should continue to utilize objectives along with mitigation goals. The overwhelming majority agreed with the continued use of objectives (95 percent yes versus five percent no), so objectives would be updated and integrated into the 2018 SHMP. Lastly, the SHMT was polled regarding the types of mitigation actions that have been the most impactful from their perspective (results in Figure 1-4 below). Planning and regulations received the most votes, which helps to direct the formulation of meaningful and impactful actions for the 2018 SHMP.

**FIGURE 1-4 MITIGATION ACTIVITIES POLLING RESULTS**



The workshop then reviewed other ongoing analyses for the SHMP including county referral and review requirements, state and local mitigation responsibilities, and the enhanced plan HMA certification process. Lastly, the workshop reviewed next steps and SHMT Action Items. Overall, the polling results and input provided by the SHMT helped to guide the formulation of new mitigation goals and objectives and mitigation strategies.

Post-workshop action items for the SHMT included the following requests:

- Report on status of current mitigation actions by March 1, 2018 (from CWCB, CAIC, CGS, CSFS, CCC, DHSEM)
- Provide technological/human-caused HIRA comments by March 15, 2018
- Provide feedback/recommendations about mitigation goals and objectives (if applicable) by April 1, 2018

- Complete any requested surveys or reporting
- Make yourself available for any interview/meeting requests
- Prepare for Workshop #2
- Review and identify existing or new mitigation responsibilities and capabilities
- Identify strategies for increasing available funding
- Evaluate opportunities for improved coordination/integration
- Provide recommendations for edits to the state’s mitigation goals and objectives
- Attend/participate in SHMT Workshop #2

An email was sent to the SHMT the following week with specific requests, including encouraging participation in an online survey to help craft Mitigation Goals, and seeking a comprehensive review of mitigation responsibilities and capabilities. SHMT members were contacted individually for follow-up regarding 2013 mitigation actions (if applicable) and potential mitigation funding capabilities.

**FIGURE 1-5 SHMT WORKSHOP #1**



### **SHMT Workshop #2**

The second SHMT workshop was held on April 10, 2018. As with the first workshop, most participated in-person, with a few members joining remotely. The agencies and organizations identified below were represented at the workshop. Full sign-in sheets and notes are on file at DHSEM.

- DHSEM
- CGS

- CWCB
- CRO
- CSFS
- CCC
- CDOT
- History Colorado
- DOH
- CDO
- FEMA

This workshop's agenda focused on:

- Introductions
- Where are we now?
- Mitigation Strategy Review & Development
- Discussions relating to enhanced Plan Maintenance, Implementation, and Coordination
- Updates on other E-SHMP Efforts
- Next Steps/Questions/Open Discussion

The second workshop also included a PowerPoint presentation lead by the Core Planning Team. The intent of this workshop was less informative and more interactive. The workshop started with a brief synopsis of where the state is in the overall planning process and progress made since the first workshop. Primarily, all sections of the HIRA were reviewed by the participants, a majority of the mitigation capabilities had been updated by the SHMT, mitigation goals were refined, and mitigation objectives and potential actions had been drafted. Based upon the online survey distributed after the first SHMT workshop, eight mitigation goals were drafted and presented to the group for final comments. The SHMT then worked through drafting objectives and linking them to the new mitigation goals. Next, SHMT members were given a worksheet to include mitigation successes since the 2013 State Plan to be included in the 2018 update. Thereafter, significant time was spent starting to draft 2018 Mitigation Actions. The Core Planning Team walked through the requirements needed from the SHMT for mitigation actions. Potential action ideas were presented to the SHMT to help facilitate discussion. Additional ideas as well as a mitigation action database were emailed to the SHMT after the workshop.

The next major topic of discussion included state agency coordination and integration of statewide hazard mitigation. SHMT members were asked to provide input on what was currently happening, what the state was missing, and what can be improved. This discussion also included input on cooperative grant management coordination between agencies.

Additionally, methods to prioritize funding were discussed. The Core Planning Team reviewed the FEMA STAPLE/E method compared to Colorado's Resiliency Prioritization Criteria. A handout was provided to compare and contrast the two, and to facilitate discussion with the

SHMT on how to integrate the Resiliency Framework into hazard mitigation project funding prioritization. The SHMT then commented on current funding sources at the state and federal level for each of the participating agencies/organizations.

The last major point of discussion was related to both standard and enhanced plan review, evaluation, and implementation. The Core Planning Team reviewed necessary steps to keep the State Plan relevant and current throughout the five-year eligibility cycle. A proposed maintenance schedule was presented by the Core Planning Team and agreed upon by the SHMT for review, evaluation, and implementation of the 2018 State Plan.

To conclude the workshop, next steps and action times were discussed with the participants. The SHMT's input on the Mitigation Strategy, mitigation successes, prioritization process, funding methods, and the implementation timeline was utilized to draft a successful and implementable Mitigation Strategy, as well as an approach to review and implement the 2018 State Plan.

Again, there were post-workshop action items for the SHMT which included the following requests:

- Review draft E-SHMP sections as they are disseminated
- Continue to complete any requested surveys or reporting
- Continue to make yourself available for any interview/meeting requests
- Prepare for Workshop #3
- Provide input into those topics presented and discussed as part of this workshop
- Begin development of new mitigation actions
- Attend / participate in SHMT Workshop #3

FIGURE 1-6 SHMT WORKSHOP #2



### SHMT Workshop #3

The third and final SHMT workshop was held on May 22, 2018. Both in-person and remote attendance was broad, and participation greatly contributed to the updated State Plan and helped guide many final decisions and paths forward. The following agencies and organizations as described below were represented at the workshop. Full sign-in sheets and notes are on file at DHSEM.

- FEMA
- DHSEM
- CWCB
- CRO
- CAIC
- CDOT
- History Colorado
- CDO
- CCC
- CDA

The agenda topics included:

- Introductions
- Where are we now?
- State Agency Coordination & Integration

- Plan Implementation & Maintenance
- System to Ensure Ongoing Enhanced Compliance
- Methodology for Assessing Mitigation Project Effectiveness
- Funding Prioritization Process
- New Mitigation Action Development
- Next Steps/Questions/Open Discussion

The final workshop also included a PowerPoint presentation lead by the Core Planning Team. The workshop began with a brief synopsis on the status of the planning process and progress made since the second workshop. Overall, the HIRA had been finalized, mitigation capabilities finalized, mitigation goals and objectives finalized, and past mitigation actions mostly finalized. The first topic discussed coordination and integration of hazard mitigation planning and projects across state agencies and organizations. The Core Planning Team reviewed how this coordination would be integrated into the Plan with input from the SHMT. It was determined to more formally include alignment with the state's resiliency sectors, and the SHMT participants provided several examples of how information could best be organized to highlight agency coordination. This proposed information was sent to the SHMT for further review and concurrence. It was later confirmed by the CRO Director that the SHMP would be a recurring agenda item on quarterly CRO meetings to demonstrate continued successful integration across all sectors.

The Plan maintenance schedule was then reviewed with one addition related to adjusting the quarterly meeting months, which was approved by the SHMT.

A detailed discussion ensued on the best way to move forward with implementation meetings. Overall, it was determined that different methods work best for different agencies/organizations, and flexibility was important. Participants concluded that the full SHMT was not necessary for each meeting, and working groups based on the objectives of specific meetings should be utilized.

The next major discussion piece focused on ways to assess mitigation project effectiveness. It was clear from the discussion that a one size fits all approach would be difficult to attain across the many agencies and organizations involved in hazard mitigation throughout the state. The feedback obtained from this meeting informed the process of assessing mitigation project effectiveness, which is summarized in Section 5 - Mitigation Strategy.

Finally, proposed new mitigation actions submitted were presented by the Core Planning Team for discussion with the SHMT. An additional brainstorming session also took place by agency SMEs to identify more potential actions. Several ideas were discussed for each agency and questions were addressed by the Core Planning Team. Overall, a few major themes were recognized during this process – cross agency initiatives, climate resilience, data needs, mapped geologic hazard data in a more useable format for local mitigation and land use

planning, dam release mapping, and a need for improved data such as LiDAR. The Core Planning Team sent a draft final version of new mitigation actions based on the discussions in the form of a Mitigation Action Database to the SHMT for review.

Post-workshop action items for the SHMT focused on the following requests:

- Review draft E-SHMP sections as they are disseminated
- Review and refine Mitigation Action Database

### **2.3 ADDITIONAL KEY STAKEHOLDER INVOLVEMENT**

Outside of the SHMT meetings and the Core Planning Team, coordination with additional key stakeholders was critical to the development of the Plan. Additional coordination was utilized for a variety of purposes such as input to specific sections of the State Plan, follow-up from the SHMT meetings, or agency-specific mitigation actions or capabilities. Additional coordination efforts are described in detail below.

#### **Academia**

- Colorado Climate Center (CCC) – The CCC is located at Colorado State University (CSU) within the department of Atmospheric Science. The CCC is the State Climate Office and provides services and expertise related to Colorado’s complex climate. In addition to being members of the SHMT, the Core Planning Team worked directly with the CCC for data and narrative regarding the impacts of climate change on natural hazards. This was accomplished through conference calls and email.
- Colorado Geological Survey (CGS) – The CGS is located at the Colorado School of Mines whose mission is to (1) help reduce the impact of geologic hazards on the citizens of Colorado, (2) promote responsible economic development of mineral and energy resources, (3) provide geologic insight into water resources, and (4) provide geologic advice and information to a variety of constituencies. In addition to being a member of the SHMT, the Core Planning Team worked directly with the CGS for data for hazard profiles for geologic related hazards. This was accomplished through in person meetings, conference calls, and email.
- Colorado Social Capital Research – The Core Planning Team worked with Dr. Daniel Aldrich from Northeastern University to include his research on a framework to capture social capital in hazard mitigation planning. This effort included summarizing the framework and relating it to hazard mitigation planning in Colorado. Additionally, Dr. Aldrich provided the Core Planning Team with GIS data to map social capital by county. This information was useful in combining with social vulnerability studies to understand and prepare for the impacts of hazard events on Colorado’s vulnerable populations. The results can be found in Section 2 - Colorado Overview in this Plan. Communication with Dr. Aldrich was accomplished using teleconference and email.
- University of Colorado Denver – A student in his last semester of an Urban and Regional Planning degree performed research on state and local government mitigation

responsibility in Colorado as his capstone project. The purpose of the analysis was to understand where responsibilities lie across the state and local jurisdictions for implementing hazard mitigation strategies and actions. The analysis can be found in Appendix A.

### **Individual Subject Matter Experts**

In addition to coordination during the SHMT meetings, the Core Planning Team conducted outreach to several subject matter experts (SMEs) for specific information.

- State Demographer (DOLA) – Communication with the State Demographer was primarily via email for solving future population data. Data and narrative was provided for inclusion and analysis in the Colorado Overview Section, as well as the Changes in Development subsection for each of the hazard profiles in the HIRA.
- State Climatologist (CCC) and Senior Climate Change Specialist (CWCB) – The Core Planning Team worked with these Climate Change SMEs to extract data and provide narrative regarding climate change impacts in Colorado as well as climate change impacts on natural hazards. Communication was through teleconference and email.
- Colorado Avalanche Information Center (CAIC) – The CAIC was a critical stakeholder for data and narrative on the Avalanche hazard profile and avalanche-related mitigation actions and capabilities throughout the state. Communication was through teleconference and email.
- Colorado Department of Transportation (CDOT) – The Core Planning Team worked with CDOT to retrieve data and craft a narrative regarding rockfall and its impacts on state highways. Communication was through teleconference and email. CDOT also provided information on vehicle-animal collisions, a Threat and Hazard Identification & Risk Assessment (THIRA), a white paper on the economic impacts of geohazards on CDOT operations, and culvert mitigation efforts.
- Colorado Geologic Survey (CGS) – The CGS provided specific geological data, GIS mapping data, and narrative regarding geologic hazards. Coordination on hazards data included expansive soils, landslide/debris flows, rockfall, subsidence, erosion/deposition, earthquakes, and radon/carbon monoxide/methane/other seeps. Coordination with the State Geologist occurred through teleconference, email, and a face-to-face meeting. The meeting included CGS, DHSEM, consultant staff from the Core Planning Team, and a representative from DOLA/CRO.

### **FEMA-State Consultation**

After the second SHMT meeting on April 10, 2018, FEMA Region VIII held its State Consultation with Colorado. Extensive state and federal participation included representatives from the following agencies:

- FEMA
- CWCB

- DHSEM
- Urban Drainage & Flood Control District (UDFCD)
- CGS
- CDO
- CRO
- CDOT
- CSFS

The purpose of an annual FEMA-State Consultation is to review all things related to hazard mitigation occurring in the state. The 2018 agenda addressed different state plans and programs related to hazard mitigation. Updates were provided by state agencies regarding the SHMP; climate, flood, and drought plans; mitigation within CSFS, CDOT, and CRO; HMA grants; Environmental Planning & Historic Preservation; FEMA RiskMAP; NFIP; local and tribal mitigation planning; earthquake programs; and the dam safety program. Additionally, FEMA discussed mitigation news, such as the Building Sciences Saves 2.0 Report and other recent initiatives. Overall, agencies discuss how they are working to incorporate mitigation into their policies and programs. The State Consultation provides a platform for agency coordination and integration regarding mitigation across the state. Since the 2018 Consultation, DHSEM has requested on-going follow-up to FEMA on deliverable action items as identified in the 2018 summary notes.

Since the 2013 State Plan, annual FEMA-State Consultations were conducted in 2015 (May 15, 2015), 2016 (September 27, 2016), and 2017 (September 25, 2017) with increasing participation as described above during the 2018 event. Completed sign-in sheets and FEMA's official summary notes are retained on file at DHSEM for all recent FEMA-State Consultations.

Additionally, semi-regular mitigation planning teleconference meetings are conducted nearly every month between both the FEMA Region VIII and DHSEM mitigation planning teams. These coordination calls aim to further mitigation planning initiatives, share current relevant topics and activities, address issues of mutual concern, develop new strategies for integrating local plans into other planning mechanisms, promote available cross sector and cross region training, and share overall best practices. FEMA Region VIII planners also provide to DHSEM's mitigation planning team a monthly plan status report for concurrence, which is also included in Colorado's monthly Dashboard Report from FEMA.

### **Community Engagement and Risk Communication (CERC) Alignment**

Alignment with CERC activities was a weekly discussion topic on the Core Planning Team calls. Specifically, the *"Mitigating Hazards through Land Use Solutions"* workshops were a cooperative endeavor between DOLA, DHSEM, and FEMA, and continues as a pilot project focused on guiding vetted communities to develop mitigation actions via adoption of land use strategies and codes, and to create mitigation incentive programs. As members of the SHMT, the workshop could be aligned with the overarching goals of the SHMP. Two successful

workshops were held, one in the Town of Edwards focusing primarily on wildfire mitigation, and one in the City of Longmont focusing primarily on flood hazards.

#### **2.4 COORDINATION WITH THE STATE FLOOD AND DROUGHT PLANS**

As noted in the Planning Teams section, the Colorado Flood Hazard Mitigation Plan and the Colorado Drought Mitigation and Response Plan have been on the same update cycle of the SHMP in 2010, 2013, and 2018. The most recent Drought Plan update began in October 2017 and was completed in September 2018; the Flood Plan update occurred from January through September 2018. There were planning teams specific to the Flood and Drought Plans and as noted previously in the Planning Teams section, participation overlap and coordination was ongoing with both the Core Planning Team and the SHMT throughout the State Plan update, as well as during the update process for the Drought and Flood Plans. For example, new mitigation actions identified at the respective Flood and Drought planning meetings were shared at the SHMT Workshop #3. The flood risk assessment utilized to update the SHMP also informed the Flood Plan. The high priority actions identified in both plans are also noted in Section 5 - Mitigation Strategy. Both are considered stand-alone plans, yet are described in each update introduction as Annexes that are integral and linked directly to the SHMP. They are not annexed within this plan due to the fact that the Drought Plan in particular has a number of annexes and appendices and an extensive vulnerability assessment and response annex. Additional details on the planning processes used to update the plans can be referenced in the respective documents. The Drought Plan can be found at <http://cwcb.state.co.us/water-management/drought/Pages/StateDroughtPlanning.aspx> and the Flood Plan can be found at <http://cwcb.state.co.us/water-management/flood/Pages/main.aspx>.

#### **2.5 ADDITIONAL PLANNING COORDINATION EFFORTS**

Relevant ongoing planning and related activities occurring since the 2013 Plan and contributing to the 2018 SHMP update include quarterly DHSEM / DOLA / CRO coordination meetings to discuss statewide planning efforts, various grants management, and overall strategies to better integrate cross-agency tasks. These meetings include members of the DHSEM Core Planning Team as well as DOLA and CRO representatives to the SHMT.

Additionally, the DHSEM Executive Steering Committee (ESC), formed in November 2017, provides monthly progress updates and decision requests resolution to DHSEM Leadership and the Finance Section (now Office of Grants Management [OGM]). This group consisted of the DHSEM Director, Chief of Staff, OEM Director, OGM Director (and various finance & accounting staff), and the DHSEM Core Planning Team from the Mitigation Section. The ESC also was instrumental in initiating a strategy for enhanced plan coordination with outside agency recipients of FEMA's Mitigation Grants Division funding and tied to HMA Grants Management Performance evaluation.

DHSEM Core Planning Team members also participate as sector representatives on the CRO Community Resiliency Working Group, the Colorado Resiliency Institutionalization Project

(CORIP), and the Planning for Hazards Steering Committee. Meetings are attended in-person or by remote teleconference.

Related to statewide climate and hazard mitigation planning, the DHSEM Core Planning Team lead is a member of the Association of Climate Change Officers (ACCO) and participated in the Compact of Colorado Communities signing event in which 28 Colorado cities and counties are working to institutionalize climate change into decision-making across all levels of local leadership. Additionally, the DHSEM mitigation planning representative attended and participated in the inaugural Colorado Communities Symposium, both as a member of the Symposium Steering Committee and as a hazard mitigation planning speaker, and continues to coordinate with local, state, and private sector statewide undertakings on climate change impacts to Colorado and efforts related to state and local hazard mitigation planning, resiliency, and emergency management. As a result of the statewide actions developed at the Symposium, DHSEM's mitigation planning lead also participates in follow-up Colorado Communities Cooperative Meetings to help chart a path for climate action implementation.

Along with other state agency and academia partners and directly related to efforts in local mitigation planning, the DHSEM mitigation team lead is a participant in the NOAA Environmental Literacy Grant submitted by the Cooperative Institute for Research in Environmental Sciences (CIRES) at CU Boulder. This project will engage with K-12 students and educators across the state via climate change curriculum development in order to increase community resilience from within. The final product will serve as a model for other states in the southwestern United States sharing similar hazards and rural community structures. The inspiration for this project came about as a result of the Symposium, is particularly focused on rural communities, and will be highlighted in the Community Resilience track and the next Colorado Communities Symposium.

The final culmination of the required statewide integrated planning process resulted in this updated 2018 Colorado State Hazard Mitigation Plan. Following the E1.1 Planning Schedule previously described, individual sections and sub-sections were sent for review and comment to the SHMT and other applicable SMEs as necessary throughout the update process to allow for incorporation of SHMT comments into the overall document. The initial final draft was shared with DHSEM staff and delivered to FEMA Region VIII for review on August 17, 2018. Access to the completed final draft of the 2018 State Plan update was provided to the SHMT for an additional review and comment period in October 2018. Any supplemental DHSEM and SHMT comments received were integrated into the final draft.

After resolving initial required revisions, the State Plan was again sent to FEMA for an additional review on November 9, 2018. Approvable Pending Adoption (APA) status was granted by FEMA on November 15, 2018 and signed by the Governor with required assurances on November 21, 2018. Final FEMA approval was received on December 19, 2018 providing for a five-year eligibility cycle in advance of the next required update.

DHSEM continues to work with internal and external agencies on enhanced plan requirements and aims to request of FEMA an enhanced plan review during this standard plan cycle.

### **3. PUBLIC INVOLVEMENT**

The final version of the updated State Hazard Mitigation Plan will be available and posted on the DHSEM website for public access after being granted final FEMA approval.

As required by the CWCB, the Colorado Flood Hazard Mitigation Plan and Colorado Drought Mitigation and Response Plan were advertised and posted on CWCB's website for 30 days before finalization and approval by the CWCB Board. No comments were received.

## **SIGNIFICANT CHANGES IN THE STATE PLAN FROM 2013**

As previously mentioned, the most significant change is that the 2018 State Plan was written to conform with FEMA enhanced plan requirements. As a result, a number of new components have been incorporated into this updated State Plan. The following is a discussion of the key changes made to the State Plan during the 2018 update process:

### **Section 1 - Plan Process**

The Plan Process section was updated to document the planning process followed for development of the updated State Plan. Some 2013 content aligned better to other updated sections and has been integrated accordingly.

### **Section 2 - Colorado Overview**

The Colorado Overview section was updated to reflect the best available data at the time of the plan development.

### **Section 3 - Hazard Identification & Risk Assessment**

The Hazard Identification & Risk Assessment (HIRA) section saw some major changes, as DHSEM was directed to profile all natural, technological, and human-caused hazards impacting the state. This allows for better incorporation and integration of the HIRA into other state planning processes, and helps to meet EMAP requirements. All hazards profiled in the 2013 State Plan were updated with the best available data at the time of plan development. In addition, the assessment of future hazard conditions includes an evaluation of how climate change will impact each hazard facing the state.

### **Section 4 - Capability Assessment**

The Capabilities Assessment was updated by the SHMT. In addition, content was re-organized to better align with Colorado's departments and agencies. A robust evaluation of local mitigation capabilities is also included and was undertaken as part of the planning process. An updated assessment of mitigation funding sources was also added to this section.

### **Section 5 - Mitigation Strategy**

There were several changes in the Mitigation Strategy section. SHMT contributions allowed for the refinement to the state's mitigation goals and objectives resulting in the development of a Mitigation Actions Database to allow for better prioritization and tracking. Some 2013 content aligned better to other updated sections and has been integrated accordingly. An updated methodology for prioritizing Actions was also developed to align with the Colorado Resiliency Framework. A new section on assessing mitigation effectiveness was added.

### **Section 6 – Local Planning**

The Local Planning section was updated utilizing all of the updated local hazard mitigation plans written and updated since 2013. Some 2013 content aligned better to other updated sections and has been integrated accordingly.

### **Section 7 - Plan Maintenance**

The Plan Maintenance section saw some major updates, as the SHMT identified a need for an improved maintenance process. This process was also developed with the understanding that the state aimed to obtain and remain an enhanced state.

### **Section 8 - Enhanced Plan**

The Enhanced Plan section is new and was developed to meet FEMA's enhanced plan requirements in addition to helping the state develop processes for ensuring continued and improved coordination and integration. Parts of this section also focus on enhanced compliance. Methodologies for funding prioritization are also included.

### **Plan Appendices**

The updated State Plan contains a number of new appendices. No appendices from the 2013 State Plan are included. These appendices focus on white papers concerning government mitigation responsibility, existing state referral processes, and an evaluation of building codes. Another appendix contains a collection of tools, templates, and resources for the SHMT to utilize going forward. Additionally, an appendix that relates to FEMA enhanced plan requirements and includes additional specifics on coordinating structures, integrated programs and plans, and related trainings as demonstrated evidence of how the state is committed to a comprehensive mitigation program is also included.

## SECTION 2. COLORADO OVERVIEW

## SECTION 2. COLORADO OVERVIEW

### CONTENTS

Section 2. Colorado Overview.....	2-2
Introduction.....	2-4
Topography .....	2-5
Climate .....	2-7
Climate Change.....	2-8
Population .....	2-9
Household Growth .....	2-11
Colorado Social Vulnerability Analysis.....	2-13
1. Age.....	2-14
2. Income.....	2-15
3. Fluency in English .....	2-16
4. Social Capital .....	2-17
5. Social Vulnerability Index.....	2-21
Transportation .....	2-23
1. Highways .....	2-24
2. Railroads.....	2-24
3. Airports .....	2-24
Land Status .....	2-25
State Assets .....	2-27
1. State-Owned Assets.....	2-27
2. State Asset Property Losses.....	2-30
Statewide Building Exposure.....	2-31
Resources .....	2-33

### LIST OF FIGURES

Figure 2-1 Colorado Vicinity Map.....	2-4
Figure 2-2 Counties and Indian Tribes in Colorado.....	2-5
Figure 2-3 Colorado Topography .....	2-7
Figure 2-4 Annual Average Temperature and Precipitation from 1950 to 1999 in Colorado ....	2-8
Figure 2-5 Population Estimates by County, 2016 .....	2-10
Figure 2-6 Population Percent Change Projections, 2010 to 2030.....	2-11

Figure 2-7 Total Projected Housing Growth, 2010 to 2030 by County .....	2-12
Figure 2-8 Projected Percent Change in Housing, 2010 to 2030 by County.....	2-13
Figure 2-9 Change in Percent of Population Over 65, 2010 to 2030 by County .....	2-15
Figure 2-10 Percent of Population Living Below the Poverty Line in 2016, by Census Tract..	2-16
Figure 2-11 Percent of People that do not Speak English Very Well or At All by Census Tract, 2016 .....	2-17
Figure 2-12 Colorado Social Capital Index .....	2-21
Figure 2-13 Colorado Social Vulnerability Assessment.....	2-23
Figure 2-14 Colorado Transportation Infrastructure .....	2-25
Figure 2-15 Colorado Land Ownership.....	2-26
Figure 2-16 State-Owned Assets by County.....	2-27

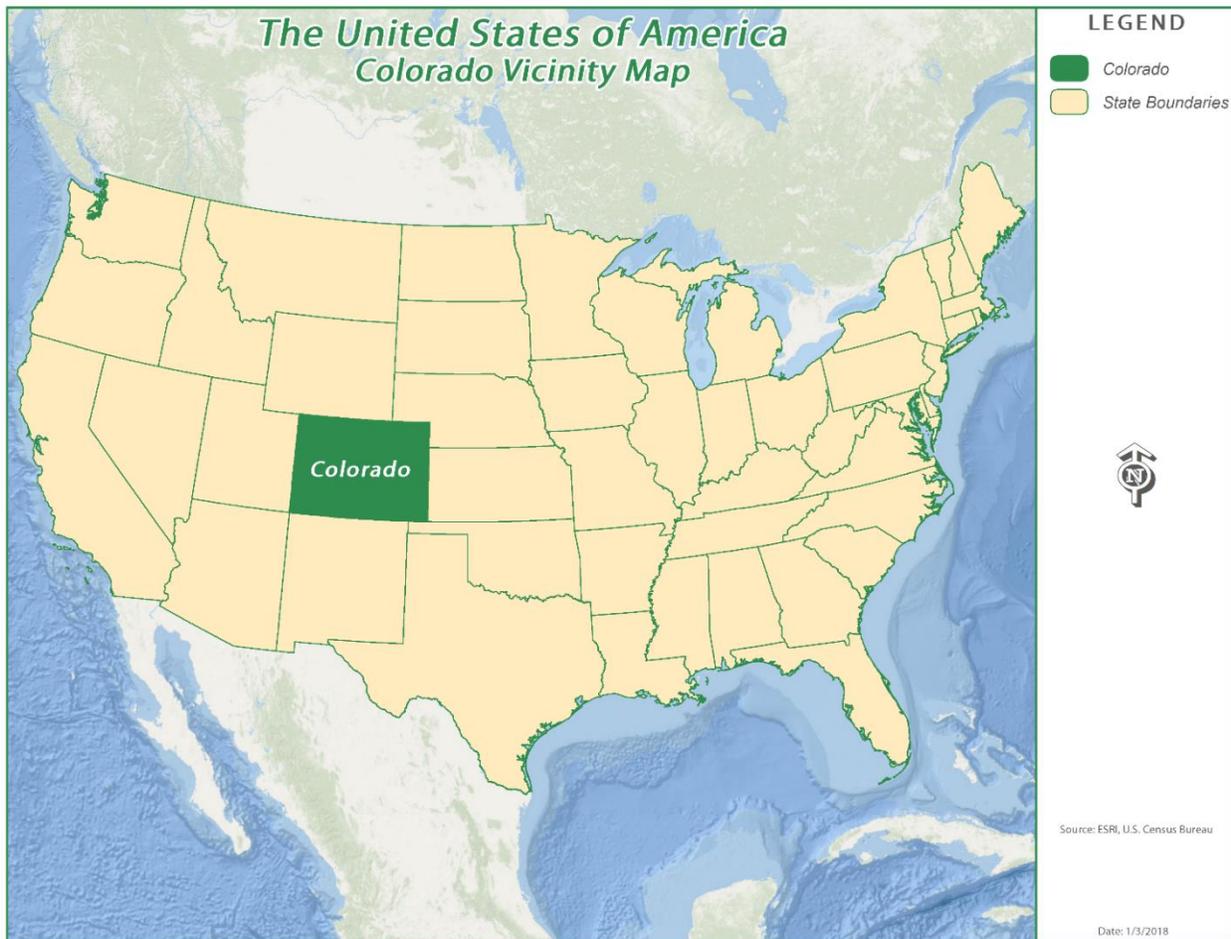
## LIST OF TABLES

Table 2-1 Bonding, Bridging, and Linking Variables.....	2-18
Table 2-2 Social Vulnerability Indicators.....	2-22
Table 2-3 Colorado Land Ownership.....	2-26
Table 2-4 State-Owned Asset Overview by County .....	2-28
Table 2-5 Asset Overview for Primary State Asset Holders.....	2-30
Table 2-6 State Asset Property Losses from Hazards.....	2-31
Table 2-7 Local Exposure by County - Total Building Value.....	2-32

# INTRODUCTION

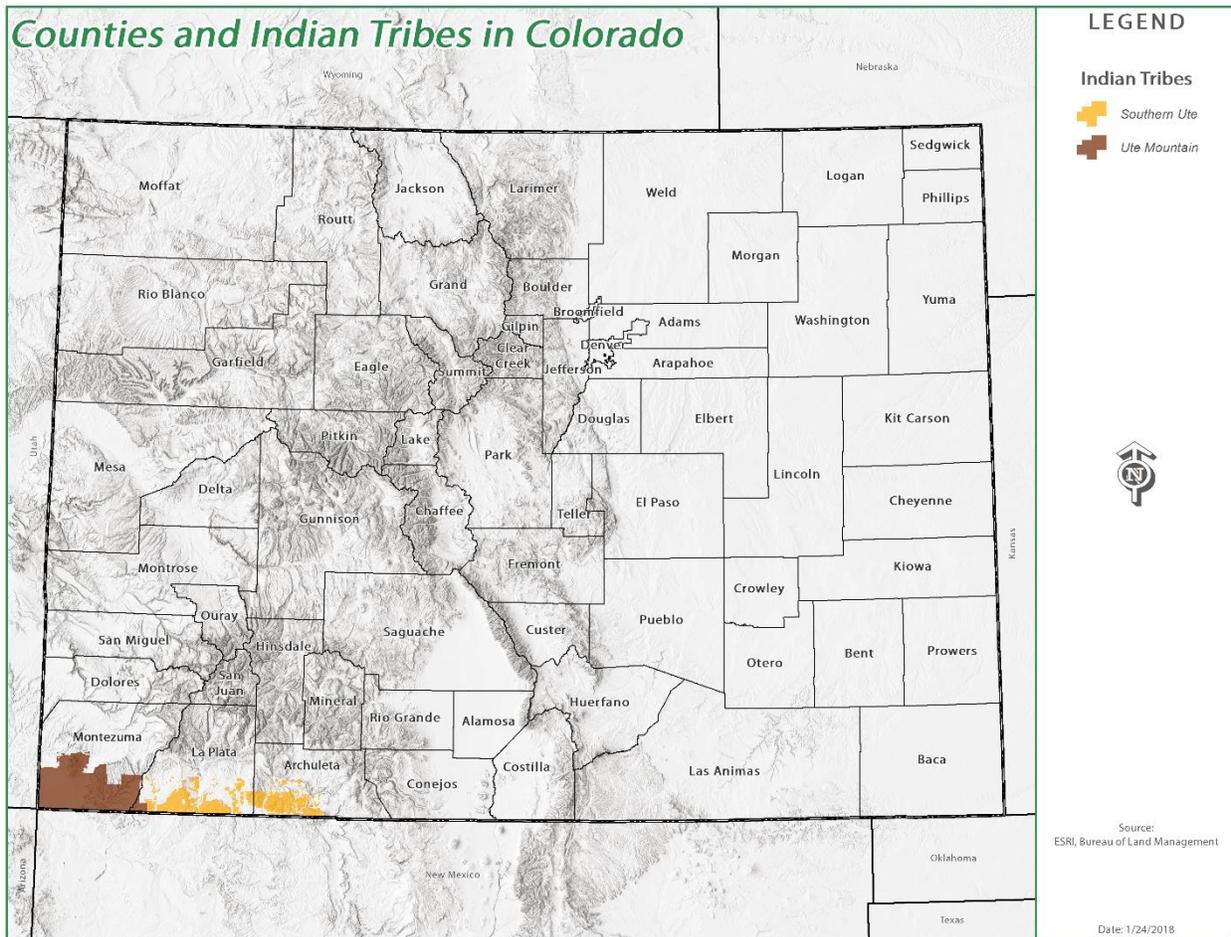
Colorado is located in the western United States, approximately 1,500 miles west of the Atlantic Ocean and 800 miles east of the Pacific Ocean, as shown in Figure 2-1. Colorado is bordered by Wyoming to the north, Nebraska to the northeast, Kansas to the east, Oklahoma and New Mexico to the south, Utah on the west, and Arizona on the southwest corner. Colorado is the eighth largest state when measured by area. Colorado is shaped as an almost perfect rectangle covering 104,247 square miles - ranging 387 miles from east to west and 276 miles from north to south.

FIGURE 2-1 COLORADO VICINITY MAP



Colorado was established as a Territory by the United States Congress in 1861 , with 17 territorial counties. In 1876, Colorado was the 38th state to join the Union. Today Colorado has 64 counties including two counties with consolidated city and county governments. Most counties were formed in the late 1800s and early 1900s, but as recently as 2001 boundaries changed when the City of Broomfield became a city and county government. The Southern Ute Indian Tribe and Ute Mountain Ute Tribe also exist in the southwestern portion of the state, as shown in Figure 2-2.

FIGURE 2-2 COUNTIES AND INDIAN TRIBES IN COLORADO



## TOPOGRAPHY

Colorado is known as the Rocky Mountain State. Elevation is one of the distinctive geographical features of Colorado; it is the nation's highest state with a mean average elevation of 6,800 feet. The state is dominated by the Rocky Mountains which run north/south through the state and separates the eastern flat high plains from the western wide river valleys, high plateaus, and rugged canyons. These mountains form the Continental Divide, separating the great watersheds of the United States into water emptying into the Pacific and Atlantic Oceans. Colorado has 54 peaks that reach 14,000 feet or higher and hundreds of mountains that reach elevations of 11,000 feet to 14,000 feet.

Colorado's varied topography divides the state into several generalized regions referenced throughout this Plan. The regions and associated counties are described below (Denver 7, 2009 and Colorado State Demography Office, 2017).

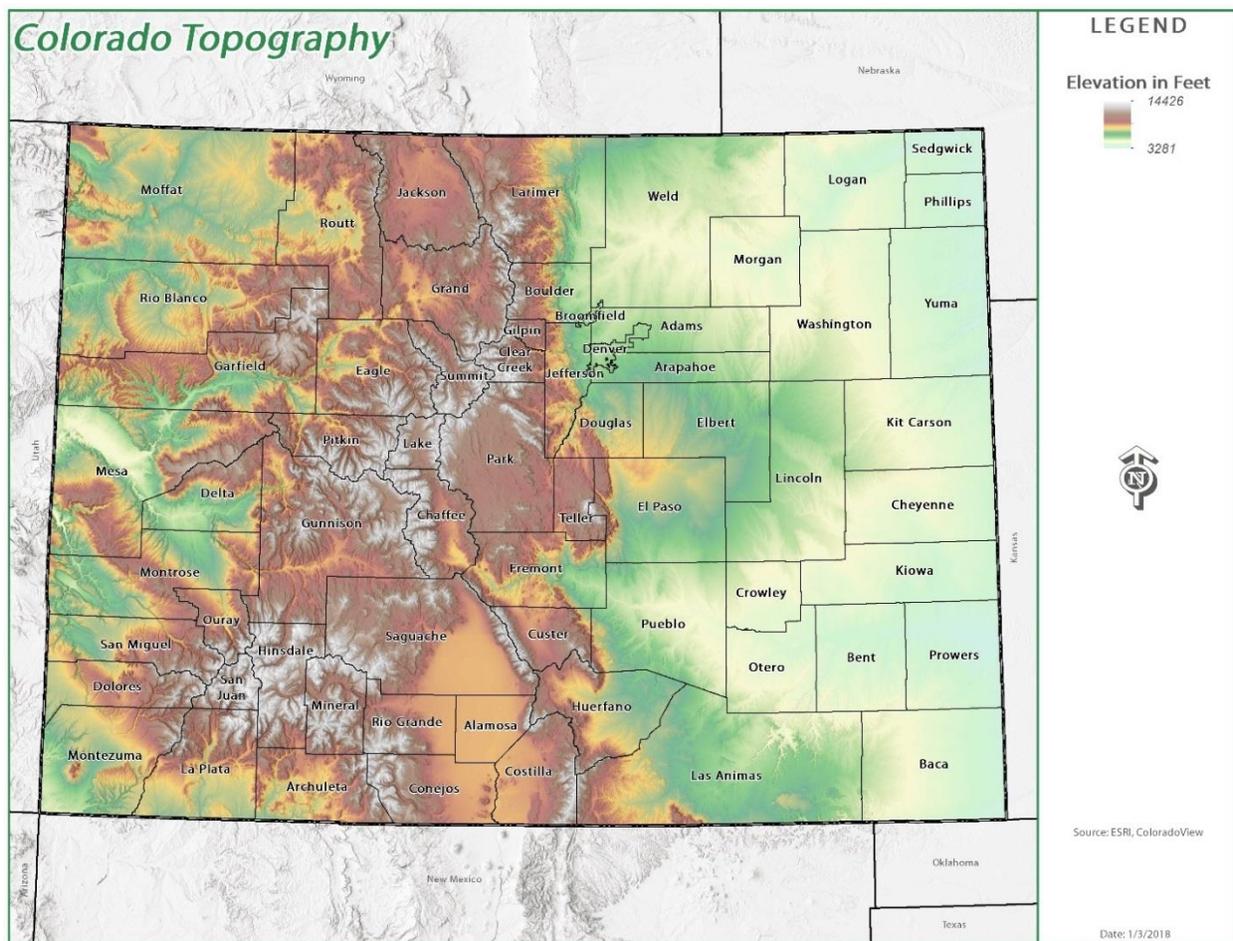
- **Eastern Plains:** Refers to most all areas east of Interstate 25 (Figure 2-14) in Colorado. In general, this refers to locations below 6,000 feet in elevation. Eastern Plains counties

include: Logan, Morgan, Phillips, Sedgwick, Washington, Yuma, Cheyenne, Elbert, Kit Carson, Lincoln, Baca, Bent, Crowley, Kiowa, Otero, and Prowers.

- **Front Range:** The Front Range is technically the front mountain range, or the eastern most range, of the Rocky Mountains. Generally, from Pueblo County north, everything from just east of the Continental Divide to Interstate 25 can be considered the Front Range. This includes major population centers of Colorado, including the City and County of Denver and most of its suburbs, the City of Boulder, Fort Collins, Colorado Springs, and Pueblo. Front Range counties include: City and County of Denver, Adams, Arapahoe, City and County of Broomfield, Douglas, Jefferson, Boulder, Larimer, Weld, El Paso, Teller, and Pueblo. The topography can vary significantly in some of these counties. For example, eastern Weld County has characteristics more similar to the Eastern Plains, whereas western Boulder and Larimer Counties have characteristics more similar to the central mountains.
- **Central Mountains:** In general, locations above 9,000 feet in elevation are considered to be the central mountains. There are some cities below that elevation that are still considered to be in the central mountains due to surrounding terrain. Central Mountain counties include: Clear Creek, Gilpin, Park, Chaffee, Custer, Fremont, Lake, Huerfano, and Las Animas.
- **Western Slope:** The Western Slope describes the mountains west of the Continental Divide, as well as the area of western Colorado outside of the mountains generally in elevations below about 7,000 feet. Outside of the mountains, the terrain is made up of numerous mesas and plateaus. Western Slope counties include: Archuleta, Dolores, La Plata, Montezuma, San Juan, Delta, Gunnison, Hinsdale, Montrose, Ouray, San Miguel, Garfield, Mesa, Moffat, Rio Blanco, Routt, Eagle, Grand, Jackson, Pitkin, and Summit.
- **Grand Valley:** The Grand Valley is a part of the Western Slope. It is an extended populated valley, approximately 30 miles long and five miles wide, located along the Colorado River in Mesa County, Colorado and Grand County, Utah. The Grand Valley is the most densely populated area on the Colorado Western Slope, including the City of Grand Junction. The Grand Valley is part of the larger Colorado Plateau desert.
- **San Luis Valley:** The San Luis Valley is the broad, generally flat, valley in south central Colorado and far north central New Mexico. It is situated between the Sangre de Cristo mountain range (the Wet Mountains) on the east and the San Juan mountain range on the west, and is one of the largest high desert valleys in the world. It extends 125 miles long and 65 miles wide with an altitude of over 7,000 feet. The San Luis Valley sits on top of the Rio Grande Rift, and contains the headwaters of the Rio Grande river. San Luis Valley counties include: Alamosa, Conejos, Costilla, Mineral, Rio Grande, and Saguache.

Figure 2-3 shows Colorado's topography.

FIGURE 2-3 COLORADO TOPOGRAPHY



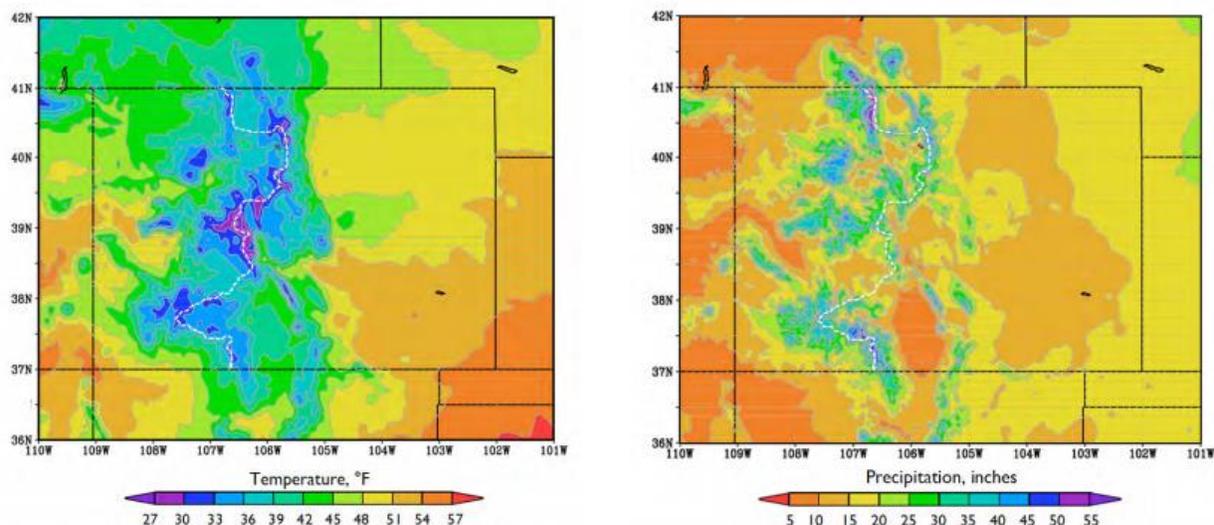
## CLIMATE

Colorado's climate is influenced by a variety of factors. Its mid-latitude location results in a prominent seasonal cycle that strongly influences which climate processes are most active at different times of the year. Colorado's interior location means that the state experiences frequent sunshine, low humidity, and rapid and large variations in temperatures. The average annual statewide precipitation is 17 inches, and average annual temperature is 43.5 degrees Fahrenheit. However, Colorado's complex topography - mountains, valleys, plateaus, and rolling plains - acts to influence temperature, pressure, wind, and precipitation patterns, which can all vary dramatically over very short distances. Across the seasons the western slopes of the state's mountain ranges are generally wetter than the eastern slopes. Generally, temperatures cool predictably with increasing elevation, by approximately 3.5°F per 1,000 feet of elevation gain. Topography also plays an important role in precipitation processes and patterns.

Precipitation typically increases with elevation in all seasons, but especially in winter when nearly all moisture falls as snow. Areas above 9,000 feet along and west of the Continental

Divide receive the most winter precipitation and annual precipitation in the state. In all mountain ranges, most of the annual total comes from cold-season precipitation. In the summer, most precipitation statewide comes from convective processes that generate frequent, sometimes daily, thunderstorms. Figure 2-4 shows the annual average temperature and precipitation from 1950 to 1999 in Colorado. The white dashed line indicates the Continental Divide (climate text adapted from Lukas et al. 2014).

**FIGURE 2-4 ANNUAL AVERAGE TEMPERATURE AND PRECIPITATION FROM 1950 TO 1999 IN COLORADO**



Source: adapted from Lukas et al. 2014

## CLIMATE CHANGE

Climate changes have already been observed in Colorado. Climate Change in Colorado (Lukas et al. 2014) reports the following as key points regarding observed climate changes in Colorado. The trend analyses for Climate Change in Colorado were performed with 30-year, 50-year, and 100-year periods, all ending in 2012, except for snowpack trends, which end in 2013.

- Statewide annual average temperatures have increased by 2.0°F over the past 30 years and 2.5°F over the past 50 years. Warming trends have been observed over these periods in most parts of the state.
- Daily minimum temperatures in Colorado have warmed more than daily maximum temperatures during the past 30 years. Temperatures have increased in all seasons, with the largest trend in summer, followed by fall, spring, and winter.
- No long-term trends in average annual precipitation have been detected across Colorado, even considering the relatively dry period since 2000.

- Snowpack, as measured by April 1 snow-water equivalent (SWE), has been mainly below-average since 2000 in all of Colorado’s river basins, but no long-term (30-year, 50-year) declining trends have been detected.
- The timing of snowmelt and peak runoff has shifted earlier in the spring by 1 to 4 weeks across Colorado’s river basins over the past 30 years, due to the combination of lower SWE since 2000, the warming trend in spring temperatures, and enhanced solar absorption from dust-on-snow.
- The Palmer Drought Severity Index (PDSI) shows a trend towards more severe soil-moisture drought conditions in Colorado over the past 30 years, reflecting the combination of the below-average precipitation since 2000 and the warming trend.
- No long-term statewide trends in heavy precipitation events have been detected. The evidence suggests that there has been no statewide trend in the magnitude of flood events in Colorado.
- Tree-ring records and other paleoclimate indicators for Colorado show multiple droughts prior to 1900 that were more severe and sustained than any in the observed record.

These climate trends are projected to continue with varying intensities depending on global greenhouse gas emission trajectories (low vs. high emissions). However, Colorado has already taken steps to reduce the state’s greenhouse gas emissions as well as increase preparedness for climate change impacts through plans and reports such as the Colorado Climate Plan, the Colorado Climate Change Vulnerability Study, and Climate Change in Colorado.

The impact of projected climate changes to each hazard is discussed in the individual hazard profiles.

## POPULATION

As of 2016, population in Colorado was estimated at 5,538,180 persons. Statewide, Colorado’s population has been growing between 1.4 and 1.8 percent per year since 2012, or between 70,000-98,000 new residents each year. This population growth is derived from a combination of natural increase in births minus deaths (totaling ~35,000 persons) and net migration (~35,000-60,000 persons). Colorado’s net migration is strongly related to job growth and its quality of life, including numerous outdoor recreational opportunities. Most of the recent and expected growth in Colorado is due to growth in the tourism, retiree, information services, construction, mining, and national/regional service industries. From 2015 to 2016, there was a slight slowdown in population increase, down from a 1.8 percent increase or 98,000 persons, to a 1.7 percent increase, or 90,000 persons. Natural increase remained about the same, however net migration slowed from 2015 to 2016. This is likely due to slowing job growth in the energy sector. From July 1, 2012 to July 1, 2016 the state population increased 6.69 percent.

Counties along the Front Range account for a significant portion of Colorado’s total population as shown in Figure 2-5. In 2015, Colorado’s population distribution averaged approximately 52.42 persons per square mile. The City and County of Denver is the state’s most populous

county with an estimated 693,292 persons in 2016. Several other counties are estimated to have over 500,000 residents including El Paso, Arapahoe, and Jefferson. Mesa County is the most populous county of the Western Slope with nearly 150,000 residents. Growth in the state varies dramatically by county with some counties more than doubling in population over the last 20 years and other counties losing population. Figure 2-5 shows the 2016 population estimates by county.

**FIGURE 2-5 POPULATION ESTIMATES BY COUNTY, 2016**

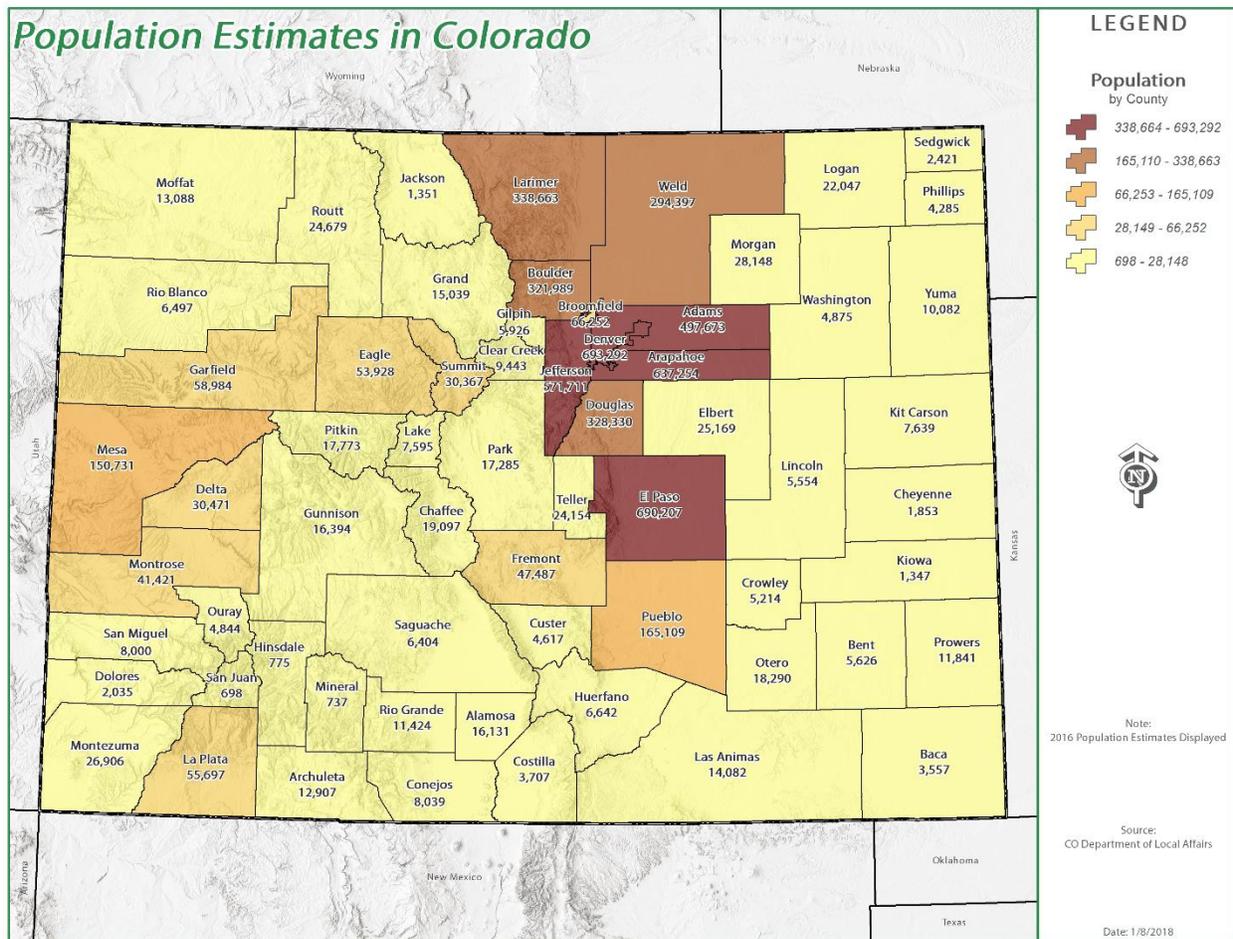
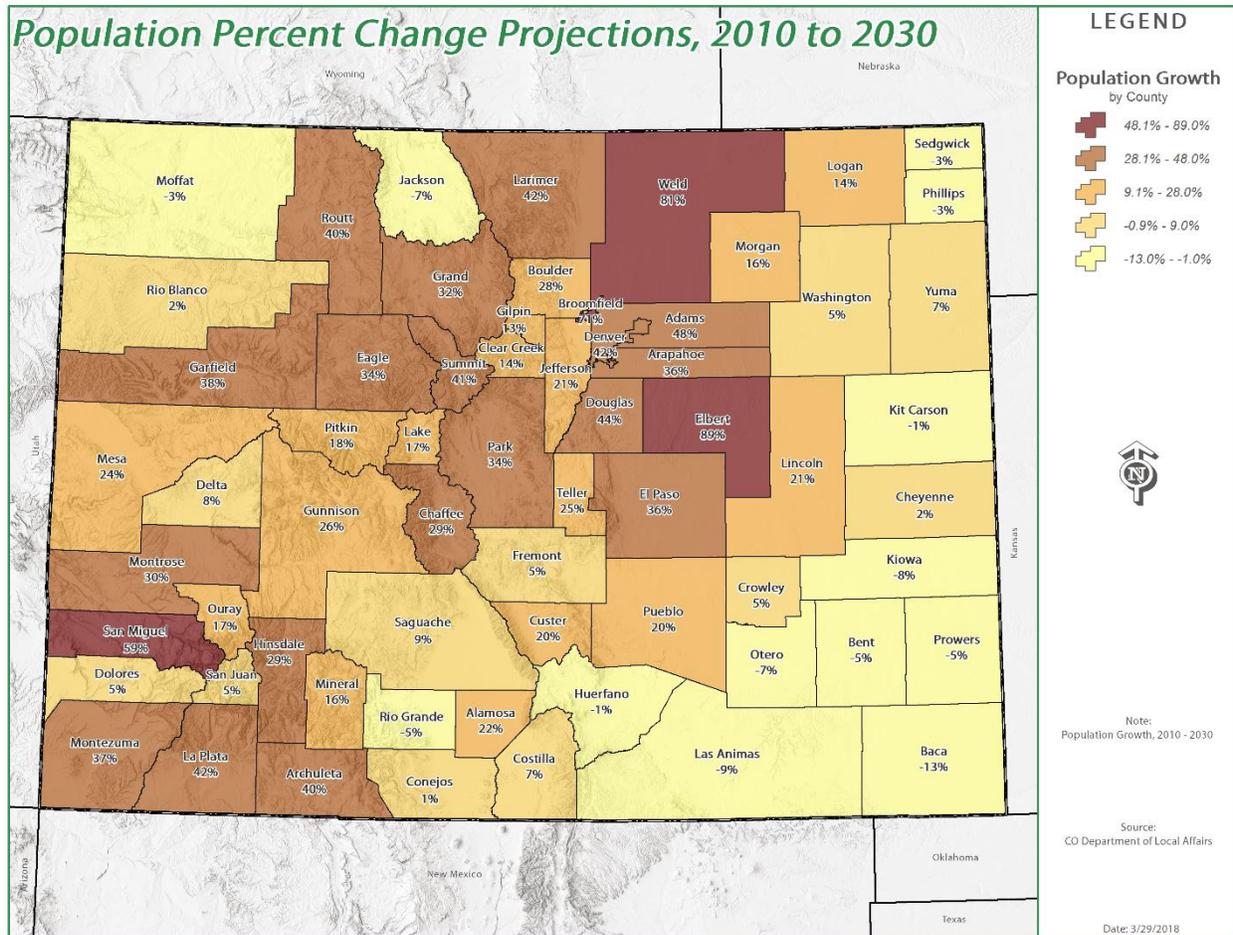


Figure 2-6 shows the projected percent change in population for the state from 2010 through 2030. This information is presented at the county level. Statewide, Colorado is projected to have a 36 percent increase in population from 2010 to 2030. What the map indicates is that as Colorado's total population grows statewide to 2030, the growth is not shared equally by all counties. In particular, there is projected to be a continual population decline in the rural communities of the Eastern Plains and San Luis Valley (SLV). At the same time, population growth is anticipated to be prevalent in the central, north-central, west-central, and southwest areas of the state. Elbert County is projected to experience the largest percent change in population from 2010 to 2030, with a projected 89 percent increase. Weld County follows closely, with an 81 percent projected increase in population. Baca County is projected to have

the lowest percent change in population from 2010 to 2030, with a projected -13 percent change.

**FIGURE 2-6 POPULATION PERCENT CHANGE PROJECTIONS, 2010 TO 2030**



Colorado is forecast to grow in population to 6.8 million by 2030. The northern Front Range is the fastest growing region in the state with an expected average annual percent change of 2.4 percent between 2010 and 2030. This is compared to the 1.5 percent average annual percent change expected statewide. The Western Slope is also expected to have above the statewide average annual percent change, while the Central Mountains, Eastern Plains, and San Luis Valley are expected to continue growing similar to the national rate near one percent.

## HOUSEHOLD GROWTH

The total number of households is projected to grow in each county in Colorado except Baca County. Arapahoe County is projected to have the highest household growth, with an increase of 115,999 houses from 2010 to 2030, while Baca County is projected to have the lowest growth with a loss of 106 houses. Regionally, counties along the northern and central Front Range, Central Mountains, and Western Slope are projected to have the greatest increase in total

households. Figure 2-7 shows total projected housing change from 2010 to 2030 by county, and Figure 2-8 shows the projected percent change in housing from 2010 to 2030 by county.

**FIGURE 2-7 TOTAL PROJECTED HOUSING GROWTH, 2010 TO 2030 BY COUNTY**

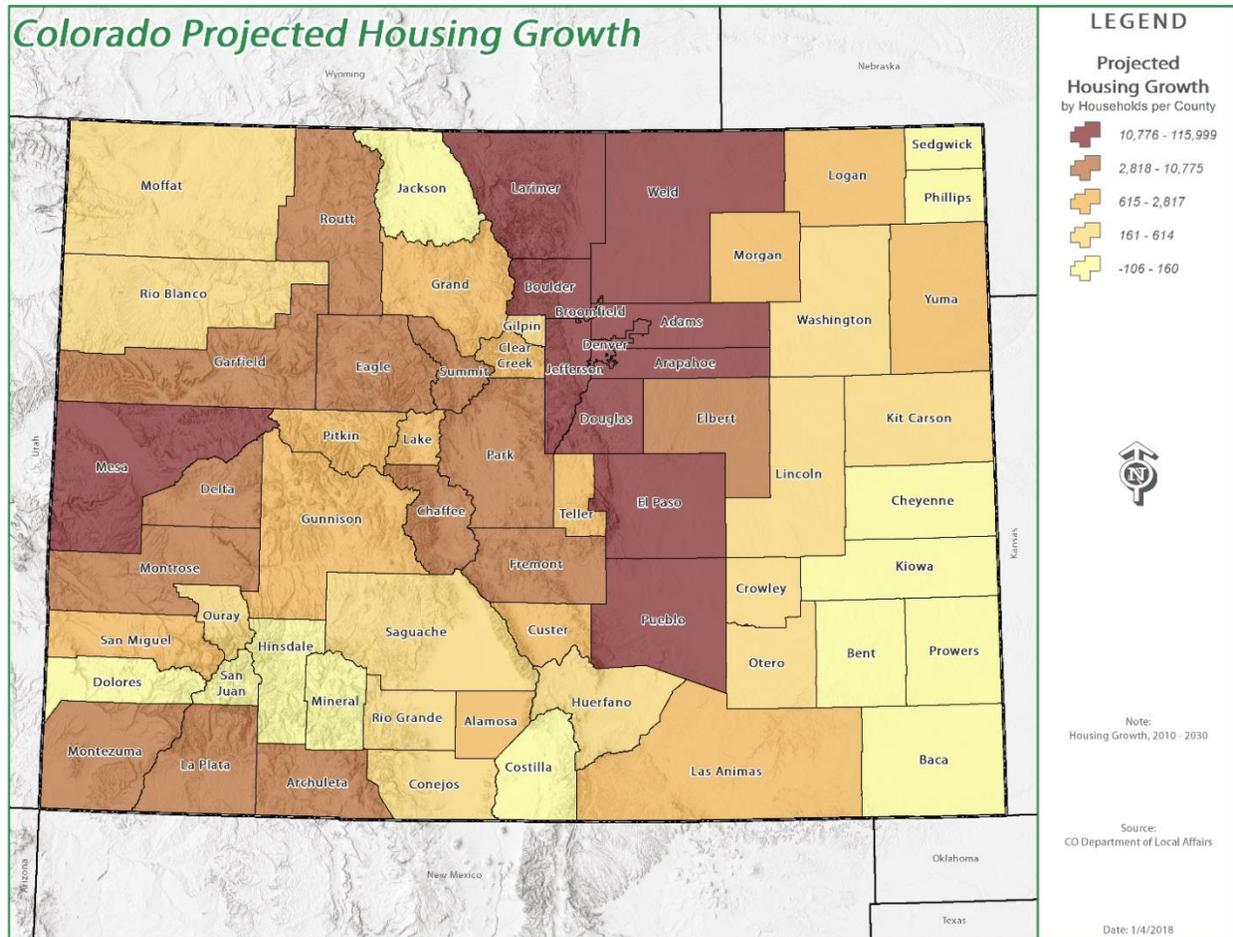
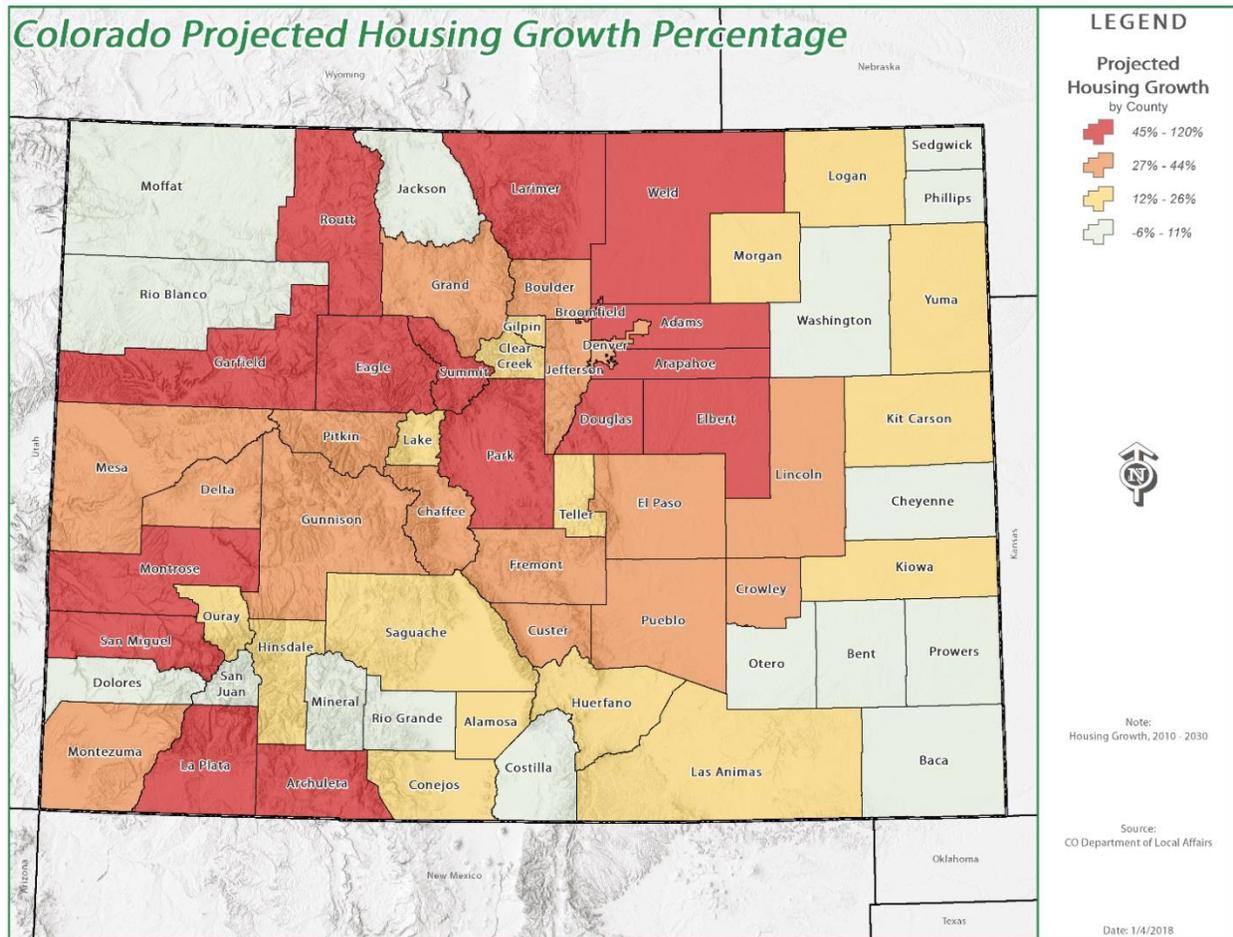


FIGURE 2-8 PROJECTED PERCENT CHANGE IN HOUSING, 2010 TO 2030 BY COUNTY



## COLORADO SOCIAL VULNERABILITY ANALYSIS

Local vulnerability to disasters depends on more than the relationship between a place and its exposure to a hazard. Social and economic factors – like race, age, income, lack of access to a vehicle, or limited language status – directly affect a community’s ability to prepare for and recover from a disaster.

Social vulnerability to disasters refers to “the characteristics and situation of a person or group that influence their capacity to anticipate, cope with, resist, or recover from the impact of a hazard” (Wisner et al. 2004). It is determined by a number of pre-existing social and economic characteristics. Very often, the impacts of hazards fall disproportionately on the most disadvantaged or marginalized people in a community – the poor, children, the elderly, the disabled, and minorities. During emergencies, for example, self-evacuation can be nearly impossible for disabled individuals or for families without a car. Not only do conditions like these limit the ability of some communities to get out of harm’s way, they also decrease the ability of communities to prepare for, mitigate, respond to, and recover from hazards and disasters. The

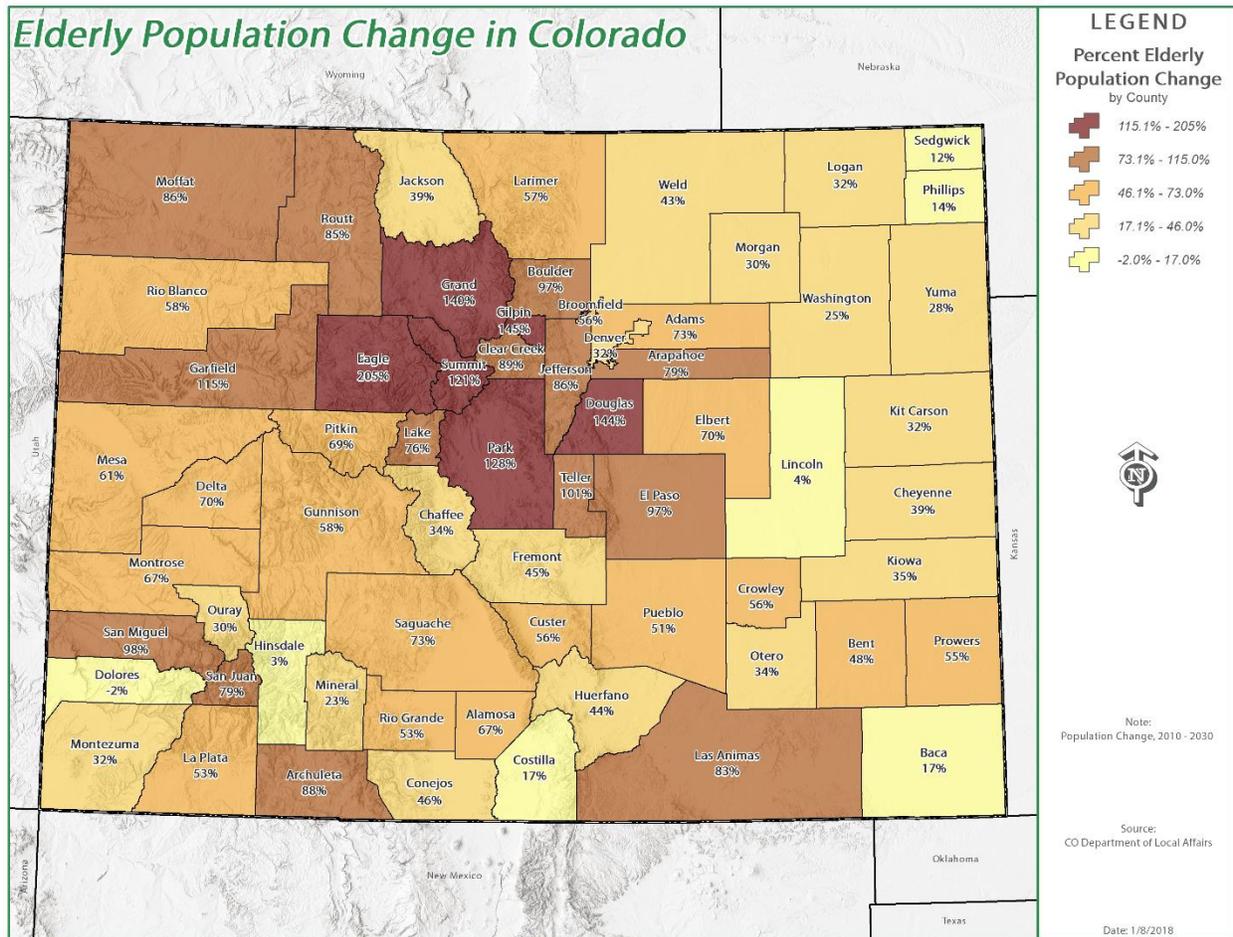
concept of social vulnerability helps explain why communities often experience a hazard differently, even when they experience the same amount of physical impacts.

The pre-existing social conditions that contribute to disaster losses can be identified using social vulnerability indicators. Highlighted below are some of the more common and impactful factors that affect social vulnerability, especially as it relates to hazard mitigation and disasters.

## 1. AGE

Historically, people over 65 years of age have not made up a large share of Colorado's population. In 2015, people 65 and older made up only 13 percent of Colorado's population, which was the sixth lowest share in the United States. However, primarily as a result of the aging of the Baby Boomer generation, the population of people 65 and older in Colorado will be 72 percent larger in 2030 than it was in 2015. Colorado currently has the third fastest growing 65+ population in the United States. Older adults are typically more vulnerable to hazards, particularly those with chronic diseases, disabilities, or who require extra assistance to evacuate an area and recover from an event. Additionally, older adults that require medication for chronic conditions may not have access to their medication following a disaster. Older adults on fixed incomes may also have more challenges overcoming financial burdens both following a disaster, affecting their ability to recover, and prior to a disaster, by implementing mitigation measures. Figure 2-9 shows the change in percent of population over 65 from 2010 to 2030 in Colorado by county. Many counties with the highest percent increase in population over 65 are in the Central Mountain, central Western Slope, and central Front Range regions, with Eagle County expecting the largest increase of population 65 and older, at 205 percent. Generally, the Eastern Plains will have the smallest percent increase of population 65 and older.

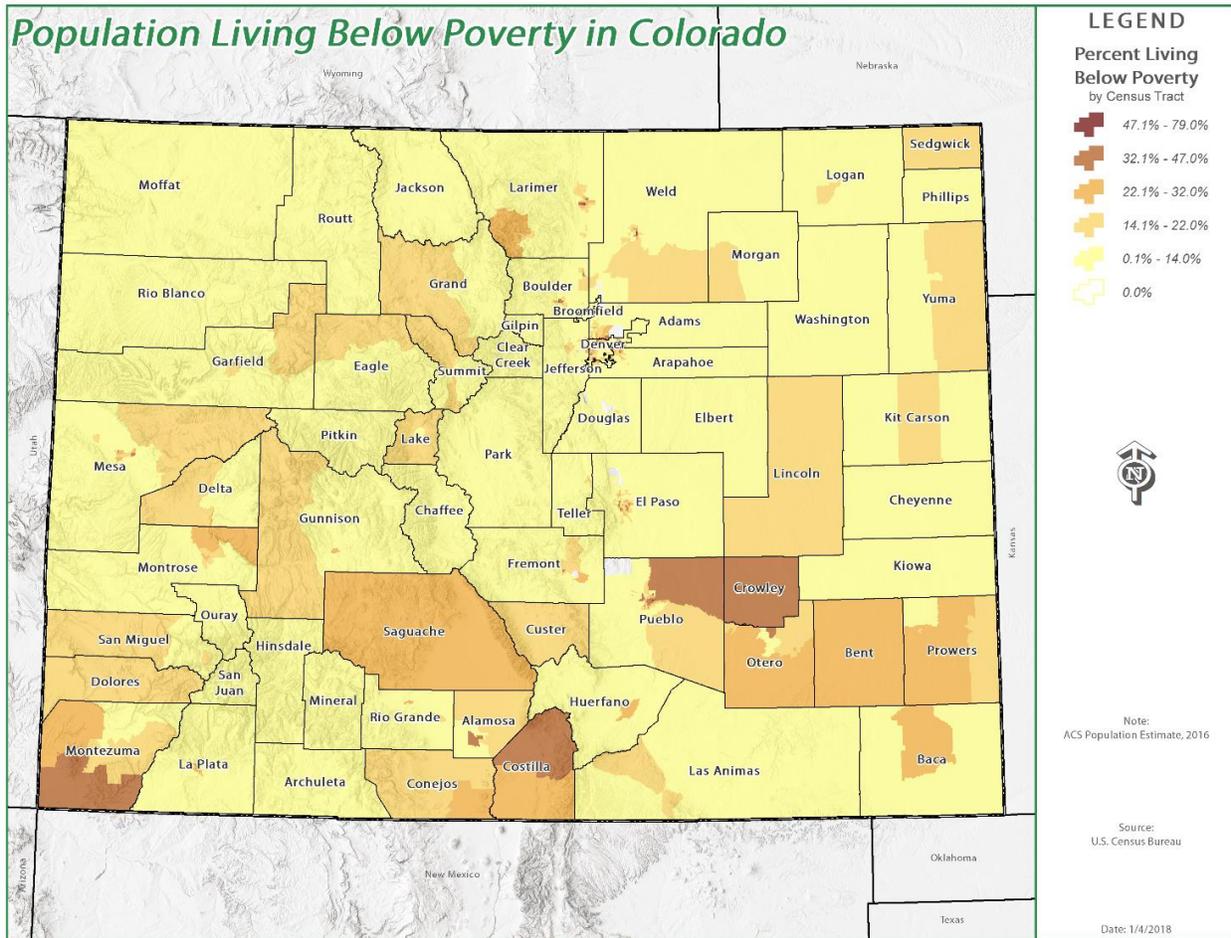
FIGURE 2-9 CHANGE IN PERCENT OF POPULATION OVER 65, 2010 TO 2030 BY COUNTY



## 2. INCOME

Income can play a large role in a person's social vulnerability to a hazard. Limited resources make preparing for, mitigating against, responding to, and recovering from a hazard more difficult. For example, a family without a vehicle may have a harder time evacuating prior to a hazard. The poor typically face fewer economic damage costs from a hazard compared to the wealthy, but the relative impact of damaging events is generally greater for low-income groups. It may take years for those who cannot afford the costs of repair, reconstruction, or relocation to recover from even a moderately damaging event. Figure 2-10 shows the percent of the population living below the poverty line in Colorado by census tract in 2016. Census tracts with a higher percent of their population living below poverty are dispersed throughout the state. However, there is a concentration of census tracts with higher percent of people living below poverty within the City and County of Denver and in immediate surrounding counties. Other areas with higher levels of population living below poverty are in the southern portion of the state, notably parts of Crowley, Pueblo, Costilla, Alamosa, and Montezuma Counties.

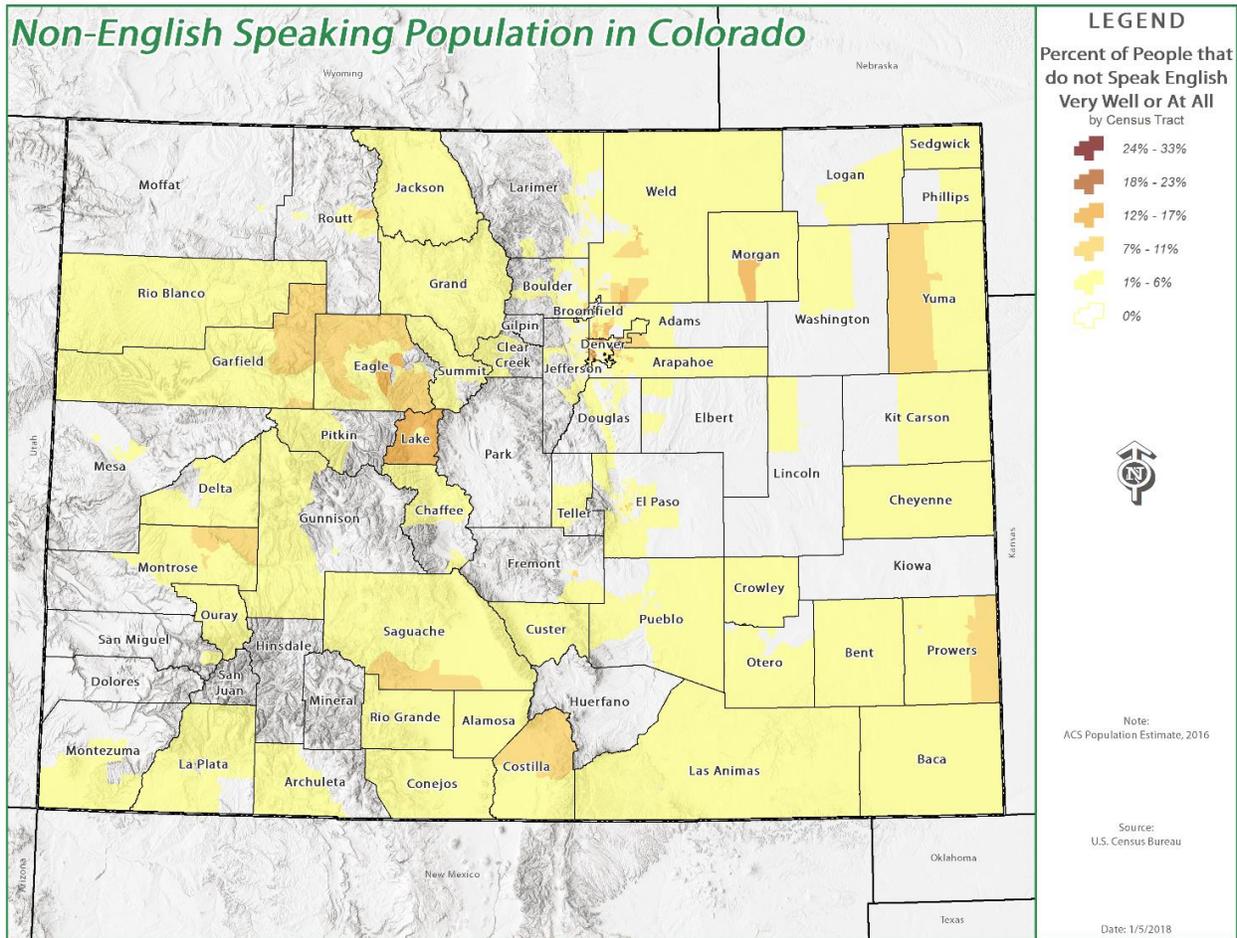
**FIGURE 2-10 PERCENT OF POPULATION LIVING BELOW THE POVERTY LINE IN 2016, BY CENSUS TRACT**



### 3. FLUENCY IN ENGLISH

Fluency in English is another strong indicator of vulnerability. Someone who does not speak English very well can have a harder time understanding hazard warnings and evacuation instructions. Additionally, after a disaster it can be more difficult to understand and utilize resources available to aid in recovery. Figure 2-11 shows the percent of people in Colorado that do not speak English very well or at all by census tract in 2016. In Colorado, counties in the Denver metro area have the highest percent of people that do not speak English very well or at all. Additionally, Lake and Eagle Counties have census tracts with higher percentages of people that are not fluent in English.

FIGURE 2-11 PERCENT OF PEOPLE THAT DO NOT SPEAK ENGLISH VERY WELL OR AT ALL BY CENSUS TRACT, 2016



## 4. SOCIAL CAPITAL

In addition to measuring social vulnerability, a community’s social capital can be similarly measured to get a more nuanced look at the community’s resilience to a disaster. The term social capital refers to, “the ties which bind people together.” Social capital better captures levels of social connections that contribute to how a community responds during a disaster and rebuilds after a disaster. Kyne and Aldrich (2017) developed a framework to quantify counties’ social capital to capture these connections.

Social capital describes the ties that bond people together and can be measured in three categories: bonding, bridging, and linking. Bonding social capital is the connection between people who share similar language, ethnicity, culture, and class, and is the most common type of social tie. During disasters, bonding ties with neighbors, friends, and kin can be lifesaving, as those individuals not only know of each other’s presence (or absence) but also are motivated to come assist in the case of danger. Bridging social capital is formed through weaker ties among people who spend less time together and have less in common. Bridging ties may be formed

through networks such as a kindergarten in an inner city, or a church in a suburban neighborhood. Bridging ties may be especially useful during and after a disaster, as these network members may be geographically distant from survivors and therefore better situated to provide aid. Linking social capital is the weakest of the three ties, and is the connection between a regular person and someone in power or authority. These ties facilitate the flow of services and assistance from well-resourced organizations, whether public or private. To understand a community's total social capital, it is important to utilize a framework that captures all three types of social relationships between people.

The relationships that form social capital within a community can be identified and measured through composite indicators. Kyne and Aldrich (2017) developed 26 variables to describe bonding, bridging, and linking to create a social capital composite index. Table 2-1 outlines the bonding, bridging, and linking variables used to create a social capital index.

**TABLE 2-1 BONDING, BRIDGING, AND LINKING VARIABLES**

No.	Social Capital (SoC) Concept	Study Variable	Justification	Source
<b>Bonding</b>				
1	Race similarity	Race Fractionalization (0=complete homogeneity to 1=complete heterogeneity)	(Alesina, Baqir, and Easterly 1999)	(US Census 2010b)
2	Educational equality	Negative absolute difference between % population with college education and % population with less than high school education	(Norris et al. 2008) (Morrow 2008)	(US Census 2010b)
3	Ethnicity similarity	Ethnicity Fractionalization (0=complete homogeneity to 1=complete heterogeneity)	(Alesina, Baqir, and Easterly, 1999)	(US Census, 2010b)
4	Race/income equality	Gini coefficient (0=perfect equality to 1=perfect inequality)	(Cutter, Burton, and Emrich 2010)	(US Census 2010b)
5	Employment equality	Absolute difference between % employed and % unemployed labor force	(Tierney, Lindell, and Perry 2001)	(US Census 2010b)
6	Racial income similarity	Racial income fractionalization (0=complete homogeneity to 1=complete heterogeneity)	(Morrow 2008)	(US Census 2010b)
7	Gender income similarity	Gender income fractionalization (0=complete homogeneity to 1=complete heterogeneity)	(Norris et al. 2008)	(US Census 2010b)
8	Language competency	% population proficient English speakers	(Morrow 2008)	(US Census 2010b)

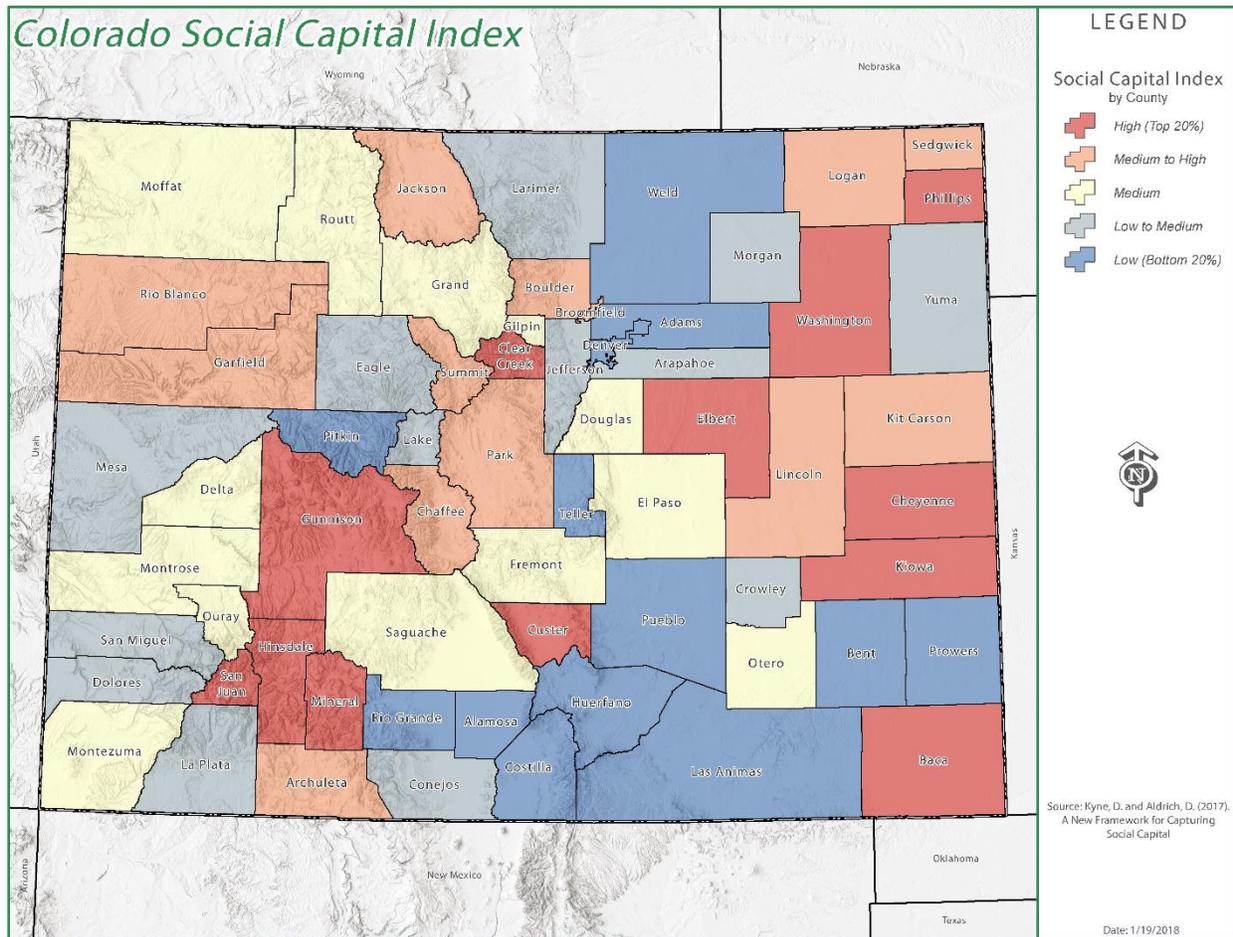
No.	Social Capital (SoC) Concept	Study Variable	Justification	Source
9	Communication capacity	% households with a telephone	(Cutter, Burton, and Emrich 2010)	(US Census 2010b)
10	Non-elder population	% population below 65 years of age	(Morrow 2008)	(US Census 2010b)
<b>Bridging</b>				
11	Religious organizations	Religious organizations per 10,000 persons	(Chamlee-Wright 2010)	(US Census 2010a)
12	Social embeddedness-religious ties	Persons affiliated with a religious organization per 10,000 persons	(Norris et al. 2008)	(US Census 2010a)
13	Civic organizations	Civic organizations per 10,000 persons	(Cutter, Ash, and Emrich 2016)	(US Census 2010a)
14	Social embeddedness-charitable ties	Member of charitable organization (%)	(Norris et al. 2008)	(ESRI 2017)
15	Social embeddedness-Church ties	Member of church board (%)	(Norris et al. 2008)	(ESRI 2017)
16	Social embeddedness-Fraternal ties	Member of fraternal order (%)	(Norris et al. 2008)	(ESRI 2017)
17	Social embeddedness-Religious clubs	Member of religious club (%)	(Norris et al. 2008)	(ESRI 2017)
18	Social embeddedness-Union ties	Member of union (%)	(Norris et al. 2008)	(ESRI 2017)
<b>Linking</b>				
19	Political linkage	% voting-age population who are eligible for voting	(Morrow 2008)	(US Census 2010b)
20	Local government linkage	% of local government employees working for local governments	(Murphy 2007)	(US Census 2010b)
21	State government linkage	% of state employees working for the state governments	(Murphy 2007)	(US Census 2010b)
22	Federal government linkage	% of federal employees working for the federal agencies	(Murphy 2007)	(US Census 2010b)

No.	Social Capital (SoC) Concept	Study Variable	Justification	Source
23	Political linkage-contribution	Contributed to political org in last 12 months (%)	(Tierney, Lindell, and Perry 2001)	(ESRI 2017)
24	Social linkage-social services	Contributed to social services org in last 12 months (%)	(Tierney, Lindell, and Perry 2001)	(ESRI 2017)
25	Religious linkage-religious contribution	Contributed to religious org in last 12 months (%)	(Tierney, Lindell, and Perry 2001)	(ESRI 2017)
26	Political linkage-political activities	Attended political rally/speech/organized protest (%)	(Tierney, Lindell, and Perry 2001)	(ESRI 2017)

Source: Kyne, D. and Aldrich, D. (2017). A New Framework for Capturing Social Capital

Through a multivariate analysis, a Social Capital Index (SoCI) was created and mapped for all counties in the United States. Results were derived for total social capital and its three subcategories: bonding, bridging, and linking. First, the values of SoCI were computed as percentile ranks. Second, the percentile ranks are classified into five categories, high (top 20 percent), medium to high, medium, low to medium, and low (bottom 20 percent). Figure 2-12 shows the results for Colorado counties SoCI. While not an absolute measure and though generalized at the county level, the results of the SoCI can be useful for the state and its communities as they work towards becoming more resilient to those hazards they face.

FIGURE 2-12 COLORADO SOCIAL CAPITAL INDEX



## 5. SOCIAL VULNERABILITY INDEX

Using the Social Vulnerability Index (or SoVI) developed by Cutter et al. (2003) the Colorado Division of Water Resources (DWR) Dam Safety Branch conducted a Colorado social vulnerability analysis at the census tract level. Local socioeconomic and demographic data were used to identify spatial patterns in social vulnerability across the state and have been applied to the hazards in the Colorado State Hazard Mitigation Plan (SHMP).

Below, Table 2-2 outlines the social vulnerability indicators that were used in the Colorado social vulnerability analysis. Indicators with plus signs are positively related to social vulnerability levels. For example, communities with higher percentages of people 65 years or older have higher levels of social vulnerability to disasters. Indicators with minus signs are negatively related to social vulnerability levels.

TABLE 2-2 SOCIAL VULNERABILITY INDICATORS

Social Vulnerability Factors	Indicators
<b>Age/Elderly</b>	65 years of Older, % population (+); People per Household (+); Renter Occupied, % of housing units (+); Social Security
<b>Special Needs</b>	Group Quarters, % population (+); Mobile Homes, % occupied housing units (+); Under 18 Under, % population (+); 5 years old, % population (+)
<b>Ethnicity</b>	Hispanic, % population (+); Native American, % population (+); Other Races, % population (+); Pacific Islander, % population (+); Linguistically Isolated, % population (+)
<b>Race, Class, Poverty</b>	African American, % population (+); Female Headed Households, % households (+); No Vehicles, % households (+); No High School diploma, % over 25 years old (+); Poverty, % population (+) Unemployment Rate (+)
<b>Wealth</b>	Asian, % population (-); Household earnings > \$200K, % households (-); Housing Density (+); Per capita income (-); Population Density (+); White, % pop (-)

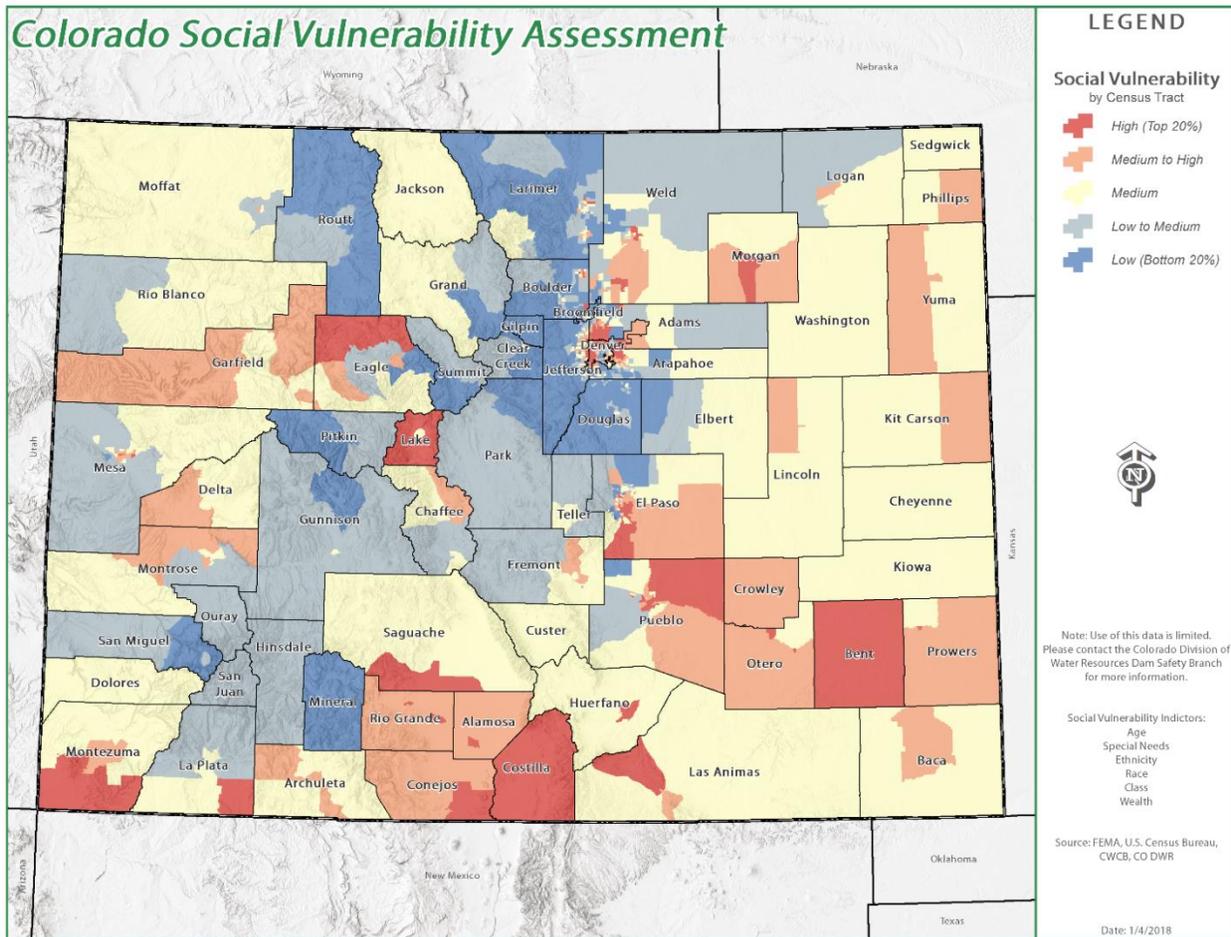
Source: U.S. Census Bureau, 2006-2010 American Community Survey and the 2010 Census

The results of the Colorado social vulnerability assessment are displayed on the map below (Figure 2-13). Social vulnerability is represented at the census tract level by five classes of vulnerability: Low (dark blue), Medium-Low (light blue), Medium (tan), Medium-High (orange), and High (red).

Social vulnerability analysis is particularly useful in the context of hazard mitigation planning because it can reveal disparities within a community that make a difference when it comes to the ability of residents to prepare, evacuate, mobilize resources, and recover from disasters. The Colorado social vulnerability assessment was designed to improve local decision making, hazard prioritization, and emergency management activities. By incorporating social vulnerability into the risk assessments of individual hazards, local communities are able to identify highly vulnerable areas and tailor their mitigation actions to accommodate all members of their community, including the most sensitive groups.

As with the SoCI, the results of this assessment are not absolute, yet should help to guide discussions and planning efforts so that communities can become less fragile and more resilient to disasters.

FIGURE 2-13 COLORADO SOCIAL VULNERABILITY ASSESSMENT



Interestingly, the results of the social capital index and social vulnerability assessment are not mirror copies of one another. Although conducted at differing scales, it is apparent that while there is agreement in some areas, there are others where the indexes tell a different story. This is not to say that either is right or better than the other, rather that there are a number of factors that should be considered when evaluating local vulnerabilities to disasters.

Incorporating both social vulnerability and social capital information when evaluating vulnerabilities can provide a more nuanced picture of the area’s resilience. When both social capital and social vulnerability information are incorporated together, the predicted vulnerability to future disasters can be better assessed and understood.

## TRANSPORTATION

Colorado’s transportation infrastructure is shown in Figure 2-14.

## 1. HIGHWAYS

The Colorado Department of Transportation (CDOT) is responsible for the state's 9,144 mile highway system which includes over 3,000 bridges. The system includes Interstate Highways, U.S. Highways, State Highways, and some arterials. The overall system handles over 28 billion vehicle miles of travel each year. In Colorado, over 40 percent of all travel takes place on the 913 miles of Interstate Highway.

This ground transportation system creates a mobility lifeline throughout the state, allowing for goods and services to be transported to even the more sparsely populated areas. Large parts of the system are vulnerable to natural hazards, including but not limited to avalanche, heavy snowfall, flood, debris flows, rockfalls, and sinkholes. Impacts include physical damage, road closures, emergency work, delays, stranded motorists, and large scale debris removal.

## 2. RAILROADS

Rail lines have a long history of providing mobility for people and goods in and through Colorado. Select rail systems are threatened by a variety of hazards due to their geographic locations. In recent years the Denver metro area has increased the extent of light rail lines reaching more population and enhancing public transportation. The light rail is administered by the Regional Transportation District, a special district commonly referred to as RTD.

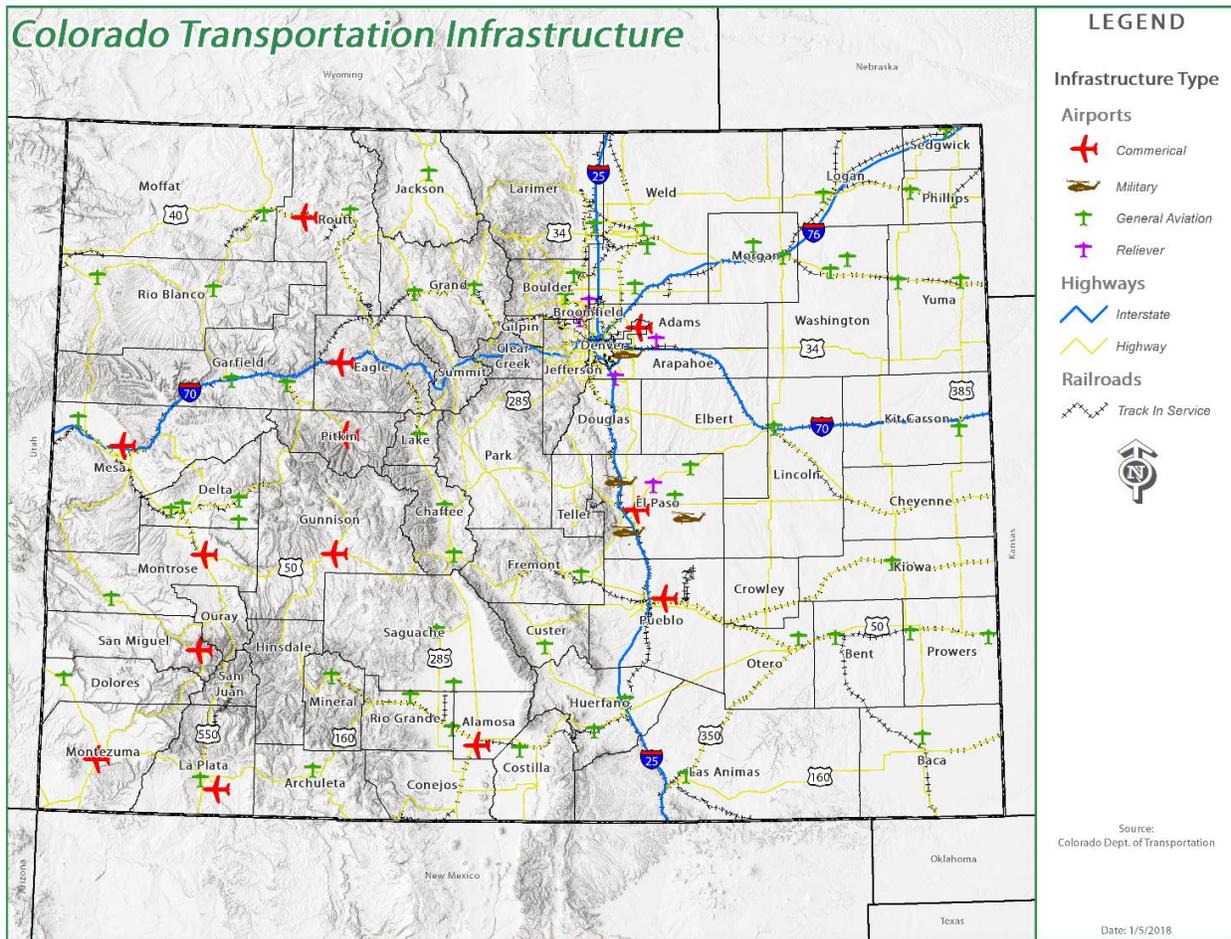
Rail transport may be affected by natural hazards including but not limited to rockfall, wildfire, earth movement, flood, and heavy snowfall. Impacts include delays, physical damage, emergency work, and debris removal.

## 3. AIRPORTS

The Colorado Airport System includes a total of 74 public-use airports. Of the public-use airports, 14 are commercial service airports and 60 are for general aviation use. Five of these general aviation use airports provide reliever service to Denver International Airport (DEN) and Colorado Springs Airport (COS).

This air transportation network, through direct or connecting flights, links Colorado with the nation and the world. This part of the mobility network is vulnerable to different hazards including severe weather such as wind, tornadoes, hail, winter weather, hazardous materials fixed facilities and transport, and earth movement. Impacts include physical damage, delays, closures, stranded travelers and workers, emergency work, and large scale debris removal.

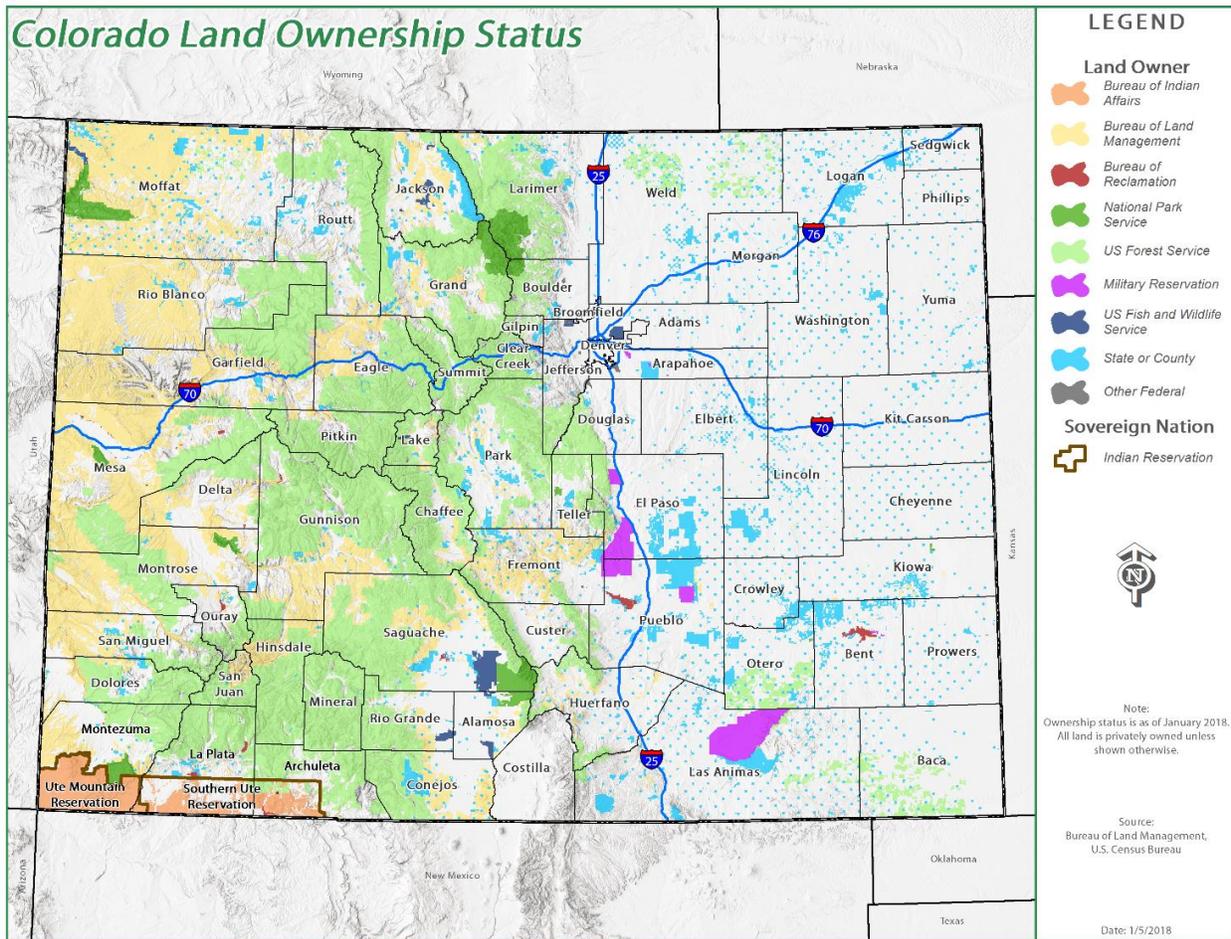
FIGURE 2-14 COLORADO TRANSPORTATION INFRASTRUCTURE



## LAND STATUS

Colorado has a significant amount of land that is owned and managed by public entities, as shown in Figure 2-15. In Colorado, approximately 42 percent of the land is owned and managed by local, state, or federal agencies. The remaining land is managed by private entities, land trusts, and non-governmental organizations (NGOs). The majority of the federal land, which covers 37 percent of the state, is in the central and western portion of the state.

FIGURE 2-15 COLORADO LAND OWNERSHIP



The total acres and related percent of total land in Colorado by entity are shown in Table 2-3.

TABLE 2-3 COLORADO LAND OWNERSHIP

Agency	Total Acres	Percent of Total
<b>Local (City, County, Special Districts)</b>	504,651	0.76%
<b>State of Colorado</b>	2,859,287	4.29%
<b>U.S. Bureau of Land Management</b>	8,359,306	12.55%
<b>U.S. Forest Service</b>	14,485,650	21.75%
<b>U.S. National Park Service</b>	669,207	1.00%
<b>Other Federal Entities</b>	686,626	1.03%
<b>Sovereign Nations (Tribes)</b>	770,287	1.16%
<b>Private/NGO/Land Trust</b>	38,280,494	57.46%
<b>Total</b>	66,615,508	100%

Source: Bureau of Land Management (BLM), 2018

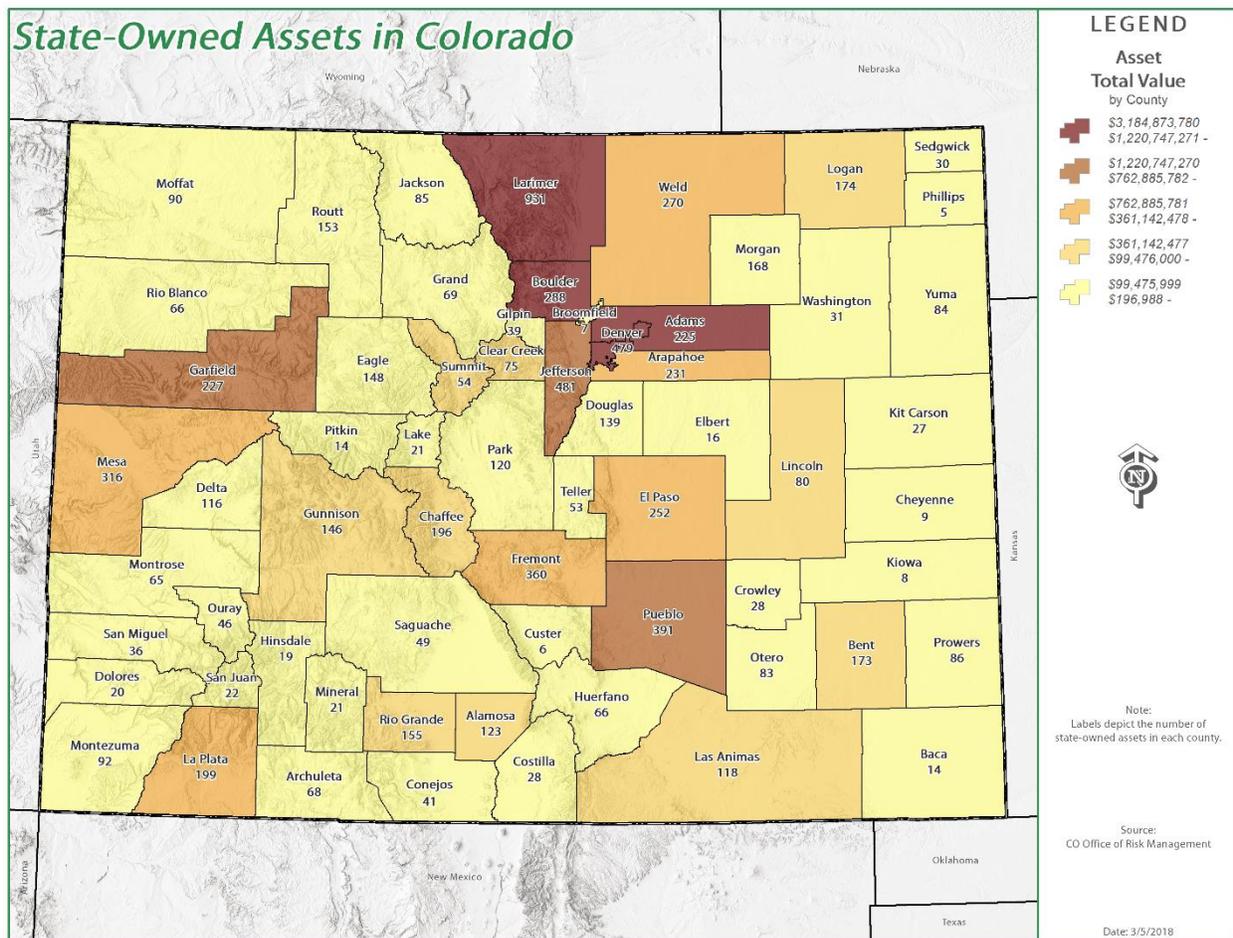
# STATE ASSETS

State assets belonging to the three branches of Colorado State Government (Legislative, Judicial, and Executive) have been defined by the Colorado Office of Risk Management (ORM). Primary agencies charged with the oversight of state assets are the Department of Corrections, Higher Education, Transportation, Human Resources, and Natural Resources. The state assets assessed in this Plan are a combination of a 2017 ORM database of state assets and a 2013 ORM database utilized during the development of the 2013 SHMP. The need to merge these datasets is due to the fact that a number of higher education state assets are no longer in the insurance pool that ORM oversees, and therefore are not currently tracked as assets by ORM.

## 1. STATE-OWNED ASSETS

The total count of state-owned assets included in the state database increased from 8,165 in 2013 to 8,232 in 2017. The 2017 total value of state-owned facilities is \$20,238,350,636. Figure 2-16 shows the number and total value of state assets by county.

FIGURE 2-16 STATE-OWNED ASSETS BY COUNTY



Generally, the highest value of state assets is concentrated along the Front Range and across the Grand Valley. Along the Front Range, the far north-central, metropolitan Denver, and south-central counties tend to represent the highest asset values. The top five counties in state asset values are Boulder, Denver, Larimer, Adams, and Jefferson. These counties, along with Pueblo County, each contain over \$1 billion in state asset value. Table 2-4 provides the count and value of state-owned facilities by county.

Although seventh overall in total count of state assets at 288, Boulder County holds the highest value of state assets at over \$3.1 billion due to the high value associated with the University of Colorado campus buildings. The City and County of Denver holds the second highest value of state assets totaling at over \$2.6 billion, and includes many State Capitol Complex buildings. Denver also ranks third in number of state assets with 479. Larimer County has the third highest value of state assets with over \$2.5 billion, attributable to the value of facilities at Colorado State University. Larimer County represents the highest total count of state assets with 931.

**TABLE 2-4 STATE-OWNED ASSET OVERVIEW BY COUNTY**

<b>County</b>	<b>Total Value</b>	<b>Count</b>
<b>Boulder</b>	\$3,184,873,780	288
<b>Denver</b>	\$2,631,589,250	479
<b>Larimer</b>	\$2,520,380,927	931
<b>Adams</b>	\$2,161,277,205	225
<b>Jefferson</b>	\$1,220,747,270	481
<b>Pueblo</b>	\$1,100,717,917	391
<b>Garfield</b>	\$935,656,624	227
<b>Fremont</b>	\$762,885,780	360
<b>Weld</b>	\$723,621,025	270
<b>El Paso</b>	\$664,445,003	252
<b>Mesa</b>	\$571,483,873	316
<b>Arapahoe</b>	\$539,093,242	231
<b>La Plata</b>	\$459,565,269	199
<b>Alamosa</b>	\$361,142,477	123
<b>Logan</b>	\$321,168,914	174
<b>Gunnison</b>	\$297,472,630	146
<b>Summit</b>	\$210,520,143	54
<b>Las Animas</b>	\$152,450,902	118
<b>Chaffee</b>	\$135,641,023	196
<b>Rio Grande</b>	\$134,839,206	155
<b>Clear Creek</b>	\$117,846,308	75
<b>Bent</b>	\$116,882,345	173
<b>Lincoln</b>	\$115,435,435	80
<b>Crowley</b>	\$99,475,999	28

County	Total Value	Count
Otero	\$79,711,658	83
Prowers	\$73,450,933	86
Morgan	\$67,190,695	168
Rio Blanco	\$63,910,055	66
Douglas	\$41,437,868	139
Delta	\$39,890,610	116
Huerfano	\$35,640,305	66
Mineral	\$30,302,497	21
Montezuma	\$26,250,957	92
Eagle	\$22,080,215	148
Routt	\$19,636,862	153
Montrose	\$19,168,190	65
Park	\$17,071,984	120
Moffat	\$15,349,886	90
Yuma	\$14,101,083	84
Jackson	\$13,799,847	85
Grand	\$12,702,273	69
Archuleta	\$12,576,015	68
Gilpin	\$10,009,237	39
Teller	\$9,932,426	53
Ouray	\$8,684,296	46
Broomfield	\$7,925,505	7
San Miguel	\$6,959,484	36
Conejos	\$6,598,803	41
Elbert	\$6,135,197	16
Saguache	\$5,188,186	49
San Juan	\$4,603,609	22
Washington	\$4,317,254	31
Dolores	\$4,252,291	20
Costilla	\$4,179,435	28
Kit Carson	\$4,146,763	27
Lake	\$2,881,105	21
Sedgwick	\$1,827,494	30
Hinsdale	\$1,605,114	19
Baca	\$1,559,394	14
Kiowa	\$1,308,651	8
Custer	\$1,130,092	6
Cheyenne	\$712,471	9
Pitkin	\$712,333	14
Phillips	\$196,988	5

Source: Colorado Office of Risk Management, 2017 and 2013 databases

Standing out as primary agencies for the oversight of state assets are the Department of Corrections, Higher Education, Transportation, Personnel and Administration, Human Services, and Natural Resources. These six agencies account for over 90 percent of the total number and related value of state assets, an overview of which is provided in Table 2-5.

**TABLE 2-5 ASSET OVERVIEW FOR PRIMARY STATE ASSET HOLDERS**

Department	Asset Overview
<b>Corrections</b>	Administrative buildings, living units, gyms, clinics, vocational shops, gate house, water towers, warehouses, industrial facilities, water tanks, parole offices, utilities (wastewater treatment, boiler rooms, pump houses, chiller plants), gas stations.
<b>Higher Education</b>	Administrative buildings, student housing (dorms, apartments, houses), classroom buildings, laboratories, recreation centers, sports facilities, event centers, utilities, bookstores, printing centers, parking garages, libraries, student centers, medical clinics, theaters, warehouses, child care facilities, agricultural facilities, vehicle support (fueling, maintenance, storage), and research facilities. Additionally includes the CU Anschutz Medical Campus.
<b>Human Services</b>	Administrative offices, mental health institutes, gyms, learning centers, group homes, client housing, nursing homes, utilities (heating/power plants, pump house) warehousing, schools, garages, veteran's homes.
<b>Natural Resources</b>	Weather stations, employee housing, offices, agricultural buildings, warehousing and storage sheds, cabins, restrooms, visitor centers, shower and laundry facilities, picnic shelters, boat storage and docks, playgrounds, vehicle support (fueling, maintenance, garages).
<b>Personnel and Administration</b>	Departmental and administrative office buildings to include the Capitol Complex, parking garages, state printing services, power generation facilities, storage facilities, radio shops.
<b>Transportation</b>	Administrative and regional offices, tunnel infrastructure and control, warehousing, vehicle maintenance garages, sand and salt sheds, fueling stations, rest areas (picnic shelters, restrooms), employee housing.

Source: Colorado Office of Risk Management

The Department of Higher Education, representing the state's university and community college system, is responsible for the highest value of state assets. It contains approximately 68 percent of the value of all state assets and nearly \$14 billion in total asset value. With a total of 2,804 assets, or 34 percent of the total count, the Department of Natural Resources is responsible for the greatest number of physical assets of any state agency.

## 2. STATE ASSET PROPERTY LOSSES

From 2008 to 2017, there has been 496 recorded property losses caused by hazards, equating to over \$33 million. Flooding is the most commonly recorded hazard resulting in property loss, with 146 recorded incidents from 2008 to 2017, as well as the most expensive, totaling over \$16

million in losses. Hail is the second most costly hazard to state assets, resulting in approximately \$6.5 million in property losses and 100 recorded incidents. Severe wind is the third most costly, resulting in approximately \$3 million in property losses and 134 recorded incidents. Table 2-6 shows the number of incidents and total amount paid of property losses from 2008 to 2017 by hazard type. It is important to note that state asset loss data is only available for state assets included in the 2017 ORM database. These numbers exclude many Higher Education assets, and therefore may under-represent actual losses.

**TABLE 2-6 STATE ASSET PROPERTY LOSSES FROM HAZARDS**

<b>Hazard Type</b>	<b>Number of Incidents</b>	<b>Losses</b>
<b>Flood</b>	146	\$16,261,086
<b>Hail</b>	100	\$6,578,918
<b>Severe Wind</b>	134	\$3,068,155
<b>Severe Winter Weather</b>	33	\$1,893,279
<b>Landslide/Mud/Debris Flows/Rock Fall/Rockside</b>	8	\$1,492,201
<b>Thunderstorms and Lightning</b>	48	\$1,041,989
<b>Erosion and Deposition</b>	3	\$1,034,285
<b>Wildfire</b>	11	\$954,197
<b>Tornado</b>	1	\$422,189
<b>Power Failure</b>	10	\$321,617
<b>Hazardous Material Release</b>	2	\$7,280
<b>Total</b>	496	\$33,075,196

## STATEWIDE BUILDING EXPOSURE

Detailed discussions of vulnerability and hazard specific information from local plans can also be found in the Colorado Drought Mitigation and Response Plan and the Flood Hazard Mitigation Plan that serve as supporting documents to the 2018 SHMP. In particular, the Flood Hazard Mitigation Plan has a roll-up of vulnerability in Section 3.3 to 3.5, and the Drought Mitigation and Response Plan includes a similar, but scaled-back discussion in Section 3.3 to 3.5.

Jurisdiction-level information related to the number of persons vulnerable to hazards can be found in Section 1.3 “Population.” This section presents total population and projected population growth by county. In addition to population, countywide building value was updated and evaluated to further determine local level vulnerability.

Table 2-7 shows the total exposure of building value by county (containing the total cost of structures). To develop this table, building and content value data from the geo databases supplied with the Hazus software was used. The source file used was hzExposureOccupB, representing replacement cost values for the general building stock at the census block level, which were overlaid with counties in GIS to obtain the total building value per county. Counties

along the Front Range hold the highest total building values, with Denver County having the highest at \$73,548,361,000. El Paso County contains the most buildings, with a total of 222,909. The number of buildings and total value of buildings is typically higher in counties with higher populations. However, when looking at the values of buildings per capita, higher values are not as tied to higher populations. Hinsdale County has the highest total value of buildings per capita, at a value of \$518,809 per person, yet a 2016 population of only 775.

**TABLE 2-7 LOCAL EXPOSURE BY COUNTY - TOTAL BUILDING VALUE**

<b>County</b>	<b>2016 Population</b>	<b>Building Count</b>	<b>Total Building Value (excluding contents)</b>	<b>Total Value Per Capita</b>
<b>Denver</b>	693,292	187,803	\$73,548,361,000	\$106,086
<b>El Paso</b>	690,207	222,909	\$66,837,839,000	\$96,837
<b>Jefferson</b>	571,711	197,757	\$65,693,341,000	\$114,907
<b>Arapahoe</b>	637,254	180,018	\$64,864,504,000	\$101,788
<b>Adams</b>	497,673	138,218	\$39,218,230,000	\$78,803
<b>Boulder</b>	321,989	106,427	\$38,453,803,000	\$119,426
<b>Douglas</b>	328,330	98,890	\$37,906,598,000	\$115,453
<b>Larimer</b>	338,663	119,355	\$33,795,465,000	\$99,791
<b>Weld</b>	294,397	90,317	\$23,768,629,000	\$80,737
<b>Mesa</b>	150,731	59,999	\$15,074,629,000	\$100,010
<b>Pueblo</b>	165,109	65,379	\$14,972,914,000	\$90,685
<b>Eagle</b>	53,928	22,648	\$7,584,392,000	\$140,639
<b>Broomfield</b>	66,252	19,562	\$7,208,724,000	\$108,808
<b>La Plata</b>	55,697	24,168	\$6,090,430,000	\$109,349
<b>Garfield</b>	58,984	22,099	\$5,913,246,000	\$100,252
<b>Summit</b>	30,367	15,716	\$5,906,075,000	\$194,490
<b>Montrose</b>	41,421	18,731	\$4,087,215,000	\$98,675
<b>Fremont</b>	47,487	19,240	\$3,862,874,000	\$81,346
<b>Routt</b>	24,679	13,172	\$3,745,901,000	\$151,785
<b>Grand</b>	15,039	12,526	\$3,453,714,000	\$229,651
<b>Pitkin</b>	17,773	9,907	\$3,401,414,000	\$191,381
<b>Park</b>	17,285	14,467	\$3,146,926,000	\$182,061
<b>Teller</b>	24,154	13,134	\$3,134,105,000	\$129,755
<b>Delta</b>	30,471	15,034	\$2,787,248,000	\$91,472
<b>Elbert</b>	25,169	9,816	\$2,678,370,000	\$106,415
<b>Gunnison</b>	16,394	9,760	\$2,542,694,000	\$155,099
<b>Montezuma</b>	26,906	12,407	\$2,484,814,000	\$92,352
<b>Morgan</b>	28,148	11,631	\$2,460,435,000	\$87,411
<b>Chaffee</b>	19,097	10,440	\$2,216,747,000	\$116,078
<b>Logan</b>	22,047	9,018	\$2,158,903,000	\$97,923
<b>Otero</b>	18,290	9,033	\$1,875,702,000	\$102,553
<b>Archuleta</b>	12,907	8,365	\$1,838,618,000	\$142,451

County	2016 Population	Building Count	Total Building Value (excluding contents)	Total Value Per Capita
Las Animas	14,082	8,224	\$1,719,907,000	\$122,135
Alamosa	16,131	6,316	\$1,712,102,000	\$106,137
San Miguel	8,000	4,617	\$1,563,369,000	\$195,421
Rio Grande	11,424	6,903	\$1,446,497,000	\$126,619
Clear Creek	9,443	5,668	\$1,412,341,000	\$149,565
Moffat	13,088	6,075	\$1,292,241,000	\$98,735
Prowers	11,841	5,899	\$1,225,346,000	\$103,483
Yuma	10,082	5,014	\$988,969,000	\$98,093
Huerfano	6,642	5,114	\$937,741,000	\$141,184
Gilpin	5,926	3,507	\$930,165,000	\$156,963
Rio Blanco	6,497	3,416	\$885,657,000	\$136,318
Kit Carson	7,639	3,813	\$868,132,000	\$113,645
Lake	7,595	4,046	\$830,831,000	\$109,392
Ouray	4,844	3,282	\$806,429,000	\$166,480
Custer	4,617	4,071	\$692,680,000	\$150,028
Conejos	8,039	4,413	\$685,018,000	\$85,212
Saguache	6,404	3,875	\$598,077,000	\$93,391
Phillips	4,285	2,333	\$516,090,000	\$120,441
Lincoln	5,554	2,513	\$480,784,000	\$86,565
Bent	5,626	2,297	\$470,963,000	\$83,712
Washington	4,875	2,665	\$467,308,000	\$95,858
Baca	3,557	2,458	\$461,077,000	\$129,625
Hinsdale	775	1,431	\$402,077,000	\$518,809
Costilla	3,707	2,618	\$367,547,000	\$99,149
Sedgwick	2,421	1,541	\$359,081,000	\$148,319
Crowley	5,214	1,625	\$322,107,000	\$61,777
Mineral	737	1,258	\$293,044,000	\$397,617
Jackson	1,351	1,358	\$274,081,000	\$202,873
Dolores	2,035	1,548	\$257,648,000	\$126,608
Cheyenne	1,853	1,085	\$218,709,000	\$118,030
Kiowa	1,347	913	\$161,706,000	\$120,049
San Juan	698	608	\$139,821,000	\$200,317
<b>Total</b>		1,878,450	\$576,500,405,000	

Source: Colorado State Demography Office, FEMA, 2017

## RESOURCES

- Colorado Division of Water Resources (DWR), Dam Safety Branch. Dam Inundation Consequence and Social Vulnerability Analysis. Laura Ferre and Bill McCormick. Project funding: FEMA NDSP Grant and CWCB Grant. 2013-2014.

- Colorado State Demography Office, 2017
- Cutter, S.L., Boruff, B.J., and Shirley, W.L. (2003). Social Vulnerability to Environmental Hazards. *Social Science Quarterly*, 84:242-261.
- Denver 7. (2009). Where is That? <https://www.thedenverchannel.com/weather/where-is-that->
- Kyne, D. and Aldrich, D. (2017). A New Framework for Capturing Social Capital.
- Lukas, J., Barsugli, J., Doesken, N., Rangwala, I., and Wolter, K. (2014). Climate Change in Colorado: A Synthesis to Support Water Resources Management and Adaptation.
- U.S. Census Bureau
- Wisner, B., Blaikie, P., Cannon, T., Davis, I. (2004). *At Risk: Natural Hazards, People's Vulnerability and Disasters*. London: Routledge.

# SECTION 3. HAZARD IDENTIFICATION AND RISK ASSESSMENT

# SECTION 3. HAZARD IDENTIFICATION AND RISK ASSESSMENT

## CONTENTS

Section 3. Hazard Identification and Risk Assessment .....	3-1
Introduction.....	3-21
1. Hazard Identification .....	3-21
2. Disaster Declaration History .....	3-23
3. Hazards Identified in Local Plans.....	3-39
4. Hazard Profiles .....	3-40
Dense Fog.....	3-45
1. Definition .....	3-45
2. Location.....	3-45
3. Extent (Magnitude/Strength).....	3-47
Dense Fog Advisory.....	3-48
Freezing Fog Advisory .....	3-48
4. Probability.....	3-48
5. Previous Occurrences.....	3-49
6. Impact Analysis.....	3-49
7. Vulnerability and Potential Losses by Jurisdiction .....	3-51
8. Future Development.....	3-55
9. Climate Change .....	3-58
10. Risk to State Assets .....	3-58
11. Resources .....	3-59
Drought.....	3-60
1. Definition .....	3-60
2. Location.....	3-61
3. Extent (Magnitude/Strength).....	3-62
4. Probability.....	3-63
5. Previous Occurrences.....	3-63
6. Impact Analysis.....	3-66
7. Vulnerability and Potential Losses by Jurisdiction .....	3-69
8. Future Development.....	3-72
9. Climate Change .....	3-74
10. Risk to State Assets .....	3-74
11. Resources .....	3-77
Extreme Heat.....	3-79
1. Definition .....	3-79
2. Location.....	3-79

3. Extent (Magnitude/Strength).....	3-81
4. Probability.....	3-83
5. Previous Occurrences .....	3-87
6. Impact Analysis.....	3-91
7. Vulnerability and Potential Losses by Jurisdiction .....	3-92
8. Future Development.....	3-93
9. Climate Change .....	3-100
10. Risk to State Assets .....	3-100
11. Resources .....	3-103
Flood.....	3-104
1. Definition .....	3-104
2. Location.....	3-104
Groundwater Flooding.....	3-105
3. Extent (Magnitude/Strength).....	3-108
4. Probability.....	3-109
5. Previous Occurrences .....	3-110
6. Impact Analysis.....	3-115
Future Flood Adaptation Measures.....	3-115
7. Vulnerability and Potential Losses by Jurisdiction .....	3-117
8. Future Development.....	3-127
9. Climate Change .....	3-134
10. Risk to State Assets .....	3-135
11. Resources .....	3-138
Hail.....	3-140
1. Definition .....	3-140
2. Location.....	3-140
3. Extent (Magnitude/Strength).....	3-142
4. Probability.....	3-143
5. Previous Occurrences.....	3-143
6. Impact Analysis.....	3-146
7. Vulnerability and Potential Losses by Jurisdiction .....	3-148
8. Future Development.....	3-154
9. Climate Change .....	3-160
10. Risk to State Assets .....	3-160
11. Resources .....	3-163
Severe Wind.....	3-164
1. Definition .....	3-164
2. Location.....	3-165
3. Extent (Magnitude/Strength).....	3-167
4. Probability.....	3-170
5. Previous Occurrences .....	3-170

6. Impact Analysis.....	3-175
7. Vulnerability and Potential Losses by Jurisdiction .....	3-176
8. Future Development.....	3-181
9. Climate Change .....	3-187
10. Risk to State Assets .....	3-187
11. Resources .....	3-190
Severe Winter Weather.....	3-191
1. Definition .....	3-191
2. Location.....	3-192
3. Extent (Magnitude/Strength).....	3-193
4. Probability.....	3-194
5. Previous Occurrences.....	3-195
6. Impact Analysis.....	3-206
7. Vulnerability and Potential Losses by Jurisdiction .....	3-207
8. Future Development.....	3-215
9. Climate Change .....	3-222
10. Risk to State Assets .....	3-222
11. Resources .....	3-225
Thunderstorms and Lightning.....	3-226
1. Definition .....	3-226
2. Location.....	3-227
3. Extent (Magnitude/Strength).....	3-228
Severe Thunderstorm Watch:.....	3-228
Severe Thunderstorm Warning:.....	3-228
4. Probability.....	3-228
5. Previous Occurrences.....	3-230
6. Impact Analysis.....	3-233
7. Vulnerability and Potential Losses by Jurisdiction .....	3-237
8. Future Development.....	3-240
9. Climate Change .....	3-246
10. Risk to State Assets .....	3-247
11. Resources .....	3-249
Tornadoes .....	3-251
1. Definition .....	3-251
2. Location.....	3-251
3. Extent (Magnitude/Strength).....	3-252
4. Probability.....	3-254
5. Previous Occurrences.....	3-254
6. Impact Analysis.....	3-257
7. Vulnerability and Potential Losses by Jurisdiction .....	3-260
8. Future Development.....	3-264

9. Climate Change .....	3-270
10. Risk to State Assets .....	3-271
11. Resources .....	3-273
Wildfire .....	3-274
1. Definition .....	3-274
Wildland-Urban Interface (WUI) .....	3-275
2. Location.....	3-275
Csfs and Wildfire Risk.....	3-277
3. Extent (Magnitude/Strength).....	3-279
Forests Converting to Grasslands .....	3-279
4. Probability.....	3-280
5. Previous Occurrences .....	3-282
Case Study: The Black Forest Fire .....	3-288
6. Impact Analysis.....	3-289
Wildfires and PM2.5 .....	3-291
7. Vulnerability and Potential Losses by Jurisdiction .....	3-293
8. Future Development.....	3-302
9. Climate Change .....	3-305
10. Risk to State Assets .....	3-306
11. Resources .....	3-309
Avalanche.....	3-311
1. Definition .....	3-311
2. Location.....	3-311
3. Extent (Magnitude/Strength).....	3-313
4. Probability.....	3-313
5. Previous Occurrences .....	3-314
6. Impact Analysis.....	3-318
7. Vulnerability and Potential Losses by Jurisdiction .....	3-321
8. Future Development.....	3-323
9. Climate Change .....	3-329
10. Risk to State Assets .....	3-330
11. Resources .....	3-333
Earthquake .....	3-334
1. Definition .....	3-334
2. Location.....	3-334
3. Extent (Magnitude/Strength).....	3-335
4. Probability.....	3-337
5. Previous Occurrences .....	3-340
6. Impact Analysis.....	3-344
7. Vulnerability and Potential Losses by Jurisdiction .....	3-346
8. Future Development.....	3-355

9. Climate Change .....	3-359
10. Risk to State Assets .....	3-359
11. Resources .....	3-360
Erosion and Deposition .....	3-362
1. Definition .....	3-362
2. Location.....	3-362
3. Extent (Magnitude/Strength).....	3-363
4. Probability.....	3-364
5. Previous Occurrences.....	3-364
6. Impact Analysis.....	3-366
7. Vulnerability and Potential Losses by Jurisdiction .....	3-367
8. Future Development.....	3-368
9. Climate Change .....	3-371
10. Risk to State Assets .....	3-371
11. Resources .....	3-372
Expansive Soils and Heaving Bedrock.....	3-373
1. Definition .....	3-373
2. Location.....	3-374
3. Extent (Magnitude/Strength).....	3-375
4. Probability.....	3-375
5. Previous Occurrences.....	3-376
6. Impact Analysis.....	3-377
7. Vulnerability and Potential Losses by Jurisdiction .....	3-378
8. Future Development.....	3-380
9. Climate Change .....	3-382
10. Risk to State Assets .....	3-382
11. Resources .....	3-384
Landslides, Mud/Debris Flows, and RockFalls .....	3-385
1. Definition .....	3-385
2. Location.....	3-386
3. Extent (Magnitude/Strength).....	3-387
4. Probability.....	3-387
5. Previous Occurrences.....	3-388
6. Impact Analysis.....	3-392
7. Vulnerability and Potential Losses by Jurisdiction .....	3-394
8. Future Development.....	3-396
9. Climate Change .....	3-399
10. Risk to State Assets .....	3-399
11. Resources .....	3-405
Radon (Rn), Carbon Monoxide (CO), Methane (CH <sub>4</sub> ) Seeps .....	3-406
1. Definition .....	3-406

2. Location.....	3-407
3. Extent (Magnitude/Strength).....	3-409
4. Probability.....	3-410
5. Previous Occurrences.....	3-410
6. Impact Analysis.....	3-411
7. Vulnerability and Potential Losses by Jurisdiction .....	3-414
8. Future Development.....	3-417
9. Climate Change .....	3-418
10. Risk to State Assets .....	3-418
11. Resources .....	3-419
Subsidence & Abandoned Mine Lands .....	3-420
1. Definition .....	3-420
2. Location.....	3-421
3. Extent (Magnitude/Strength).....	3-426
4. Probability.....	3-426
5. Previous Occurrences.....	3-429
6. Impact Analysis.....	3-433
7. Vulnerability and Potential Losses by Jurisdiction .....	3-434
8. Future Development.....	3-438
9. Climate Change .....	3-439
10. Risk to State Assets .....	3-439
11. Resources .....	3-441
Animal Disease .....	3-442
1. Definition .....	3-442
2. Location.....	3-444
3. Extent (Magnitude/Strength).....	3-444
4. Probability.....	3-444
5. Previous Occurrences .....	3-444
6. Impact Analysis.....	3-449
7. Vulnerability and Potential Losses by Jurisdiction .....	3-451
8. Future Development.....	3-451
9. Climate Change .....	3-451
10. Risk to State Assets .....	3-452
11. Resources .....	3-452
Pandemic .....	3-453
1. Definition .....	3-453
2. Location.....	3-453
3. Extent (Magnitude/Strength).....	3-453
4. Probability.....	3-454
5. Previous Occurrences.....	3-455
6. Impact Analysis.....	3-456

7. Vulnerability and Potential Losses by Jurisdiction .....	3-459
8. Future Development.....	3-463
9. Climate Change .....	3-465
10. Risk to State Assets .....	3-465
11. Resources .....	3-465
Wildlife-Vehicle Collisions .....	3-467
1. Definition .....	3-467
2. Location.....	3-467
3. Extent (Magnitude/Strength).....	3-471
4. Probability.....	3-471
5. Previous Occurrences.....	3-471
6. Impact Analysis.....	3-475
7. Vulnerability and Potential Losses by Jurisdiction .....	3-477
8. Future Development.....	3-478
9. Climate Change .....	3-484
10. Risk to State Assets .....	3-485
11. Resources .....	3-485
Pest Infestation .....	3-486
1. Definition .....	3-486
2. Location.....	3-487
3. Extent (Magnitude/Strength).....	3-489
4. Probability.....	3-490
5. Previous Occurrences.....	3-490
6. Impact Analysis.....	3-493
7. Vulnerability and Potential Losses by Jurisdiction.....	3-494
8. Future Development.....	3-496
9. Climate Change .....	3-496
10. Risk to State Assets .....	3-496
11. Resources .....	3-496
Infrastructure Failure.....	3-498
1. Definition .....	3-498
2. Location.....	3-499
3. Extent (Magnitude/Strength).....	3-500
4. Probability.....	3-501
5. Previous Occurrences.....	3-502
6. Impact Analysis.....	3-504
7. Vulnerability and Potential Losses by Jurisdiction .....	3-506
8. Future Development.....	3-510
9. Climate Change .....	3-510
10. Risk to State Assets .....	3-510
11. Resources .....	3-510

Dam and Levee Failure.....	3-512
1. Definition .....	3-512
2. Location.....	3-514
3. Extent (Magnitude/Strength).....	3-518
4. Probability.....	3-519
5. Previous Occurrences.....	3-520
6. Impact Analysis.....	3-522
7. Vulnerability and Potential Losses by Jurisdiction .....	3-523
8. Future Development.....	3-526
9. Climate Change .....	3-530
10. Risk to State Assets .....	3-531
11. Resources .....	3-533
Hazardous Materials Release.....	3-534
1. Definition .....	3-534
2. Location.....	3-535
3. Extent (Magnitude/Strength).....	3-541
4. Probability.....	3-542
5. Previous Occurrences .....	3-542
6. Impact Analysis.....	3-546
7. Vulnerability and Potential Losses by Jurisdiction .....	3-547
8. Future Development.....	3-559
9. Climate Change .....	3-560
10. Risk to State Assets .....	3-560
11. Resources .....	3-561
Mine Accidents .....	3-562
1. Definition .....	3-562
2. Location.....	3-562
3. Extent (Magnitude/Strength).....	3-564
4. Probability.....	3-564
5. Previous Occurrences.....	3-565
6. Impact Analysis.....	3-570
7. Vulnerability and Potential Losses by Jurisdiction .....	3-571
8. Future Development.....	3-572
9. Climate Change .....	3-572
10. Risk to State Assets .....	3-572
11. Resources .....	3-572
Power Failure .....	3-574
1. Definition .....	3-574
2. Location.....	3-574
3. Extent (Magnitude/Strength).....	3-574
4. Probability.....	3-575

5. Previous Occurrences.....	3-580
6. Impact Analysis.....	3-583
7. Vulnerability and Potential Losses by Jurisdiction .....	3-585
8. Future Development.....	3-589
9. Climate Change.....	3-589
10. Risk to State Assets .....	3-589
11. Resources .....	3-590
Radiological Release .....	3-591
1. Definition .....	3-591
2. Location.....	3-592
3. Extent (Magnitude/Strength).....	3-593
4. Probability.....	3-595
5. Previous Occurrences.....	3-595
6. Impact Analysis.....	3-597
7. Vulnerability And Potential Losses By Jurisdiction.....	3-598
8. Future Development.....	3-601
9. Climate Change.....	3-601
10. Risk To State Assets.....	3-601
11. Resources .....	3-602
Chemical, Biological, Radiological, and Nuclear Attack .....	3-603
1. Definition .....	3-603
2. Location.....	3-605
3. Extent (Magnitude/Strength).....	3-608
4. Probability.....	3-613
5. Previous Occurrences.....	3-616
6. Impact Analysis.....	3-622
7. Vulnerability and Potential Losses by Jurisdiction .....	3-627
8. Future Development.....	3-631
9. Climate Change.....	3-631
10. Risk to State Assets .....	3-632
11. Resources .....	3-633
Cyber Attack.....	3-636
1. Definition .....	3-636
2. Location.....	3-637
3. Extent (Magnitude/Strength).....	3-638
4. Probability.....	3-638
5. Previous Occurrences .....	3-639
6. Impact Analysis.....	3-641
7. Vulnerability and Potential Losses by Jurisdiction .....	3-642
8. Future Development.....	3-643
9. Climate Change.....	3-643

10. Risk to State Assets .....	3-643
11. Resources .....	3-645
Explosive Attack .....	3-646
1. Definition .....	3-646
2. Location.....	3-646
3. Extent (Magnitude/Strength).....	3-647
4. Probability.....	3-648
5. Previous Occurrences .....	3-649
6. Impact Analysis.....	3-650
7. Vulnerability and Potential Losses by Jurisdiction .....	3-651
8. Future Development.....	3-652
9. Climate Change .....	3-653
10. Risk to State Assets .....	3-653
11. Resources .....	3-653
Risk Assessment Summary.....	3-655
1. Hazard Profile Key Takeaways.....	3-655
2. Statewide Significant Risks.....	3-667
3. Most Vulnerable Jurisdictions .....	3-668
4. Vulnerability and Loss Estimation Methodology.....	3-685
5. Resources .....	3-703

## LIST OF FIGURES

Figure 3-1 Disasters In Colorado, 1980 To 2017 By Hazard Type.....	3-28
Figure 3-2 Presidential Disaster And Emergency Declarations, 1955 To 2017 By Hazard Type 3-31	
Figure 3-3 Colorado Disasters With High Insured Dollar Losses By Hazard Type, 1984-2017 ..3-38	
Figure 3-4 Year Average Dense Fog Advisories, 2006 To 2013.....	3-46
Figure 3-5 Dense Fog Advisory For Grand Junction Area, January 2016.....	3-46
Figure 3-6 Dense Fog Exposure Projections, 2010 To 2030 .....	3-58
Figure 3-7 Drought Time Series With Before And After Drought Conditions: January 2011-October 2015 .....	3-66
Figure 3-8 Drought Hazard Rating In Local Hazard Mitigation Plans .....	3-71
Figure 3-9 Overall Socioeconomic Sector Vulnerability, By County (From 2018 Drought Plan). 3-73	
Figure 3-10 Average Highest Temperatures In July.....	3-80
Figure 3-11 Heat Index Table .....	3-82
Figure 3-12 Colorado Temperature Trends, 1900 To 2012.....	3-85
Figure 3-13 Colorado Temperature Trends .....	3-86
Figure 3-14 Colorado Temperature Trends .....	3-87
Figure 3-15 Historic Extreme Heat Events (1981-2017).....	3-90
Figure 3-16 Extreme Heat Hazard In Local Mitigation Plans .....	3-93
Figure 3-17 Extreme Heat Exposure Projections, 2010 To 2030.....	3-99

Figure 3-18 100-Year Floodplains And Dfirm Availability In Colorado.....	3-105
Figure 3-19 Fema Nfhl Status In Colorado .....	3-106
Figure 3-20 Colorado River Flows.....	3-107
Figure 3-21 Major River Drainage Basins In Colorado.....	3-108
Figure 3-22 Historic Flood Events, 1950 To 2017.....	3-112
Figure 3-23 Total Estimated Flood Losses In Colorado.....	3-123
Figure 3-24 Flood Profiled In Local Mitigation Plans .....	3-124
Figure 3-25 Flood Exposure Projections, 2010 To 2030 .....	3-133
Figure 3-26 State Assets At Risk For Flood.....	3-136
Figure 3-27 National Severe Hail Days .....	3-141
Figure 3-28 Hail Events In Colorado .....	3-142
Figure 3-29 Hail Hazard In Local Mitigation Plans .....	3-152
Figure 3-30 Damage From Hail Events In Colorado By County.....	3-153
Figure 3-31 Hail Exposure Projections, 2010 To 2030.....	3-159
Figure 3-32 Severe Thunderstorm Wind Days Per Year From 2003 To 2012.....	3-165
Figure 3-33 Wind Zones In The United States.....	3-166
Figure 3-34 Severe Wind Events In Colorado, 1955 To 2016.....	3-167
Figure 3-35 Colorado Annual Average Wind Speed.....	3-169
Figure 3-36 Damage From Severe Wind Events By County.....	3-179
Figure 3-37 Severe Wind Hazard Profiled In Local Mitigation Plans .....	3-180
Figure 3-38 Severe Wind Exposure Projections, 2010 To 2030 .....	3-186
Figure 3-39 Winter Storm Location.....	3-193
Figure 3-40 National Weather Service Wind Chill Chart.....	3-194
Figure 3-41 Severe Winter Weather Events In Colorado, 1960-2017 .....	3-198
Figure 3-42 Severe Winter Weather Profiled In Local Mitigation Plans .....	3-209
Figure 3-43 Severe Winter Weather Damage In Colorado, 1960-2017.....	3-212
Figure 3-44 Severe Winter Weather Exposure Projections, 2010 To 2030 .....	3-221
Figure 3-45 Colorado Lightning Flashes.....	3-227
Figure 3-46 National Weather Service Watch Vs Warning.....	3-228
Figure 3-47 Lightning Events In Colorado .....	3-233
Figure 3-48 Damage From Thunderstorms By County.....	3-238
Figure 3-49 Thunderstorm And Lightning Hazard In Local Mitigation Plans.....	3-239
Figure 3-50 Thunderstorm And Lightning Exposure Projections, 2010 To 2030.....	3-246
Figure 3-51 Tornado Events In Colorado.....	3-252
Figure 3-52 National Atmospheric Factors Contributing To Tornadoes.....	3-254
Figure 3-53 Annual Average Tornado Watches Per Year, 1993-2012.....	3-256
Figure 3-54 Tornadoes Per County, 1955-2014.....	3-257
Figure 3-55 Tornado Hazard In Local Mitigation Plans.....	3-262
Figure 3-56 Tornado Damages .....	3-263
Figure 3-57 Tornado Exposure Projections, 2010 To 2030 .....	3-270
Figure 3-58 Colorado Land Cover By Vegetation Type.....	3-276
Figure 3-59 Wildfire Risk In Colorado.....	3-278
Figure 3-60 Wildland Urban Interface Risk.....	3-279
Figure 3-61 Wildfires On Federal Lands, 1980 To 2017.....	3-287
Figure 3-62 Colorado State Forest Service Risk Of Post-Fire Erosion In Watersheds That Are Important Sources Of Drinking Water.....	3-290
Figure 3-63 Wildland Urban Interface Risk Ratio Rank By County .....	3-297

Figure 3-64 Wildland Risk Ratio Rank By County .....	3-298
Figure 3-65 Wildfire Hazard Profiled In Local Mitigation Plans .....	3-299
Figure 3-66 State Assets By Wildfire Threat Level.....	3-307
Figure 3-67 Avalanche Forecast Zones In Colorado.....	3-312
Figure 3-68 Colorado Avalanche Fatalities By County .....	3-315
Figure 3-69 Avalanche Fatalities By State, Winter 1950/1951 To Winter 2016/2017.....	3-319
Figure 3-70 Avalanche Hazard Rank In Local Mitigation Plans .....	3-323
Figure 3-71 Avalanche Exposure Rating Incorporating Growth .....	3-329
Figure 3-72 Avalanche Paths Impacting Highways By County .....	3-332
Figure 3-73 Earthquake History And Hazard In Colorado.....	3-335
Figure 3-74 National Seismic Hazard Map .....	3-336
Figure 3-75 Quaternary Faults In Colorado .....	3-338
Figure 3-76 Forecast For Damage From Natural And Induced Earthquakes In 2017 .....	3-339
Figure 3-77 Forecast For Ground Shaking Intensity From Natural And Induced Earthquakes 2017 .....	3-340
Figure 3-78 Usgs Community Internet Intensity Maps For Colorado, June 2013 – November 2017 .....	3-342
Figure 3-79 Induced Earthquake Areas.....	3-344
Figure 3-80 Quaternary Faults And Earthquake Scenarios In Colorado.....	3-347
Figure 3-81 Earthquake Total Annualized Loss By County .....	3-353
Figure 3-82 Earthquake Risk By County (Per Capita) .....	3-354
Figure 3-83 Earthquake Hazard In Local Mitigation Plans.....	3-355
Figure 3-84 Future Earthquake Exposure.....	3-359
Figure 3-85 Stream Erosion And Deposition System.....	3-363
Figure 3-86 Erosion And Deposition Hazard In Local Mitigation Plans .....	3-368
Figure 3-87 Erosion And Deposition Exposure Projections .....	3-370
Figure 3-88 Expansive Soils In Colorado.....	3-375
Figure 3-89 Expansive Soils And Heaving Bedrock Rating In Colorado By County.....	3-379
Figure 3-90 Expansive Soils And Heaving Bedrock Hazard In Local Mitigation Plans .....	3-380
Figure 3-91 Future Expansive Soils Exposure Projections .....	3-382
Figure 3-92 State Asset Exposure To Expansive Soils By County.....	3-383
Figure 3-93 Landslides And Debris Flow Hazards In Colorado.....	3-386
Figure 3-94 Landslide Hazard Rating In Local Hazard Mitigation Plans.....	3-396
Figure 3-95 State Assets Landslide Exposure .....	3-401
Figure 3-96: Radon Zones In Colorado By County .....	3-408
Figure 3-97: Coal Bed Formations In Colorado.....	3-409
Figure 3-98: Mean Indoor Radon Test Values (2011-2015) .....	3-414
Figure 3-99: Lung Cancer Death Rates By County (1990-2015) .....	3-415
Figure 3-100: Carbon Monoxide Hospitalizations By County.....	3-416
Figure 3-101: Colorado Natural Gas Production By County (2011) .....	3-417
Figure 3-102 Potential Subsidence Areas In Colorado.....	3-422
Figure 3-103 Potential Undermined Areas In Colorado.....	3-423
Figure 3-104 Inactive Coal Mine Locations.....	3-424
Figure 3-105 Statewide Historic Underground Coal Mine Extents And Reported Coal Mine- Related Subsidence Events.....	3-425
Figure 3-106 Potential Collapsible Soil Areas In Colorado .....	3-426
Figure 3-107 Evaporative Bedrock Locations In Colorado.....	3-427

Figure 3-108 Collapsible Soil Case Histories In Colorado .....	3-429
Figure 3-109 Subsidence Area Rank By County.....	3-435
Figure 3-110 Undermined Area Rank By County.....	3-436
Figure 3-111 Collapsible Soil Rank By County .....	3-437
Figure 3-112 Subsidence Hazard In Local Mitigation Plans .....	3-438
Figure 3-113 Hantavirus Cases, Colorado 1955-2017 .....	3-446
Figure 3-114 Human Plague By Year And Disease Type, Colorado 1975-2015 .....	3-447
Figure 3-115 Human Tularemia Cases, Colorado 1955 To 2015.....	3-449
Figure 3-116 Pandemic Profiled In Local Mitigation Plans.....	3-462
Figure 3-117 CDOT Regions .....	3-468
Figure 3-118 Total Reported Wildlife-Vehicle Collisions By County (2005-2014) .....	3-474
Figure 3-119 Total Property-Damage Only Wildlife-Vehicle Collisions (2005-2014) .....	3-475
Figure 3-120 Number Of Constructed Wildlife Crossings By County .....	3-478
Figure 3-121 Wildlife-Vehicle Collision Exposure Rating Incorporating Growth.....	3-484
Figure 3-122 Rangeland Grasshopper Hazard In The Western United States .....	3-488
Figure 3-123 Emerald Ash Borer In Boulder County .....	3-489
Figure 3-124 Pest Disasters In Colorado, 1980 To 2017.....	3-492
Figure 3-125 Pest Disasters Profiled In Local Mitigation Plans.....	3-495
Figure 3-126 Colorado Commercial/Retail Sales By County .....	3-507
Figure 3-127 Colorado Manufacturing Production By County.....	3-507
Figure 3-128 Colorado Financial Sector Employment By County .....	3-508
Figure 3-129 Colorado Healthcare Services By County .....	3-508
Figure 3-130 Colorado Transportation Infrastructure .....	3-509
Figure 3-131 Colorado State-Owned Assets .....	3-509
Figure 3-132 High And Significant Hazard Dams In Colorado.....	3-515
Figure 3-133 Levees In Colorado.....	3-516
Figure 3-134 Colorado High Hazard Dam Release Study Results .....	3-518
Figure 3-135 Dam Failure Hazard In Local Mitigation Plans.....	3-526
Figure 3-136 Dam Failure Exposure By County.....	3-530
Figure 3-137 Active And Plugged Oil And Gas Wells In Colorado.....	3-537
Figure 3-138 Colorado Railroad System.....	3-538
Figure 3-139 Colorado Hazardous And Nuclear Materials Route Restrictions .....	3-539
Figure 3-140 Gas Transmission And Hazardous Liquid Pipelines In The U.S.....	3-541
Figure 3-141 HAZMAT Fixed Facility Incident Damages, 1990 To 2016.....	3-550
Figure 3-142 HAZMAT Transportation Incident Damages By County, 1971 To 2017.....	3-554
Figure 3-143 HAZMAT Pipeline Incident Damages By County, 1968 To 2017.....	3-557
Figure 3-144 HAZMAT Risk Ranking In Local Hazard Mitigation Plans .....	3-558
Figure 3-145 Pending Well Permits.....	3-560
Figure 3-146 Active Mine Locations .....	3-563
Figure 3-147 Inactive Coal Mine Locations.....	3-564
Figure 3-148 Colorado Energy Asset Vulnerability To Hazards By County .....	3-586
Figure 3-149 Designated Nuclear Routes In Colorado.....	3-593
Figure 3-150 Colorado Population Density .....	3-606
Figure 3-151 Radiological Device Dispersal Models .....	3-607
Figure 3-152 Likely Military Nuclear Strike Targets In The United States.....	3-608
Figure 3-153 Effects And Treatment Of Some Chemical Weapons Developed For Military Use	3-609

Figure 3-154 Damage Zones For A 10 KT Nuclear Explosion .....	3-613
Figure 3-155 Capacity Of Different Explosives .....	3-647
Figure 3-156 Explosive Attack Incidents In The United States (1970-2016).....	3-648

## LIST OF TABLES

Table 3-1 Hazards Identified For Colorado.....	3-22
Table 3-2 Disasters In Colorado, 1980 To 2017 .....	3-23
Table 3-3 Presidential Disaster And Emergency Declarations, 1955 To 2017.....	3-28
Table 3-4 FEMA Fire Management Assistance, 1978 To 2017.....	3-31
Table 3-5 USDA Secretarial Disasters In Colorado, 2003 To 2017.....	3-33
Table 3-6 Colorado Disasters With High Insured Dollar Losses, 1984-2017 .....	3-36
Table 3-7 Hazards Identified In Local Plans .....	3-39
Table 3-8 Primary Areas Of Consideration Within Hazard Profiles .....	3-41
Table 3-9 Hazard Analysis Summary Category Descriptions .....	3-41
Table 3-10 Hazard Impact Summary.....	3-45
Table 3-11 Fog Types And Descriptions.....	3-47
Table 3-12 Years With Fog Events.....	3-48
Table 3-13 Dense Fog Events Causing Injury Or Death.....	3-49
Table 3-14 Counties And Zones With Dense Fog Events, 1996 To 2017 .....	3-50
Table 3-15 Dense Fog EMA P Impact Summary .....	3-51
Table 3-16 Transportation Crashes Due To Fog.....	3-52
Table 3-17 Dense Fog Events By County, 1996-2017 .....	3-53
Table 3-18 Dense Fog Future Exposure Projections.....	3-55
Table 3-19 Combined Risk Methodology .....	3-55
Table 3-20 Dense Fog Exposure Projections, 2010 To 2030 .....	3-56
Table 3-21 Hazard Profile Summary .....	3-61
Table 3-22 Drought Monitor Categorization.....	3-62
Table 3-23 Historical Dry And Wet Periods In Colorado.....	3-64
Table 3-24 Drought EMA P Impact Summary.....	3-67
table 3-25 Summary Of The 2018 Drought Plan Vulnerability Assessment, By Sector .....	3-69
Table 3-26 Drought Vulnerability For Counties With High Risk In Local Plans .....	3-71
Table 3-27 Climate Change Impacts .....	3-74
Table 3-28 State Assets Key Impacts From Drought .....	3-75
Table 3-29 Potential Drought Losses Based On Historic Economic Impacts.....	3-76
Table 3-30 Hazard Profile Summary .....	3-79
Table 3-31 Heat Index Table.....	3-83
Table 3-32 Summary Of Extreme High Temperatures In Colorado By County, 1981-2017 ...	3-88
Table 3-33 Extreme Heat EMA P Impact Summary .....	3-91
Table 3-34 Housing Projections (2010 To 2030) And Historical Events .....	3-94
Table 3-35 Combined Risk Methodology .....	3-96
Table 3-36 Extreme Heat Exposure Projections .....	3-96
Table 3-37 Extreme Heat Exposure Projections, 2010 To 2030 .....	3-96
Table 3-38 Climate Change Impacts .....	3-100
Table 3-39 State Asset Exposure Projections, 2010 TO 2030.....	3-101
Table 3-40 Hazard Profile Summary .....	3-104
Table 3-41 Notable Flood Events In Colorado, 1864 - 2017.....	3-110

Table 3-42 Insured Flood Losses, 1975 To 2017.....	3-112
Table 3-43 NFIP Insurance Claims History.....	3-113
Table 3-44 Flood EMA P Impact Summary.....	3-116
Table 3-45 Hazus Estimated Building Damages And Total Economic Losses .....	3-118
Table 3-46 Hazus Estimated Debris, Displacement, And Shelter Needs .....	3-120
Table 3-47 Local Hazard Mitigation Plans .....	3-124
Table 3-48 Housing Projections (2010 To 2030) And Historical Events .....	3-128
Table 3-49 Flood Exposure Projections.....	3-130
Table 3-50 Combined Risk Methodology .....	3-131
Table 3-51 Flood Exposure Projections, 2010 To 2030.....	3-131
Table 3-52 Climate Change Impacts .....	3-134
Table 3-53 Value And Count Of State Assets In The 100-Year Floodplain By County .....	3-136
Table 3-54 Hazard Profile Summary .....	3-140
Table 3-55 Hail Measurements .....	3-143
Table 3-56 Hail Events, Deaths, And Injuries, 2007-2017 .....	3-144
Table 3-57 Hail Events, Deaths, Injuries, And Damage By Decade.....	3-144
Table 3-58 Hail EMA P Impact Summary .....	3-146
Table 3-59 Top Damaging Hail Events In Colorado.....	3-147
Table 3-60 Hail Damage By County Population Density, 1996-2017.....	3-149
Table 3-61 Hail Events, Deaths, Injuries And Damage In Colorado By County, 1996-2017.....	3-150
Table 3-62 Local Hazard Mitigation Plans .....	3-153
Table 3-63 Housing Projections (2010 To 2030) And Historical Hail Events .....	3-154
Table 3-64 Hail Exposure Projections .....	3-156
Table 3-65 Combined Risk Methodology .....	3-157
Table 3-66 Hail Exposure Projections, 2010 To 2030 .....	3-157
Table 3-67 Climate Change Impacts .....	3-160
Table 3-68 State Asset Exposure Projections, 2010 To 2030.....	3-161
Table 3-69 Hazard Profile Summary .....	3-164
Table 3-70 Beaufort Wind Scale .....	3-167
Table 3-71 Wind Events, Deaths, And Injuries, 2006 To 2016 .....	3-170
Table 3-72 Wind Events, Deaths, Injuries, And Damage By Decade.....	3-171
Table 3-73 Colorado Severe Wind Events, 2013 To 2017.....	3-172
Table 3-74 Severe Wind EMA P Impact Analysis Summary.....	3-176
Table 3-75 Severe Wind Events, Deaths, Injuries And Damage In Colorado By County , 1996-2017 .....	3-176
Table 3-76 Local Hazard Mitigation Plans .....	3-180
Table 3-77 Housing Projections (2010 To 2030) And Historical Wind Events .....	3-181
Table 3-78 Wind Exposure Projections .....	3-183
Table 3-79 Combined Risk Methodology (Wind).....	3-184
Table 3-80 Wind Exposure Projections, 2010 To 2030 .....	3-184
Table 3-81 Climate Change Impacts .....	3-187
Table 3-82 State Asset Exposure Projections, 2010 To 2030.....	3-188
Table 3-83 Hazard Summary .....	3-192
Table 3-84 Winter Storm Severity Index.....	3-193
Table 3-85 Severe Winter Weather Events, Deaths, Injuries, And Property Damage, 2007 To 2017 .....	3-195
Table 3-86 Winter Weather Events, 1960 To 2017 .....	3-195

Table 3-87 Heavy Snowfall Events In Colorado.....	3-198
Table 3-88 Extreme Cold Events In Colorado, 1983 To 2017.....	3-199
Table 3-89 Counties Experiencing Extreme Cold Events, 1960 To 2017.....	3-200
Table 3-90 Winter Weather EMAP Impact Summary .....	3-206
Table 3-91 Average Annual Minimum Temperature Record By County.....	3-208
Table 3-92 Damages By County .....	3-210
Table 3-93 Local Hazard Mitigation Plans .....	3-212
Table 3-94 Housing Projections (2010 To 2030) And Historical Events .....	3-215
Table 3-95 Severe Winter Weather Exposure Projections.....	3-217
Table 3-96 Combined Risk Methodology .....	3-217
Table 3-97 Severe Winter Weather Exposure Projections , 2010 To 2030 .....	3-219
Table 3-98 Climate Change Impacts .....	3-222
Table 3-99 State Asset Exposure Projections, 2010 To 2030.....	3-223
Table 3-100 Hazard Profile Summary .....	3-226
Table 3-101 Average Lightning Flashes In Colorado By Day/Month, 1950-2017.....	3-229
Table 3-102 Days With Thunderstorm Events .....	3-229
Table 3-103 Thunderstorm And Lightning Events, 1950-2017.....	3-230
Table 3-104 Property And Crop Damage By County, 1950-2017 .....	3-234
Table 3-105 Thunderstorm And Lightning EMAP Impact Summary.....	3-237
Table 3-106 Local Mitigation Plans .....	3-239
Table 3-107 Housing Projections (2010 To 2030) And Historical Events .....	3-241
Table 3-108 Thunderstorm And Lightning Exposure Projections.....	3-243
Table 3-109 Combined Risk Methodology .....	3-243
Table 3-110 Thunderstorm AND Lightning Exposure Projections, 2010 TO 2030.....	3-244
Table 3-111 Climate Change Impacts .....	3-247
Table 3-112 State Assets Exposure Projections, 2010 To 2030.....	3-248
Table 3-113 Hazard Profile Summary .....	3-251
Table 3-114 Enhanced Fujita Scale Of Tomado Intensity .....	3-253
Table 3-115 Colorado Tornado Numbers And Strength, 2007 To 2017 .....	3-253
Table 3-116 Tornado Events, Deaths, And Injuries, 2007-2017 .....	3-255
Table 3-117 Tornado Events, Deaths, Injuries, And Damage By Decade.....	3-255
Table 3-118 Tornadoes Causing Death Or At Least Seven Injuries, 1915-2017 .....	3-258
Table 3-119 Tornado EMAP Impact Summary .....	3-259
Table 3-120 Tornado Events, Deaths, And Injuries By County, 1950-2017.....	3-260
Table 3-121 Local Hazard Mitigation Plans .....	3-263
Table 3-122 Housing Projections (2010 To 2030) And Historical Events .....	3-264
Table 3-123 Tornado Exposure Projections.....	3-267
Table 3-124 Combined Risk Methodology .....	3-267
Table 3-125 Tornado Exposure Projections, 2010 To 2030 .....	3-268
Table 3-126 State Asset Exposure Projections, 2010 To 2030.....	3-271
Table 3-127 Hazard Profile Summary .....	3-274
Table 3-128 Average Number Of Wildfires By Decade .....	3-280
Table 3-129 Colorado Counties By Percent Of Acres At Risk .....	3-281
Table 3-130 Notable Fire Events In Colorado, 1937 To 2017.....	3-283
Table 3-131 Wildfire Losses, 2007 To 2017 .....	3-286
Table 3-132 Wildfire EMAP Impact Summary.....	3-292
Table 3-133 Wildfire Losses By County And NWS Reporting Zone.....	3-293

Table 3-134 Local Hazard Mitigation Plans .....	3-299
Table 3-135 Wildfire Exposure Projections.....	3-303
Table 3-136 Wildfire Exposure Projections, 2010 To 2030.....	3-303
Table 3-137 Impacts Of Climate Change On Wildfire In Colorado.....	3-306
Table 3-138 State Assets By Wildfire Threat Level.....	3-307
Table 3-139 Wildfire Threat To State Assets By County .....	3-308
Table 3-140 Hazard Profile Summary .....	3-311
Table 3-141 Impact Pressure Damage.....	3-313
Table 3-142 Fatal Avalanches By Location, 2007-2018.....	3-315
Table 3-143 Significant Avalanches By Decade .....	3-317
Table 3-144 Avalanche EMAP Impact Summary .....	3-320
Table 3-145 Avalanche Damage In Colorado By County: 1960 To 2008.....	3-321
Table 3-146 Housing Projections (2010 To 2030) And Historical Avalanche Fatalities (1950 To 2016).....	3-324
Table 3-147 Avalanche Exposure Projections .....	3-326
Table 3-148 Combined Risk Methodology.....	3-326
Table 3-149 Avalanche Exposure Projections, 2010 To 2030.....	3-327
Table 3-150 Climate Change Impacts .....	3-329
Table 3-151 - State Assets At Risk To Avalanche.....	3-330
Table 3-152 State Highway System Avalanche Corridors And Monitored Slide Paths.....	3-331
Table 3-153 Hazard Profile Summary .....	3-334
Table 3-154 Notable Earthquake Events In Colorado: 1870 - 2017.....	3-341
Table 3-155 Colorado Induced Earthquake Incidents .....	3-343
Table 3-156 Earthquake Emap Impact Summary .....	3-345
Table 3-157 Earthquake Loss And Casualties By County .....	3-347
Table 3-158 Annualized Earthquake Loss By County .....	3-350
Table 3-159 Earthquake Exposure Projections.....	3-356
Table 3-160 Risk Methodology.....	3-356
Table 3-161 Earthquake Exposure Projections, 2010 To 2030.....	3-357
Table 3-162 State Asset Construction Type And Total Value*.....	3-360
Table 3-163 Hazard Profile Summary .....	3-362
Table 3-164 Erosion And Deposition EMAP Impact Summary .....	3-366
Table 3-165 Erosion And Deposition Exposure Projections .....	3-369
Table 3-166 Erosion And Deposition Exposure Projections, 2010 To 2030 .....	3-369
Table 3-167 Climate Change Impacts .....	3-371
Table 3-168 Hazard Profile Summary .....	3-374
Table 3-169 Expansive Soils EMAP Impact Summary .....	3-378
Table 3-170 Future Expansive Soils Exposure Projections .....	3-381
Table 3-171 Expansive Soils Exposure Projections, 2010 To 2030.....	3-381
Table 3-172 Hazard Profile Summary .....	3-385
Table 3-173 Notable Landslide, Mud/Debris Flow/Rockfall Events In Colorado From 1903 To 2017 .....	3-388
Table 3-174 Landslide, Mud/Debris Flow , And Rockfall Events That Led To Injuries And Deaths 1960-2017.....	3-393
Table 3-175 Landslide, Mud/Debris Flow , Rockfall EMAP Impact Summary.....	3-393
Table 3-176 Landslide Vulnerability For Counties With High Risk In Local Plans .....	3-395
Table 3-177 Future Landslide Risk Categorization Method .....	3-397

Table 3-178 Combined Future Landslide Risk Ranking .....	3-397
Table 3-179 Climate Change Impacts .....	3-399
Table 3-180 State Assets Landslide Hazard Exposure By County.....	3-400
Table 3-181 Direct And Indirect Costs Of Geohazards Events .....	3-403
Table 3-182 Transportation Commission Contingency Funding Requests , 2008-2015.....	3-404
Table 3-183: Hazard Profile Summary .....	3-406
Table 3-184 Radon-CO-Methane EMA P Impact Summary .....	3-413
Table 3-185 Hazard Profile Summary .....	3-421
Table 3-186 Subsidence EMA P Impact Summary .....	3-434
Table 3-187 State Assets At Risk To Subsidence By Use Type.....	3-439
Table 3-188 State Assets At Risk To Subsidence By County.....	3-440
Table 3-189 Hazard Profile Summary .....	3-443
Table 3-190 2015 Colorado Zoonoses Report.....	3-444
Table 3-191 Counties Testing Wildlife For Plague.....	3-447
Table 3-192 Species Of Wildlife Tested.....	3-448
Table 3-193 Animal Disease EMA P Impact Summary .....	3-450
Table 3-194 Climate Change Impacts .....	3-451
Table 3-195 Hazard Summary Table.....	3-453
Table 3-196 World Health Organization's Pandemic Flu Phases.....	3-454
Table 3-197 Deaths By Age Group Caused By H1N1 .....	3-456
Table 3-198 Pandemic EMA P Impact Summary Table .....	3-458
Table 3-199 Youngest And Oldest Populations By County , 2016.....	3-459
Table 3-200 Local Hazard Mitigation Plans .....	3-462
Table 3-201 Population Change By County, 2010 - 2030.....	3-463
Table 3-202 Climate Change Impacts .....	3-465
Table 3-203 Hazard Profile Summary .....	3-467
Table 3-204 Roadkill Incidents By Highway And Milepost (2016).....	3-468
Table 3-205 Wild Animal Crashes By County (2005-2014) .....	3-471
Table 3-206 Wild Animal Crashes Statewide (2005-2014).....	3-475
Table 3-207 WVC EMA P Impact Summary .....	3-476
Table 3-208 Housing Percent Change (2010 To 2030) And Historical Wvcs (2005 To 2014)....	3-479
Table 3-209 WVC Exposure Projections .....	3-481
Table 3-210 Combined Risk Methodology .....	3-481
Table 3-211 WVC Exposure Projections, 2010 To 2030.....	3-482
Table 3-212 Hazard Profile Summary .....	3-486
Table 3-213 State Disasters In Colorado, 1980 To 2017.....	3-491
Table 3-214 USDA Secretarial Disasters In Colorado, 2003 To 2017.....	3-491
Table 3-215 Pest Infestation EMA P Impact Summary .....	3-494
Table 3-216 Climate Change Impacts .....	3-496
Table 3-217 Hazard Profile Summary .....	3-499
Table 3-218 COLORADO INFRASTRUCTURE RANKINGS.....	3-502
Table 3-219 FEMA Hazard Potential Classification System For Dams .....	3-513
Table 3-220 Dam Failure Profile Summary.....	3-514
Table 3-221 Dams With The Greatest Maxium Storage Capacity.....	3-515
Table 3-222 Colorado Dam Safety Ranking Based On Dam Release Operations.....	3-517
Table 3-223 EMA P Dam Failure Impact Summary .....	3-522

Table 3-224 Counties With Over Five High Hazard Dams.....	3-524
Table 3-225 Dam Failure Exposure Projections.....	3-527
Table 3-226 Risk Methodology.....	3-527
Table 3-227 Dam Failure Exposure Projections , 2010 To 2030.....	3-528
Table 3-228 State Asset Exposure Projections , 2010 To 2030.....	3-531
Table 3-229 Hazardous Material Classes.....	3-534
Table 3-230 Hazard Profile Summary .....	3-535
Table 3-231 Colorado National Priority List Sites.....	3-536
Table 3-232 Colorado Fixed Facility HAZMAT Incidents Per Year, 1990 To 2016 .....	3-542
Table 3-233 Number Of Oil Spills From Wells In Colorado From 1999 To 2017 .....	3-543
Table 3-234 Hazardous Material Transportation Incidents Reported In Colorado From 2009 To 2017 By Transport Type.....	3-544
Table 3-235 Colorado Significant Hazardous Liquid And Natural Gas Pipeline Incidents From 1997 To 2016.....	3-545
Table 3-236 Hazardous Material Incident EMAP Impact Summary .....	3-546
Table 3-237 HAZMAT Fixed Facility Incident Damages, Fatalities, Injuries, And People Evacuated From 1990 To 2016.....	3-547
Table 3-238 Oil And Gas Well Spills By County From 2013 To 2017.....	3-550
Table 3-239 Hazardous Material Transportation Incident Damages , Fatalities, Injuries, And People Evacuated From 1971 To 2017 .....	3-552
Table 3-240 Hazardous Liquid And Natural Gas Pipeline Incident Damages , Fatalities, And Injuries From 1968 To 2017.....	3-555
Table 3-241 Local Hazard Mitigation Plans .....	3-558
Table 3-242 Hazard Profile Summary .....	3-562
Table 3-243 Mine Accident Fatalities: 1839 To 2000 .....	3-566
Table 3-244 Abandoned Mine Shaft Fatalities And Injuries: 1955 To 2000.....	3-567
Table 3-245 Mine Accidents EMAP IMPACT SUMMARY .....	3-571
Table 3-246 Hazard Profile Summary .....	3-574
Table 3-247 Hazards Most Likely To Affect Colorado's Energy Supply .....	3-576
Table 3-248 Electrical Transmission Outages Affecting Colorado, 2000-2016.....	3-581
Table 3-249 Energy Disruption EMAP IMPACT Summary .....	3-584
Table 3-250 Impact Of Energy Disruptions ON Essential Public Services .....	3-589
Table 3-251 Hazard Summary .....	3-592
Table 3-252 Acute Radiation Illness Chart .....	3-594
Table 3-253 Past Occurrences Of Radioactive Transportation Spills.....	3-596
Table 3-254 Radiological Release EMAP Impact Summary .....	3-598
Table 3-255 Hazmat Releases Involving Radiological Materials By County.....	3-599
Table 3-256 Hazard Summary Table.....	3-605
Table 3-257 Diseases/Agents Listed By The CDC As Potential Bioterror Threats.....	3-610
Table 3-258 Impact Of Probable Weaponized Biological Diseases .....	3-610
Table 3-259 Types Of Radioactive Materials By Industry.....	3-612
Table 3-260 Incidents Involving Radiological Materials.....	3-615
Table 3-261 Chemical Attacks In The United States.....	3-618
Table 3-262 Incidents Of Stolen Or Missing Plausible RDD Materials .....	3-622
Table 3-263 CBRN Attack EMAP Impact Summary .....	3-626
Table 3-264 Biological Attack Scenerio Likely Losses .....	3-629
Table 3-265 Hazard Profile Summary .....	3-637

Table 3-266 Largest Data Breaches Targeting Colorado Entities, 2005-2017.....	3-639
Table 3-267 Cyber Attack EMAP Impact Summary.....	3-642
Table 3-268 Hazard Profile Summary .....	3-646
Table 3-269 Previous Explosive Attacks In Colorado.....	3-649
Table 3-270 Explosive Attack EMAP Impact Summary .....	3-651
Table 3-271 Summary Of Local Jurisdiction Hazard Vulnerability Rankings .....	3-669
Table 3-272 Hazard Risk Ranking By Local Jurisdiction.....	3-671
Table 3-273 Jurisdictions With Severe Winter Weather Ranked As A 'Top Four Hazard' ....	3-674
Table 3-274 Jurisdictions With Wildfire Ranked As A 'Top Four Hazard' .....	3-677
Table 3-275 Jurisdictions With Flood Ranked As A 'Top Four Hazard' .....	3-680
Table 3-276 Jurisdictions With Drought Ranked As A 'Top Four Hazard' .....	3-683
Table 3-277 Vulnerability And Loss Estimation Methodology Summary.....	3-686

# INTRODUCTION

The purpose of the Hazard Identification and Risk Assessment (HIRA) is to identify natural, technological, and human-caused hazards and to evaluate the risk they pose to the State of Colorado, the health and safety of its citizens, property, and economy. A vulnerability and risk assessment is a decision support tool for determining the need for and prioritization of mitigation measures to protect assets, processes, and people. While it is financially unfeasible to reduce risk from every hazard event, vulnerability and risk assessments can help ensure that the available resources and actions taken are justified and implemented based on the threat, vulnerability, and risk.

Hazard identification and the assessment of associated risks is a shared responsibility between the state and local communities. Both the state and local communities assess the risks from hazards as part of their respective planning processes. While local governments focus on the hazards, vulnerabilities, and risks on a local or regional scale, the state focus remains on the regional and statewide implications of hazards.

The HIRA is divided into the following sections, providing a detailed discussion of process, approach, and content:

- Introduction
- Hazard Identification
- Disaster Declaration History
- Hazards Identified in Local Plans
- Hazard Profiles
- Risk Assessment Summary

## 1. HAZARD IDENTIFICATION

This section identifies the hazards that are probable, or based on future probability, likely to negatively impact the State of Colorado. The primary methods of determining which hazards to include in the 2018 State Plan update included the evaluations of:

- Previous State Plans
- Disasters and Emergencies in Colorado
- Insured Losses
- Local Mitigation Plans

The hazards identified for Colorado and used for this risk assessment are defined in Table 3-1.

TABLE 3-1 HAZARDS IDENTIFIED FOR COLORADO

Natural Hazards	
<b>Atmospheric Hazards</b>	Dense Fog
	Drought ^
	Extreme Heat ^
	Flood ^
	Hail ^
	Severe Wind ^
	Thunderstorms and Lightning ^
	Tornado ^
	Wildfire ^
	Severe Winter Weather ^
<b>Geologic Hazards</b>	Avalanche ^
	Earthquake ^
	Erosion and Deposition ^
	Expansive Soils and Heaving Bedrock ^
	Landslide/Mud/Debris Flows/Rock Fall/Rockslide ^
	Radon/Carbon Monoxide/Methane/Other Seeps
	Sinkholes/Subsidence/Abandoned Mine ^
<b>Biological Hazards</b>	Animal Disease Outbreak
	Pandemic/Epidemiology (Epidemic/Pandemic)
<b>Other Natural Hazards</b>	Wildlife Vehicle Collisions
	Pest Infestation (Emerald Ash Borer, Grasshopper, etc.) ^
Other Hazards	
<b>Technological Hazards</b>	Critical Infrastructure Disruption/Failure
	Dam/Levee Failure
	Hazardous Materials Release
	Mine Accident
	Power Failure
	Radiological Release
	Telecommunications Failure
<b>Human-Caused Hazards</b>	Chemical, Biological, Radiological, and Nuclear (CBRN) Attacks
	Cyber Attack
	Explosive Attack

^ Denotes a hazard included in the 2013 Plan

### 1.1 PREVIOUS STATE PLANS

The Colorado Division of Homeland Security & Emergency Management (DHSEM) Mitigation Team worked directly with Subject Matter Experts (SMEs) to review the natural hazards as listed in the 2013 State Plan. To ensure potential integration of this HIRA with other state planning efforts and the Emergency Management Accreditation Program (EMAP), it was determined that a number of new applicable hazards would be profiled. In addition, a few of the 2013 hazard definitions were expanded or modified to ensure all hazards potentially affecting the state are included in this HIRA.

## 2. DISASTER DECLARATION HISTORY

Historic state and federal-level disaster or emergency declarations were reviewed to ensure coverage of events in the State Plan. These state and federal declarations are listed in the tables below as a consolidated set of data rather than including in each hazard profile section.

### 2.1 STATE DECLARATIONS

Colorado disasters and emergencies declared by the Governors from 1980 to late 2017 are shown in Table 3-2. Note the diversity in types of events declared: grasshopper infestation, drought, wildfires, tornadoes, rockfalls, floods, sinkholes, mudslides, and blizzards. During review of the final draft of the SHMP, it was noted that other state disasters have occurred since the development of the HIRA. Specifically, a rockfall/landslide event after a severe thunderstorm occurred on Highway 550 at Ruby Walls, causing a disaster emergency declared by the state. For the sake of the analysis in the HIRA, disaster events were only included through December 2017.

TABLE 3-2 DISASTERS IN COLORADO, 1980 TO 2017

Year	Hazard	Location
1980	Grasshopper Infestation	Logan, Morgan, Sedgwick, Phillips, Washington, Weld Counties
1980	Flooding	Weld, Logan, Washington, Morgan, Larimer, Sedgwick Counties
1980	Severe Winter Storm	Cheyenne, Kit Carson Counties
1981	Water System	City of Trinidad and Vicinity
1981	Grasshopper Infestation	Eastern Colorado Counties
1981	Dam Safety	Adams, Weld Counties
1981	Tornadoes	Adams, Denver, Jefferson, Weld Counties
1982	Severe Winter Storm	Denver, Arapahoe, Adams, Jefferson, Boulder, El Paso, Weld Counties
1982	Dam Failure	Lawn Lake Dam, Larimer County
1982	Flooding	Ouray County
1984	Severe Winter Storm	Conejos County
1984	Water System	Oak Creek, Routt County
1984	Flooding	Delta, Dolores, Hinsdale, Saguache, Mesa, Montrose, Moffat, Rio Blanco, Pitkin, San Miguel, Ouray, Eagle, Gunnison Counties, Town of Silt
1986	Earth Slide	Delta County
1986	Earthflow	SH 133, N of Paonia Reservoir
1986	Winter Storm	Weld County

<b>Year</b>	<b>Hazard</b>	<b>Location</b>
1987	Wildfire	Garfield County
1987	Flood Mitigation	Alamosa County
1987	Wildfire	Cheyenne, Lincoln, Elbert Counties
1987	Flooding	Park County
1988	Wildfire - 3 Executive Orders (EOs)	Lefthand Canyon, Boulder County, Larimer County, Fremont County
1988	Tornado	Denver County
1989	Wildfire	Black Tiger Fire, Boulder County
1989	Flooding	Town of Rico
1990	Hailstorm	Denver, Boulder Counties
1990	Wildfire	Olde Stage Fire, Boulder County
1990	Severe Thunderstorm	El Paso County
1990	Tornado	Limon
1990	Blizzard	Several Locations
1992	Flood	Fort Collins
1994	Flood	Pueblo County, Town of Lyons, Boulder County
1994	Wildfires	Garfield, Delta, Douglas, Jefferson Counties; statewide
1995	Flood	Weld, Morgan Counties
1996	Tornadoes	Morgan, Washington Counties
1996	Wildfire	Buffalo Creek, Jefferson County
1996	Flood	Buffalo Creek, Jefferson County
1996	Wildfire, Drought, Severe Weather	Several Locations
1997	Blizzard - 2 EOs in October, December	South Central Colorado, eastern
1997	Landslides	Jefferson County
1997	Flooding	Fort Collins, Weld, Morgan, Logan, Phillips, Clear Creek, Elbert, Kiowa, Baca, Otero, Lincoln, Crowley, Prowers, Sedgwick Counties; Town of Holyoke
1998	Landslides, Rockfalls	Archuleta, Garfield, Mesa, Gunnison, Rio Blanco Counties
1998	Wildfire	Mt. Evans
1999	Flood - 2 Executive Orders	Sedgwick, Washington Counties
1999	Flooding, Landslides, Mudslides	Bent, Crowley, Custer, El Paso, Elbert, Fremont, Kiowa, Larimer, Otero, Las Animas, Pueblo, Weld Counties
2000	Flood	Elbert County
2000	Wildfires - multiple Executive Orders	Jefferson, Park, Boulder, Larimer, Las Animas Counties
2001	Severe Winter Storms	Eastern Plains and Front Range

<b>Year</b>	<b>Hazard</b>	<b>Location</b>
2002	Wildfires	Statewide
2002	Mudslides	San Miguel County
2002	Drought	All counties
2003	Sinkhole	Interstate 70, Eagle County
2003	Wildfire	Cherokee Fire
2003	Snow Emergency	Statewide
2004	Wildfire	Larimer County
2004	Tornadoes	Logan County
2005	Wildfire	Pueblo, Custer Counties
2006	Snow Emergencies - 2 Executive Orders	December - 24 counties
2006	Severe Winter Storm - October	Southern Colorado, including El Paso County
2006	Wildfires - multiple Executive Orders	Garfield, Teller, Custer Counties
2006	Wildfire - 2 Executive Orders	Las Animas, Huerfano Counties; Costilla, Huerfano Counties
2006	Drought	South Platte Basin in Northern Colorado
2006	Flooding	Douglas, Teller, Fremont, Pueblo, Garfield Counties
2007	Tornado	Holly, Prowers Counties
2007	Tornadoes	Prowers, Phillips, Cheyenne Counties
2007	Rockfalls	Interstate 70, U.S. Highway 6 Garfield; Clear Creek, Jefferson Counties
2008	Wildfires	Crowley County
2008	Contamination of Water Supply	City of Alamosa
2008	Severe Tornadoes in Northern CO	Weld, Larimer Counties
2008	Wildfire	Housetop Fire, Mesa County
2008	Wildfires	Las Animas County
2009	Severe Blizzard	Statewide
2009	Severe Spring Snowstorm	Statewide
2010	Wildfire	Larimer County
2010	Wildfire	Boulder County
2010	Rockslide	Interstate 70
2011	Wildfire	Custer, Fremont Counties
2011	Wildfire	Las Animas County
2011	Wildfire	Teller County
2011	Wildfire	Las Animas County
2011	Wildfire	Larimer County
2011	Flooding	Boulder County
2011	Wildfire	Jefferson County

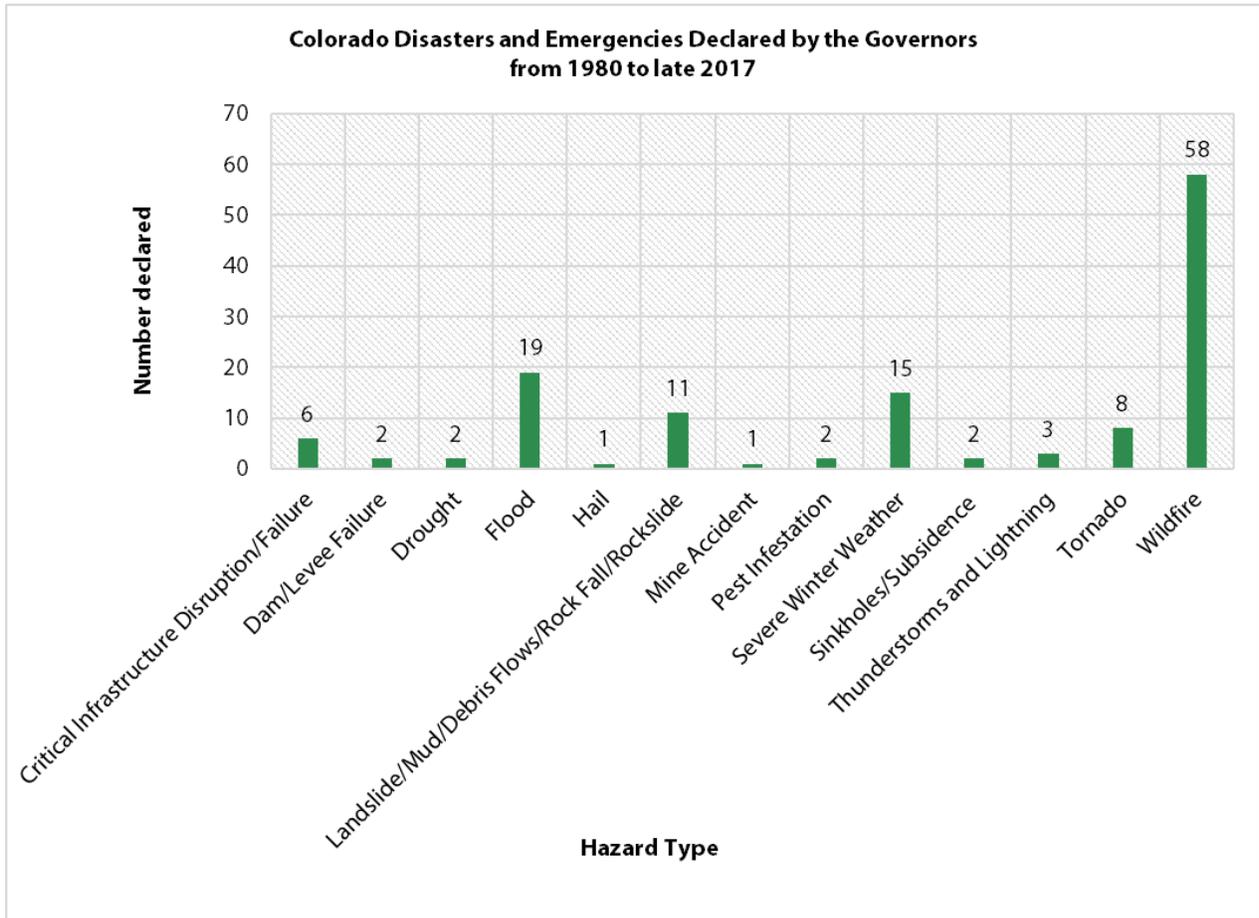
<b>Year</b>	<b>Hazard</b>	<b>Location</b>
2012	Wildfire	Moffat County
2012	Wildfire	Larimer County
2012	Wildfire	Montezuma County
2012	Wildfire	Custer County
2012	Wildfire	Garfield County
2012	Flooding	El Paso, Larimer Counties
2012	Bridge Damage	Fremont County
2012	Wildfire	Rio Blanco County
2012	Sinkhole	Lake County
2012	Wildfire	Mesa County
2012	Wildfire	Mesa County
2012	Wildfire	El Paso County
2012	Wildfire	Montezuma County
2012	Wildfire	El Paso County
2012	Wildfire	Larimer County
2012	Wildfire	Larimer County
2012	Wildfire	Larimer County
2012	Wildfire	Jefferson County
2013	Winter Storm	Statewide
2013	Flooding	Adams, Arapahoe, Broomfield, Boulder, Chaffee, Clear Creek, Crowley, Denver, El Paso, Gilpin, Fremont, Jefferson, Lake, Larimer, Lincoln, Logan, Morgan, Otero, Park, Pueblo, Prowers, Sedgwick, Washington, Weld Counties
2013	Wildfire	Garfield County
2013	Flooding	El Paso County
2013	Wildfire	Jefferson County
2013	Wildfire	Mineral, Rio Grande, Hinsdale Counties
2013	Wildfire	Huerfano, Las Animas Counties
2013	Wildfire	Grand County
2013	Wildfire	Huerfano County
2013	Wildfire	El Paso County
2013	Wildfire	Fremont County
2014	Landslide	Mesa County
2014	Rockslide	U.S. Highway 550 over Red Mountain Pass
2014	Extreme Weather	Statewide
2015	Mine Accident	Gold King Mine, Silverton, and downstream waters

<b>Year</b>	<b>Hazard</b>	<b>Location</b>
<b>2015</b>	Severe Weather	Communities east of the Continental Divide, Rio Blanco, Garfield Counties
<b>2016</b>	Wildfire	Larimer County
<b>2016</b>	Wildfire	Custer, Pueblo Counties
<b>2016</b>	Wildfire	Pueblo County
<b>2016</b>	Wildfire	Fremont County
<b>2016</b>	Wildfire	Boulder County
<b>2016</b>	Blizzard	Northeastern Colorado, including Denver metropolitan area
<b>2016</b>	Rockslide	U.S. Highway 70 in Glenwood Canyon
<b>2017</b>	Wildfire	Summit County
<b>2017</b>	Wildfire	Statewide
<b>2017</b>	Wildfire	Moffat County
<b>2017</b>	Snow and Heavy Rains	Jefferson, Boulder, Larimer, Weld Counties
<b>2017</b>	Extreme Weather and Flooding	Bent, Custer, Fremont, Huerfano, Otero, Pueblo Counties
<b>2017</b>	Wildfire	Boulder County
<b>2017</b>	Wildfire	Logan, Phillips Counties

Source: Colorado.gov, 2017

Figure 3-1 portrays Colorado disasters and emergencies declared by the Governors from 1980 to late 2017 by hazard type. The hazard types were consolidated into hazard types consistent with Table 3-1. Note that wildfire have been the cause of a majority of state declarations, nearly three times more than the next highest event type, flooding. Severe winter weather and landslides/etc. are the next most common causes for a state declaration.

FIGURE 3-1 DISASTERS IN COLORADO, 1980 TO 2017 BY HAZARD TYPE



Source: Colorado.gov, 2017

## 2.2 FEDERAL DECLARATIONS

Colorado has received 21 presidential disaster declarations and four emergency declarations for events since 1955 as shown in Table 3-3.

TABLE 3-3 PRESIDENTIAL DISASTER AND EMERGENCY DECLARATIONS, 1955 TO 2017

Year	Disaster Number	Disaster Event Description	Assistance Program	Federal (\$ Millions)
1955	DR-33-CO	Flooding		
1956	DR-59-CO	Flooding		
1965	DR-200-CO	Tornadoes, Severe Storms, Flooding		
1969	DR-261-CO	Severe Storms, Flooding		
1970	DR-293-CO	Heavy Rains, Flooding		
1973	DR-379-CO	Dam Failure		

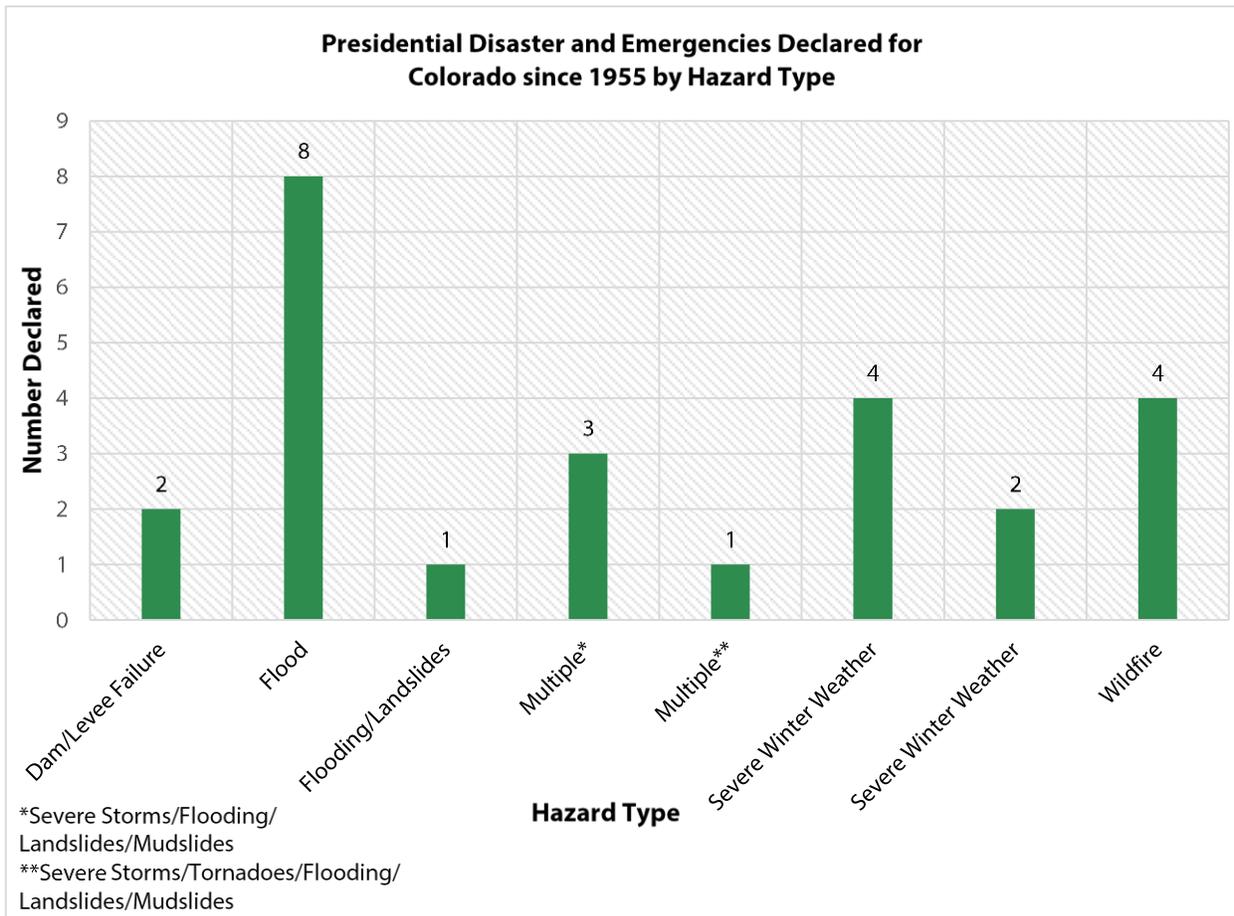
Year	Disaster Number	Disaster Event Description	Assistance Program	Federal (\$ Millions)
1973	DR-385-CO	Heavy Rains, Snowmelt, Flooding		
1973	DR-396-CO	Flooding, Landslides		
1976	DR-517-CO	Severe Storms, Flash Flood		
1982	DR-665-CO	Estes Park Dam Break Flood		
1984	DR-719-CO	Western Slope Flooding		
1997	DR-1186-CO	Flood Disaster in Colorado	Public Assistance Individual Assistance Hazard Mitigation	5.3 2.2 2.0
1999	DR-1276-CO	Severe Storms, Flooding, Landslides and Mudslides	Public Assistance Individual Assistance Hazard Mitigation	4.9 0.7 1.0
2001	DR-1374-CO	Severe Winter Storms	Public Assistance Hazard Mitigation	4.6 0.6
2002	DR-1421-CO	Wildfires	Individual Assistance Hazard Mitigation	Unknown 0.3
2003	EM-3185-CO	Snow Emergency	Public Assistance	6.2
2006	EM-3270-CO	Snow Emergency	Public Assistance	11.0
2006	EM-3271-CO	Snow Emergency		
2008	DR-1762-CO	Severe Storms and Tornadoes	Individual Assistance Hazard Mitigation	1.1 0.18
2012	DR-4067-CO	Wildfires	Public Assistance Hazard Mitigation	5.0 0.82
2013	DR-4133-CO	Wildfires	Public Assistance Hazard Mitigation	173.4 0.02

Year	Disaster Number	Disaster Event Description	Assistance Program	Federal (\$ Millions)
2013	DR-4134-CO	Wildfires	Public Assistance Hazard Mitigation	6.6 1.15
2013	DR-4145-CO	Severe Storms, Flooding, Landslides, and Mudslides	Public Assistance Individual Assistance Hazard Mitigation	345.2 61.9 67.39
2013	EM-3365-CO	Severe Storms, Flooding, Landslides, and Mudslides	Public Assistance Individual Assistance	61.9 345.2
2015	DR-4229-CO	Severe Storms, Tornadoes, Flooding, Landslides, and Mudslides	Public Assistance Hazard Mitigation	20.2 3.30

Source: FEMA, 2017

Figure 3-2 displays presidential disaster and emergencies declared for Colorado since 1955 by hazard type. The hazard types were consolidated into hazard types consistent with Table 3-1. Flooding is the number one cause for Presidential disasters and emergencies declared in Colorado, with twice as many declarations than the second most common hazards, wildfire and severe winter weather.

FIGURE 3-2 PRESIDENTIAL DISASTER AND EMERGENCY DECLARATIONS, 1955 TO 2017 BY HAZARD TYPE



Source: FEMA, 2017

In addition to presidential declarations, Colorado has received 64 fire assistance awards for suppression and management since 1978, as shown in Table 3-4.

TABLE 3-4 FEMA FIRE MANAGEMENT ASSISTANCE, 1978 TO 2017

Year	Fire	Year	Fire
1978	Deer Creek Canyon	2003	Cloudy Pass
1980	Bear Trap	2003	Lincoln Complex
1989	Sunnyside	2003	Overland
1990	Old Stage	2003	Cherokee Ranch
1994	Wake Complex	2003	Buckhorn Creek
1994	South Canyon	2004	Picnic Rock
1994	Roxborough Complex	2004	McGruder
1996	Buffalo Creek	2005	Mason
2000	Bobcat	2006	Mauricio Canyon

<b>Year</b>	<b>Fire</b>	<b>Year</b>	<b>Fire</b>
2000	Hi Meadow	2006	Mato Vega
2000	Eldorado	2006	Red Apple
2001	Armageddon-Carter Lake	2007	Newcastle
2002	Snaking	2008	Ordway
2002	Cuerno Verde	2008	Nash Ranch
2002	Black Mountain	2009	Olde Stage
2002	Schoonover	2010	Fourmile Canyon
2002	Iron Mountain	2010	Reservoir Road
2002	Spring-Trinidad Complex	2011	Indian Gulch
2002	Fisher-Trinidad Complex	2012	Crystal
2002	Ute Pass	2012	Duckett
2002	Coal Seam	2012	Lower North Fork
2002	Hayman	2012	High Park
2002	Dierich Creek	2012	Waldo Canyon
2002	Missionary Ridge	2012	Weber
2002	Valley	2012	Wetmore
2002	Million	2013	Black Forest
2002	Wiley Ridge	2013	Royal Gorge
2002	Grizzly Gulch	2013	West Fork Complex
2002	Again	2013	East Peak
2002	Burn Canyon	2016	Cold Spring
2002	Big Elk	2016	Beulah Hill
2002	Panorama	2016	Junkins

Source: FEMA, 2017

Colorado also regularly receives United States Department of Agriculture (USDA) secretarial disaster declarations. These declarations typically result from hail, windstorms, drought, early freezes, and grasshopper infestations. Table 3-5 shows Secretarial Disasters since 2003, however, years prior produced many additional declarations. Since 2003, Colorado has received a secretarial disaster declaration for drought every year except 2007 and 2016.

TABLE 3-5 USDA SECRETARIAL DISASTERS IN COLORADO, 2003 TO 2017

Year	Type	Declaration Number	Affected Counties
2003	Drought	S1797	Baca, Bent, Elbert, Kiowa, Lincoln, Prowers
2003	Drought, Insects	S1843	Alamosa, Archuleta, Chaffee, Conejos, Costilla, Crowley, Custer, Dolores, Fremont, Garfield, Hinsdale, Huerfano, La Plata, Lake, Las Animas, Mesa, Mineral, Moffat, Montezuma, Otero, Pueblo, Rio Blanco, Rio Grande, Routt, Saguache
2003	Drought	S1890	Cheyenne, Phillips
2004	Drought, Freeze, Hail	S1947	Baca, Chaffee, Cheyenne, Custer, Eagle, Fremont, Garfield, Grand, Jackson, Kiowa, Kit Carson, Lake, Lincoln, Phillips, Pitkin, Prowers, Pueblo, Routt, Summit, Yuma
2004	Drought	S2009	Moffat
2005	Drought	S2031	Huerfano, Las Animas, Rio Blanco
2005	Drought, Freezing Temperatures	S2160	Delta, Kit Carson
2005	Drought, Wind, Heavy Rain, Hail	S2188	Crowley, El Paso, Lincoln, Otero, Park, Phillips, Pueblo, Teller, Washington, Yuma
2005	Drought, Crop Diseases, Insect Infestation	S2217	Logan
2005/6	Drought, Crop Diseases, Insect Infestation	S2287	Huerfano, Kiowa, Las Animas, Sedgwick
2005/6	Drought, Fire, High Winds, Heat	S2327	Adams, Alamosa, Baca, Broomfield, Chaffee, Cheyenne, Conejos, Costilla, Custer, Denver, Dolores, Douglas, Elbert, Fremont, Hinsdale, Huerfano, Kit Carson, Lake, Las Animas, Mineral, Montezuma, Morgan, Prowers, Pueblo, Rio Grande, Saguache, San Miguel, Weld
2006	Heat, High Winds, Insect Pests, Late Freeze, Drought	S2329	Arapahoe, Archuleta, Bent, Boulder, Crowley, Delta, El Paso, Gunnison, Jefferson, Kiowa, La Plata, Montrose, Ouray, Park, Phillips, Teller, Washington
2006	Heat, High Winds, Drought	S2351	Eagle, Garfield, Larimer, Logan, Otero, Pitkin, Rio Blanco, Yuma
2006	Drought	S2382	Jackson, Lincoln, Mesa, Moffat
2006	Drought	S2480	Sedgwick

Year	Type	Declaration Number	Affected Counties
2008	Drought	S2750	Adams, Arapahoe, Baca, Bent, Cheyenne, Crowley, Douglas, El Paso, Elbert, Huerfano, Kiowa, Kit Carson, Las Animas, Lincoln, Logan, Otero, Park, Prowers, Pueblo, Teller, Washington, Weld
2008	Drought	S2802	Fremont
2009	Drought	S2970	Dolores, Mesa, Montezuma, Montrose, San Miguel
2010	Drought	S2987	Yuma, Fremont, Otero, Montrose, Mesa, Dolores, Montezuma, San Miguel
2011	Drought	S3113	Bent, El Paso, Kiowa, Las Animas, Lincoln, Prowers, Pueblo
2012	Drought	S3229	Arapahoe, Cheyenne, Crowley, Elbert, El Paso, Kiowa, Kit Carson, Lincoln, Pueblo, Washington
2012	Drought, Excessive Heat, High Winds	S3260	Statewide
2012	Drought	S3267, S3269, S3276, S3281, S3282, S3284, S3289, S3290, S3315, S3319, S3347	Statewide
2012	Freezing Conditions	S3307	Delta, Garfield, Gunnison, Mesa, Montrose, Ouray, Pitkin, San Miguel
2013	Drought	S3455, S3456, S3459, S3461, S3463, S3466	Statewide
2013	Drought	S3505, S3508, S3518, S3539	Statewide
2013	Drought	S3545	Archuleta, Conejos, Hinsdale, La Plata, Mineral, Rio Grande, Saguache
2013	Drought	S3548	Adams, Alamosa, Arapahoe, Archuleta, Boulder, Broomfield, Chaffee, Clear Creek, Conejos, Costilla, Custer, Delta, Denver, Douglas, Eagle, Fremont, Garfield, Gilpin, Grand, Gunnison, Hinsdale, Huerfano, Jackson, Jefferson, Larimer, Mesa, Mineral, Moffat, Montrose, Ouray, Park, Pitkin, Rio Blanco, Rio Grande, Routt, Saguache, San Miguel, Teller
2013	Drought	S3550	Moffat
2013	Freeze	S3573	Baca, Prowers
2013	Drought	S3575	Eagle, Garfield, Grand, Lake, Pitkin, Routt, Summit

Year	Type	Declaration Number	Affected Counties
2013	Frost, Freezes	S3583	Delta, Garfield, Gunnison, Mesa, Montrose, Ouray, Pitkin, San Miguel
2013	Drought	S3641	Baca, Cheyenne, Kiowa, Kit Carson, Prowers, Yuma
2014	Drought	S3627	Arapahoe, Baca, Bent, Cheyenne, Costilla, Crowley, Custer, Douglas, Elbert, El Paso, Fremont, Huerfano, Kiowa, Kit Carson, Las Animas, Lincoln, Logan, Otero, Phillips, Prowers, Pueblo, Sedgwick, Teller, Washington, Yuma
2014	Drought	S3629	Baca, Cheyenne, Kiowa, Kit Carson, Prowers, Yuma
2014	Drought	S3630	Baca, Costilla, Las Animas
2014	Drought	S3632	Baca
2014	Drought	S3634	Dolores, Mesa, Montezuma, Montrose, San Miguel
2014	Drought	S3645	Archuleta, Conejos, Costilla
2014	Drought	S3651	Montezuma
2014	Drought	S3653	Archuleta, La Plata, Montezuma
2014	Drought	S3669	Phillips, Sedgwick, Yuma
2014	Drought	S3698	Yuma
2014	Drought	S3703	Sedgwick
2014	Drought	S3714	Garfield, Moffat, Rio Blanco
2014	Drought	S3715	Archuleta, Conejos, Dolores, Hinsdale, La Plata, Mineral, Montezuma, Rio Grande, San Juan, San Miguel
2014	Excessive Rain, High Winds, and Hail	S3733	Kit Carson, Yuma
2014	Freeze	S3760	Delta, Garfield, Gunnison, Mesa, Montrose, Ouray, Pitkin, San Miguel
2014	Hail	S3764	Bent, Crowley, Kiowa, Las Animas, Otero, Pueblo
2015	Drought	S3783	Montezuma
2015	Drought	S3785	Arapahoe, Baca, Bent, Cheyenne, Costilla, Crowley, Elbert, El Paso, Huerfano, Kiowa, Kit Carson, Las Animas, Lincoln, Otero, Prowers, Pueblo, Washington
2015	Drought	S3787	Baca, Cheyenne, Kiowa, Kit Carson, Prowers, Yuma
2015	Drought	S3788	Archuleta, Baca, Costilla, La Plata, Las Animas, Montezuma

Year	Type	Declaration Number	Affected Counties
2015	Drought	S3790	Baca
2015	Drought	S3792	Dolores, Mesa, Montezuma, Montrose, San Miguel
2015	Drought	S3802	Archuleta, Conejos
2015	Drought	S3826	Garfield, Moffat, Rio Blanco
2015	Severe Freeze	S3925	Delta, Gunnison, Mesa, Montrose
2016	Hail	S4087	Weld, Larimer
2017	Drought	S4145	Adams, Boulder, Broomfield, Weld, Arapahoe, Baca, Bent, Cheyenne, Crowley, Douglas, Elbert, El Paso, Kiowa, Kit Carson, Larimer, Las Animas, Lincoln, Logan, Morgan, Prowers, Pueblo, Washington
2017	Drought	S4148	Baca, Prowers
2017	Drought	S4152	Baca
2017	High Winds, Hail, Excessive Rain, and Flash Flooding	S4208	Kit Carson
2017	Freeze	S4249	Delta, Gunnison, Mesa, Montrose
2017	Hail	S4250	Bent, Crowley, Kiowa, Las Animas, Otero, Pueblo
2017	Hail Storms and Hard Rain	S4251	Dolores, La Plata, Montezuma, Montrose, Ouray, San Juan, San Miguel

Source: USDA Farm Service Agency, 2017

### 2.3 INSURED LOSSES

Current insurance industry standards classify a catastrophe as a natural disaster that causes at least \$25 million in insured damage. Colorado has experienced at least 23 such catastrophes since 1984, the majority representing significant hailstorm events as shown in Table 3-6. The costliest insured catastrophe in Colorado history is the recent hailstorm that hit the Front Range in May 2017 and caused \$2.3 billion in damages.

TABLE 3-6 COLORADO DISASTERS WITH HIGH INSURED DOLLAR LOSSES, 1984-2017

Year	Natural Hazard	Insured Loss (\$ Millions)	
		At Time of Loss	2015 Dollars*
1984	Hail	276.7	633.3
1990	Tornado (Limon)	20.0	36.4
1990	Hail	625.0	1.11 Billion
1991	Hail	100.0	174.6
1994	Hail	225.0	361.0

Year	Natural Hazard	Insured Loss (\$ Millions)	
		At Time of Loss	2015 Dollars*
1996	Hail	122.0	184.9
1997	Hail	128.0	189.6
1998	Hail	87.8	128.1
2002	Wildfires	70.3	92.9
2003	Winter Storm	93.3	120.5
2004	Hail	146.5	184.4
2004	Hail	62.2	78.2
2008	Tornadoes/Hail	193.5	213.7
2009	Tornadoes/Hail (Denver Metro)	353.3	391.6
2009	Hail/Wind (Denver Metro)	767.6	850.8
2009	Hail (Pueblo)	232.8	258.1
2010	Wildfire	217.0	236.6
2011	Hail	164.8	174.2
2012	Hail	321.1	330.3
2012	Wildfire	113.7	117.7
2012	Wildfire – Colorado Springs	453.7	470.0
2013	Wildfire – Black Forest Fire	420.5	429.3
2013	Flood	71.7	72.9
2014	Hail	213.3	214.8
2016	Hail – Colorado Springs	352.8	352.8**
2017	Hail – Denver Metro	2.3 Billion	NA

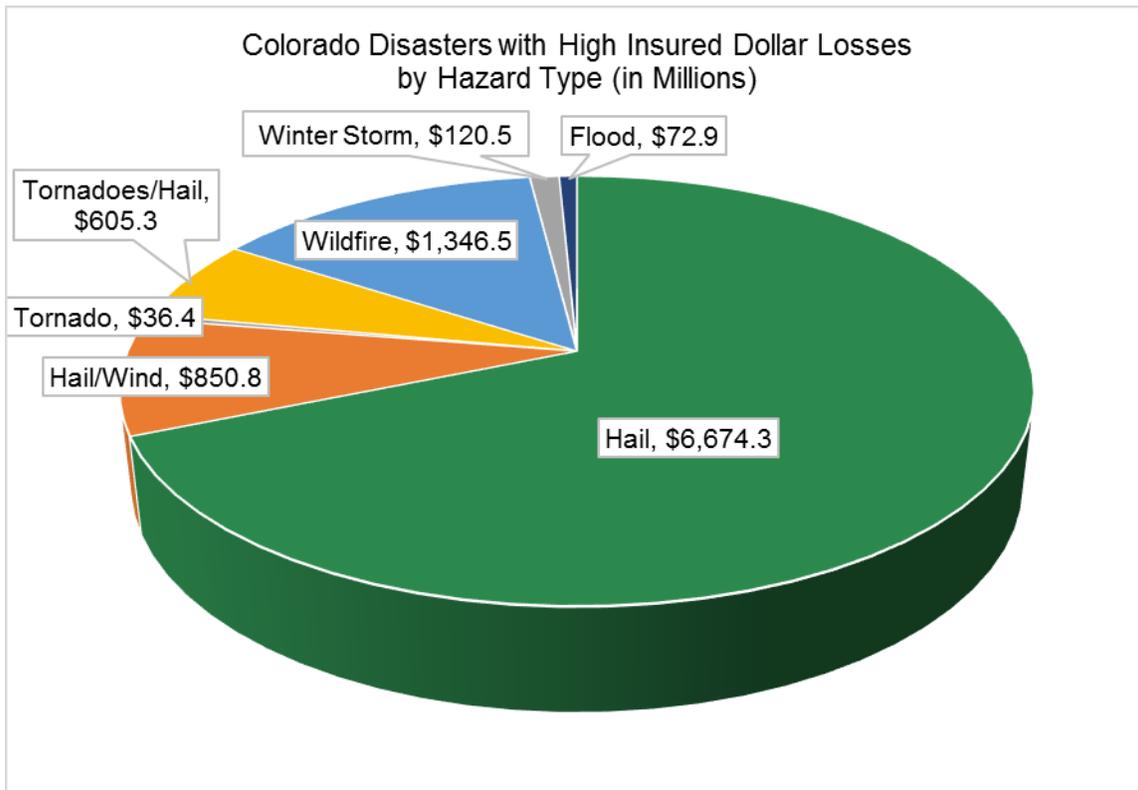
\*2015 estimated costs calculated by the Insurance Institute according to the consumer price index

\*\*Denotes 2016 dollars

Source: Rocky Mountain Insurance Information Association (RMIIA), 2017

Figure 3-3 displays Colorado disasters with high insured dollar losses by hazard type, in millions of dollars. Hail is the number one disaster with high insured dollar losses, with a total of over six billion dollars in losses from 1984-2017. This is approximately five times higher than wildfire, which is the disaster with the second highest insured dollar losses at over one billion in losses from 1984-2017.

**FIGURE 3-3 COLORADO DISASTERS WITH HIGH INSURED DOLLAR LOSSES BY HAZARD TYPE, 1984-2017**



Source: RMIA, 2017

Other costly disasters in Colorado include wildfires, winter storms, floods, and tornadoes. Prior to 2010, the 2002 wildfire season in Colorado was the most expensive in state history. The overall estimated cost of the Iron Mountain, Coal Seam, Missionary Ridge, and Hayman Fires in Colorado is \$70.3 million in insured losses. Companies received 1,236 customer claims for the Hayman and Missionary Ridge Fires at a cost of around \$56.4 million. The Fourmile Canyon Fire in September 2010 then became the costliest fire in Colorado with over \$217 million in insured losses. Colorado’s most costly wildfire disaster in state history, the Waldo Canyon Wildfire of 2012, caused \$453.7 million of insured losses. The 2013 Black Forest Fire nearly matched that figure, causing \$420.5 million dollars of insured losses.

Additional events considered as catastrophes from an insurance industry perspective include the most expensive winter storm from snow and ice damage in Colorado history with the blizzard in March 2003. The estimated price tag from this storm was nearly \$93.3 million, with more than 28,000 claims filed. Also, in June of 1990, a tornado touched down in Limon, Colorado causing an estimated \$20 million in insured damages. The 2013 flood also resulted in insured losses of \$71.7 million.

### 3. HAZARDS IDENTIFIED IN LOCAL PLANS

Sixty-nine local hazard mitigation plans were reviewed for hazards profiled and they remain consistent with the natural hazards profiled by the 2018 State Plan. Table 3-7 displays hazards identified in local plans.

TABLE 3-7 HAZARDS IDENTIFIED IN LOCAL PLANS

<b>Atmospheric Hazards</b>	Drought
	Extreme Temperatures
	Flood
	Hailstorm
	Lightning
	Precipitation
	Thunderstorm
	Tornado
	Windstorm
	Winter Weather
	Wildfire
<b>Geologic Hazards</b>	Avalanche
	Earthquake
	Erosion/Deposition
	Expansive Soils
	Landslide, Mud/Debris Flow
	Subsidence/Sinkholes
	Volcano
<b>Other Natural Hazards</b>	Agricultural Infestation
	Public Health
	Space related hazards
	Zoological
<b>Human-Caused Hazards</b>	Civil Disobedience
	Dam/Levee Failure
	Fire
	Hazardous Materials
	Terrorism
	Vehicle Wildlife Collision

## 4. HAZARD PROFILES

Hazards are grouped into the following types and sub-types for the purpose of developing profiles:

Natural Hazards	
<b>Atmospheric Hazards</b>	Dense Fog
	Drought
	Extreme Heat
	Flood
	Hail
	Severe Wind
	Thunderstorms and Lightning
	Tornado
	Wildfire
	Severe Winter Weather
<b>Geologic Hazards</b>	Avalanche
	Earthquake
	Erosion and Deposition
	Expansive Soils and Heaving Bedrock
	Landslide/Mud/Debris Flows/Rock Fall/Rockslide
	Radon/Carbon Monoxide/Methane/Other Seeps
	Sinkholes/Subsidence
<b>Biological Hazards</b>	Animal Disease Outbreak
	Pandemic
<b>Other Natural Hazards</b>	Wildlife Vehicle Collisions
	Pest Infestation (Emerald Ash Borer, Grasshopper, etc.)
Other Hazards	
<b>Technological Hazards</b>	Critical Infrastructure Disruption/Failure
	Dam/Levee Failure
	Hazardous Materials Release
	Mine Accident
	Power Failure
	Radiological Release
	Telecommunications Failure
<b>Human-Caused Hazards</b>	Chemical, Biological, Radiological, and Nuclear (CBRN) Attacks
	Cyber Attack
	Explosive Attack

This grouping allows for a more logical and cohesive approach toward analysis and understanding than if the hazards were presented in alphabetical order.

Primary areas of consideration within hazard profiles in this Plan are listed below in Table 3-8 and described in more detail following the table. The 2018 State Plan update includes

improvements to consolidate information on state assets and a new sub-section focused on expected future climate change and its relationship and impact to hazards.

**TABLE 3-8 PRIMARY AREAS OF CONSIDERATION WITHIN HAZARD PROFILES**

2018 Profile Sections	2013 Profile Sections
<ul style="list-style-type: none"> <li>• Definition</li> <li>• Hazard Profile Summary</li> <li>• Location</li> <li>• Extent (Magnitude/Severity)</li> <li>• Probability</li> <li>• Previous Occurrences</li> <li>• Impact Analysis</li> <li>• Vulnerability and Potential Losses by Jurisdiction</li> <li>• Future Development</li> <li>• Climate Change</li> <li>• Risk to State Assets</li> <li>• Resources</li> </ul>	<ul style="list-style-type: none"> <li>• Definition</li> <li>• Hazard Profile Summary</li> <li>• Location</li> <li>• Extent (Magnitude/Severity)</li> <li>• Probability</li> <li>• Previous Occurrences</li> <li>• Vulnerability and Potential Losses by Jurisdiction</li> <li>• Future Development</li> <li>• Resources</li> </ul>

#### 4.1 DEFINITION

General definitions and characteristics of hazards are included in the HIRA to provide a common understanding as to what the event is and why it is of enough concern to make it a hazard in Colorado. These definitions and characteristics were reviewed and updated or enhanced for some hazards.

#### 4.2 HAZARD PROFILE SUMMARY

For each hazard, a rollup of the analysis is provided for reference and to use as a tool for determining which hazards may have precedence when it comes to allocating statewide mitigation resources. This hazard analysis summary provides an impact and associated description for geographic location, previous occurrences, future probability, and magnitude and severity. The criteria for each of these impact designations are provided in Table 3-9.

**TABLE 3-9 HAZARD ANALYSIS SUMMARY CATEGORY DESCRIPTIONS**

Location	
<b>Statewide</b>	Occurring across the state and largely indiscriminate of geologic or environmental considerations.
<b>Regional</b>	Occurring predominately in sub-areas of the state based on location and associated exposure to atmospheric, geologic, or other environmental conditions.
<b>Local</b>	Occurring within an impact confined to a small or geographically isolated area or relating to, or characteristic of a particular place.
Previous Occurrences	
<b>Perennial</b>	Active throughout the year on multiple occasions or lasting indefinitely.

<b>Seasonal</b>	Occurring at specific times of the year or dependent on a particular season and associated atmospheric conditions.
<b>Sporadic</b>	Occurring at irregular intervals; having no pattern or order in time; appearing singly or at widely scattered localities; dependent on aggravating or cascading circumstances.
<b>Probability</b>	
<b>Expected</b>	Annual event or assumed to occur at least once per year.
<b>Likely</b>	Occurs in the range of about once every 10 years.
<b>Occasional</b>	Occurs only every 11 to 100 years. Considered an “once in a lifetime” event.
<b>Unlikely</b>	Occurs greater than every 100 years.
<b>Extent (Magnitude/Severity)</b>	
<b>Catastrophic</b>	Mass fatality and casualty; significant population displacement or other quality of life impacts; damage to property, facilities, infrastructure resulting in loss of use or accessibility; service disruption; need for outside resources.
<b>Extensive</b>	Isolated deaths and injuries; quality of life impacts; major or long-term impact to property, facilities, infrastructure, or critical services.
<b>Moderate</b>	Minimal death or injury; limited quality of life impacts; minor or short-term impact on property, facilities, infrastructure, or critical services.
<b>Minimal</b>	No deaths and few injuries; minor quality of life impacts; little or no impact on property, facilities, infrastructure, or critical services.

### 4.3 LOCATION

Hazards occurring in Colorado range from statewide to regional with some specifically associated with the geologic attributes of a localized area. The geographic extent for each hazard is presented in text and supported by tables or maps where available and appropriate. In many cases, the statewide geographic extent of hazards has been refined in this Plan update.

### 4.4 EXTENT (MAGNITUDE/SEVERITY)

Assessment of severity is expressed in terms of consequence of impacts such as injuries and fatalities; damage to personal property, infrastructure, state or local critical assets, and the environment; negative effects on the economy; and the degree and extent with which the hazard affects the ability to provide essential services. Magnitude and severity is further considered in the vulnerability assessment and consequence analysis.

### 4.5 PROBABILITY

The likelihood of a hazard occurring again looks toward past frequency to assist in determining the probability of future occurrence. For some hazards, the future probability of events is further supported by assumptions that favorable environmental conditions resulting in a hazard event will continue to develop or persist.

#### **4.6 PREVIOUS OCCURRENCES**

Every county in the state has experienced the adverse effects of hazards. Descriptions of previous occurrences, or known hazard incidents, are included to help frame the extent of the hazard's impact on areas of Colorado. In some cases, detailed accounts are provided for significant historic hazard events. Occurrences for every hazard were reviewed and updated from the 2013 Plan. Detailed historic events and associated deaths, injuries, and total damage by county are included for some hazards.

#### **4.7 IMPACT ANALYSIS**

The "Impact Analysis" sections include a summary table of potential overall consequences of each hazard based on the Impact Analysis of Potential for Detrimental Impacts of Hazards finalized for the Emergency Management Accreditation Program (EMAP).

#### **4.8 VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION**

Specific characteristics of local jurisdictions may make them more susceptible to damage from a given hazard. It is important to understand the hazards that most impact a jurisdiction and understand what is vulnerable (people, property, economy, environment, critical infrastructure, etc.) and to what degree the losses will be if the vulnerable are impacted.

#### **4.9 FUTURE DEVELOPMENT**

An effective way to reduce future losses in a community is to avoid development in known hazard areas and to enforce the development of safe structures in other areas. In other words, keep people, businesses, and buildings out of harm's way from the beginning. This sub-section provides a general description of the connectivity between local risk and future expected development where mitigation options can be considered in future land use decisions to ensure safe development.

#### **4.10 CLIMATE CHANGE**

It is now required that states evaluate changes to climate conditions that may affect and influence their long-term vulnerability to natural hazards. These changes to climate conditions may be described as "climate change" or "future conditions" throughout this Plan. The impact of climate change on location, extent, intensity, frequency, and duration is analyzed for each climate-related natural hazard. The following definitions are used to describe each potential impact:

- **Location** is the geographic areas that are affected by the hazard, such as a floodplain.
- **Extent** is the strength or magnitude of the hazard, such as water depth.
- **Intensity** is a measurable amount of impact, such as wind force.
- **Frequency** is the rate at which the hazard occurs or is repeated over a particular period of time, such as yearly.
- **Duration** is the amount of time a single hazard event lasts, such as a 30-minute rainfall event.

#### **4.11 RISK TO STATE ASSETS**

An evaluation of a hazard's impacts specifically to state assets is an important output from this planning process. The intent is that these results will serve as a vital input into the state's mitigation strategy and integrated planning efforts, and will help to identify potential actions and projects that the state can consider implementing to reduce its vulnerabilities. This content was previously included in its own section of the 2013 Plan. For the 2018 Plan, a state asset is defined as a state-owned property (buildings, vehicles, etc.) belonging to the three branches of Colorado State Government (Legislative, Judicial, and Executive) that has been defined by the Colorado Office of Risk Management (ORM). Information such as the number of state assets, state agency that owns the asset, and total value of the asset is available.

It is important to note that this definition of state assets does not include the risk to the community, or may not include all historic, cultural, or natural environment assets. It is difficult to quantify the associated social impacts with hazards, but factors that contribute to Colorado's social vulnerability are discussed in Section Two of this Plan. People are at risk to hazards throughout the entire State of Colorado, and a disaster can cause cascading impacts to the community. For example, in addition to casualties, a disaster can result in business and economic disruption, longer commute times due to reroutes, and secondary hazards such as increased risk for flooding after a wildfire. Additionally, disruption to critical facilities such as hospitals can severely impact people who require continuous medication or long-term health care. Although these risks are not quantified, they are an important aspect in the state's mitigation strategy and planning efforts.

History Colorado's Office of Archaeology and Historic Preservation (OAHP) maintains a database of historic and archaeological properties recorded throughout the State and is responsible for coordinating compliance with Federal law under the National Historic Preservation Act of 1966 for organizations and various agencies that receive Federal funding. Also for all archaeological and paleontological resources recorded on State, County, City or local lands, the State of Colorado holds title to both the sites (deposits) and any collections from those known locations; the Office of the State Archaeologist, a division of OAHP, has responsibilities to coordinate and consider their care with other parties.

#### **4.12 RESOURCES**

All resources utilized in each hazard profile are documented. This assists in both clarifying data sources but in also showing integration across other state plans and resources.

# DENSE FOG



## 1. DEFINITION

Fog is cloud made of water droplets at or near the Earth’s surface. It is formed when the difference between air temperature and the dew point, the temperature to which air must be cooled in order to become saturated with water, is less than 4°F.

When fog forms in populated areas, it can greatly reduce or restrict the line of sight, making driving and aviation extremely dangerous. Each year, fog is responsible for numerous transportation accidents. Though typically minor, accidents can result in serious injuries, and even death. Table 3-10 describes the hazard impact summary for dense fog.

TABLE 3-10 HAZARD IMPACT SUMMARY

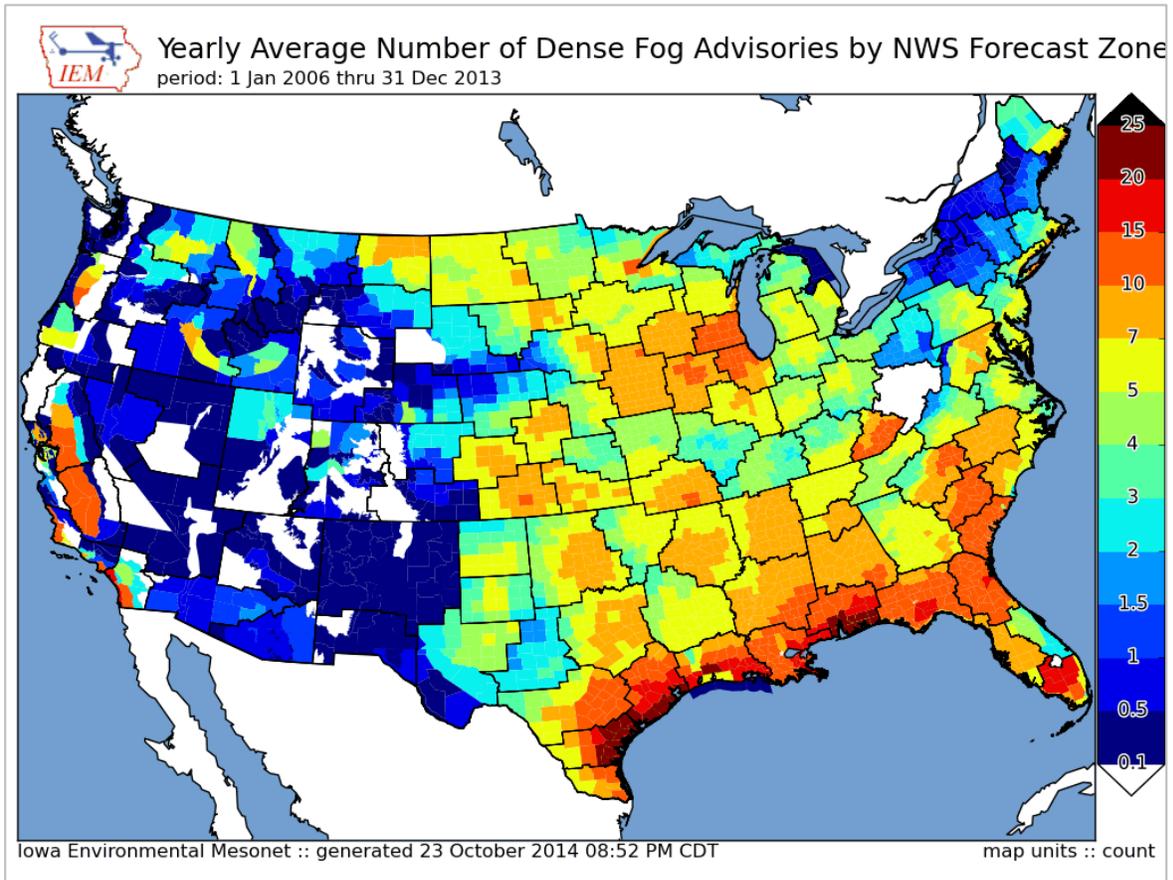
Consideration	Impact	Description
<b>Location</b>	Local / Regional	Dense fog is typically limited to mountain valleys, bodies of water, and low-lying areas.
<b>Previous Occurrence</b>	Seasonal	The late fall and winter months are the primary season for when dense fog events occur. While most of the events happen from November through February, Dense Fog can occur at any time of year.
<b>Probability</b>	Expected	Atmospheric conditions that produce major fog events are expected to occur in the future with the same frequency as they have in the past.
<b>Extent</b>	Moderate	Dense fog can badly hinder the line of sight when driving. This can have major repercussions for vehicular traffic, air traffic, and first responders.

## 2. LOCATION

Fog typically forms in low-lying areas and valleys. Oftentimes this will occur at night as the cool air from the mountains will descend rapidly due to being thinner and drier at high altitudes. If moisture is present within the valley below, this cool, sinking air can cause the condensation of water vapor and create fog. Figure 3-4 shows the yearly average number of dense fog advisories issued by the National Weather Service (NWS). Colorado as a whole sits on the low end of the scale, with the Eastern Plains experiencing the maximum for the state at between five to seven days annually.

Figure 3-5 shows a Dense Fog Advisory that occurred for the Grand Junction area on January 19<sup>th</sup>, 2016. This map effectively shows how fog affects areas between mountains. Note that the fog advisory area contours with river corridors and the changes in elevation.

FIGURE 3-4 YEAR AVERAGE DENSE FOG ADVISORIES, 2006 TO 2013



Source: Iowa Environmental Mesonet

FIGURE 3-5 DENSE FOG ADVISORY FOR GRAND JUNCTION AREA, JANUARY 2016



Source: Denver Post

### 3. EXTENT (MAGNITUDE/STRENGTH)

The National Weather Service provides resources and descriptions for six different types of fogs that can form within the United States (Table 3-11). All of these, except for Fog Over Water, can be an issue within Colorado, as the state is landlocked, and does not have bodies of water (oceans, great lakes) with sufficient enough size for this hazard to form.

TABLE 3-11 FOG TYPES AND DESCRIPTIONS

Type of Fog	Description
<b>Advection Fog</b>	Forms when moist air passes over a cooled surface by wind. The air is cooled from the ground below. Unlike Radiation Fog, it can form in windy conditions.
<b>Freezing Fog</b>	Fog that is supercooled. Freezing fog can freeze instantly to surfaces when temperatures are at or below freezing. This may include tree branches, roads, stairways, sidewalks, and vehicles. The ice that forms can be extremely hazardous. Aircraft may be affected, as well, and may require de-ice treatment before takeoff.
<b>Mountain / Valley Fog</b>	Overnight, the ground cools as the heat that was gathered during the day is released back into the air. Denser, cooler air on top of mountains sinks into the valley, filling it. This cooler air is much closer to the dew point, and becomes saturated.
<b>Radiation Fog</b>	This fog forms overnight as the air near the ground cools and stabilizes. The fog first forms near the surface, and thickens upward as higher layers of air cool. Thicker instances most commonly form in valleys and over stable bodies of water. Tends to dissipate under the sun.
<b>Super Fog</b>	Forms when a mixture of smoke and moisture is released from smoldering organic material and combines with cooler, nearly-saturated air. Visibilities can be lowered to less than 10 feet.

Source: NOAA

In the event that dense fog forms, the National Weather Service will issue a Dense Fog Advisory, or a Freezing Fog Advisory if temperatures are at or below freezing. Advisories, unlike watches and warnings, are for when there is an event in progress. There are not currently watches or warnings for fog events. Dense Fog Advisories are broadcast on local radio and television channels, alerting the public to the threat.

## DENSE FOG ADVISORY

*Issued by your local National Weather Service office when widespread dense fog develops. When this happens, visibilities frequently drop to one-quarter of a mile or less. These conditions make travel difficult. Take extra caution when on the road or avoid driving if possible.*

## FREEZING FOG ADVISORY

*Issued by your local National Weather Service office when fog develops and surface temperatures are at or below freezing. The tiny liquid droplets in the fog can freeze instantly to any surface, including vehicles and road surfaces. Freezing fog makes driving, boating, flying and other forms of transportation particularly hazardous. Visibilities are typically at or below one mile.*

## 4. PROBABILITY

Most years since 1996 have had at least one reported fog event within the state, with the exceptions being 1999, 2000, 2001, 2007, and 2011. The year with the lowest number of events was 2012. The highest number in any one year was in 2015 with 50 events. On average, there have been just over 11 dense fog events per year. Table 3-12 shows years with dense fog events in Colorado since 1996.

TABLE 3-12 YEARS WITH FOG EVENTS

Year	Number of Events
1996	3
1997	7
1998	7
2002	8
2003	14
2004	22
2005	3
2006	3
2008	4
2009	11
2010	26
2012	1
2013	24
2014	4
2015	50
2016	20
2017	31
<b>Total</b>	<b>238</b>

## 5. PREVIOUS OCCURRENCES

According to the National Centers for Environmental Information (NCEI), there have only been three instances where dense fog has been the cause of severe injury or death. This database, however, does not fully take into account traffic accidents that are the result of fog. There have likely been other incidents of fog that have resulted in injuries or deaths. Those that are known to have caused injuries or death are described in Table 3-13.

TABLE 3-13 DENSE FOG EVENTS CAUSING INJURY OR DEATH

Date	Description of Event
<b>December 17, 1996</b>	Dense fog along the Colorado River Basin from De Beque Canyon to New Castle resulted in several collisions which closed I-70 in both directions for three hours. The visibility in some areas was reduced to 10 feet. Only minor injuries were reported.
<b>June 26, 1997</b>	A woman was killed when she pulled in front of an oncoming tractor trailer just northwest of Berthoud. Dense fog had reduced visibility to less than 100 yards at the time of the accident.
<b>August 24, 2008</b>	Extremely dense fog was cited as playing a major role in the fatal crash of a single engine, fixed wing Piper aircraft, resulting in three fatalities. The crash occurred about a quarter mile from the Yuma airport.

Source: NOAA

## 6. IMPACT ANALYSIS

Dense fog has affected most of Colorado. Though fog itself is fairly innocuous in most conditions, it is the difficulties that arise from limited visibilities that result in deaths, injuries, or property damage. To date, there have been four deaths and five injuries, all a result of transportation incidents. There has been a total of \$350,000 in property damage, with no crop damage reported. Table 3-14 shows number of dense fog events, deaths, injuries, property damage, and crop damage by counties and zones from 1996 to 2017. Table 3-15 describes the impact summary for dense fog.

TABLE 3-14 COUNTIES AND ZONES WITH DENSE FOG EVENTS, 1996 TO 2017

County / Zone	# of Events	Deaths	Injuries	Property Damage	Crop Damage
Animas River Basin	21	-	-	\$ -	\$ -
Central and South Weld County	1	-	-	\$ -	\$ -
Central Colorado River Basin	8	-	-	\$ -	\$ -
Central Gunnison And Uncompahgre River Basin	13	-	-	\$ -	\$ -
Central Yampa River Basin	33	-	-	\$ -	\$ -
Crowley And Otero Counties/La Junta and Vicinity	1	-	-	\$ -	\$ -
De Beque To Silt Corridor	14	-	5	\$ 150,000	\$ -
Eastern Larimer And Northwestern Weld Counties/ Fort Collins And Vicinity / E Larimer / NW Weld	2	1	-	\$ -	\$ -
Four Corners/ Upper Dolores River Basin	8	-	-	\$ -	\$ -
Gore and Elk Mountains/Central Mountain Valleys	1	-	-	\$ -	\$ -
Grand Valley	60	-	-	\$ -	\$ -
Larimer County Below 6000 Feet / NW Weld County	1	-	-	\$ -	\$ -
Lower Yampa River Basin	14	-	-	\$ -	\$ -
Morgan County	1	-	-	\$ -	\$ -
Northern El Paso County/Monument Ridge	4	-	-	\$ -	\$ -
Northern Sangre De Cristo Mountains Between 8500 & 11000 Feet	1	-	-	\$ -	\$ -
Northwestern San Juan Mountains	1	-	-	\$ -	\$ -
Paradox Valley / Lower Dolores River Basin	8	-	-	\$ -	\$ -
Roan and Tavaputs Plateaus	1	-	-	\$ -	\$ -
San Juan River Basin	10	-	-	\$ -	\$ -
Southern El Paso County/Colorado Springs and Vicinity	4	-	-	\$ -	\$ -
Southern San Luis Valley	1	-	-	\$ -	\$ -
Southwestern San Juan Mountains	1	-	-	\$ -	\$ -
Upper Gunnison River Valley	14	-	-	\$ -	\$ -
Upper Yampa River Basin	14	-	-	\$ -	\$ -
Yuma County	1	3	-	\$ 200,000	\$ -

County / Zone	# of Events	Deaths	Injuries	Property Damage	Crop Damage
<b>Grand Total</b>	<b>238</b>	<b>4</b>	<b>5</b>	<b>\$ 350,000</b>	<b>\$ 0</b>

Source: NOAA

TABLE 3-15 DENSE FOG EMAP IMPACT SUMMARY

Consideration	Description
<b>General Public</b>	The general public can be severely impacted by dense fog, typically when they have to drive. Many people may not know how to adequately drive in foggy conditions, which can lead to transportation accidents.
<b>First Responders</b>	First responders can be negatively impacted by dense fog, as it necessitates slower driving speeds. Emergency vehicles are not able to respond as quickly as they can in daylight or otherwise clear conditions. In many emergencies, seconds and minutes count, so fog could potentially be responsible for increased injuries or deaths.
<b>Property</b>	Property is not likely to be affected by dense fog directly.
<b>Facilities and Infrastructure</b>	Facilities and infrastructure are not likely to be affected directly by fog. However, freezing fog may lead to power line damages, causing power outages.
<b>Economic</b>	Fog can delay workers getting to their jobs in the early morning. This can result in lost work hours.
<b>Environment</b>	There is not likely to be any adverse effects from dense fog. Freezing fog may result in downed small tree branches.
<b>Continuity of Government and Services</b>	Government business can be significantly delayed due to heavy fog. Employees may need to work remotely if hazardous conditions warrant.
<b>Confidence in Government</b>	The public has high expectations that government will continue to function. First responders and police are expected to perform duties regardless of weather conditions.
<b>Critical Assets</b>	Schools within the affected area may have their days delayed or cancelled due to heavy fog. State workers may miss significant portions of their day if they cannot get to work.

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

One of the largest risks that fog poses is the lack of visibility to drivers. The Colorado Department of Transportation (CDOT) tracks weather-related crashes. Since 2005, there have been 3,393 crashes as a result of dense fog conditions. A year-by-year breakdown can be found in Table 3-16. It is not known how many of these resulted in injuries or fatalities, as

recorded by CDOT. A separate 2014 study by the American Automobile Association found that, between 1990 and 2012, there had been 86 fatal accidents relating to fog in Colorado. Of the 12,064 fatal accidents in this timeframe, fog was responsible for 0.71 percent of all within the state.

**TABLE 3-16 TRANSPORTATION CRASHES DUE TO FOG**

<b>Year</b>	<b>Number of Crashes</b>
<b>2005</b>	459
<b>2006</b>	275
<b>2007</b>	449
<b>2008</b>	232
<b>2009</b>	346
<b>2010</b>	305
<b>2011</b>	266
<b>2012</b>	171
<b>2013</b>	277
<b>2014</b>	268
<b>2015</b>	345
<b>Total</b>	<b>3,393</b>

Source: CDOT

The National Weather Service provides suggested tips for ensuring safe driving during fog events if the need arises (NWS, Driving in Fog). These suggestions include:

- Slow down and allow extra time to reach your destination.
- Make your vehicle visible to others both ahead of you and behind you by using your low-beam headlights since this means your taillights will also be on. Use fog lights if you have them.
- Never use your high-beam lights. Using high beam lights causes glare, making it more difficult for you to see what’s ahead of you on the road.
- Leave plenty of distance between you and the vehicle in front of you to account for sudden stops or changes in the traffic pattern.
- To ensure you are staying in the proper lane, follow the lines on the road with your eyes.
- In extremely dense fog where visibility is near zero, the best course of action is to first turn on your hazard lights, then simply pull into a safe location such as a parking lot of a local business and stop.
- If there is no parking lot or driveway to pull into, pull your vehicle off to the side of the road as far as possible. Once you come to a stop, turn off all lights except your hazard

flashing lights, set the emergency brake, and take your foot off of the brake pedal to be sure the tail lights are not illuminated so that other drivers don't mistakenly run into you.

A review of all local hazard mitigation plans in the State of Colorado found that dense fog has not been profiled by any jurisdiction.

Table 3-17 shows the number of events, injuries, and deaths per county. Because forecast zones span multiple counties, some events are duplicated per county. This is noteworthy particularly where deaths and injuries are concerned, as it is not known in which county they took place.

The county that has experienced the most events is Garfield County with 98, followed closely by Mesa County at 96. The next closest are Rio Blanco with 48, and Moffat and Routt, both with 47. These areas all have extremely diverse geographies, which leads them to being part of numerous NWS forecasting zones.

**TABLE 3-17 DENSE FOG EVENTS BY COUNTY, 1996-2017**

<b>County</b>	<b>Total Events</b>	<b>Deaths</b>	<b>Injuries</b>
<b>Adams</b>	-	-	-
<b>Alamosa</b>	1	-	-
<b>Arapahoe</b>	-	-	-
<b>Archuleta</b>	11	-	-
<b>Baca</b>	-	-	-
<b>Bent</b>	-	-	-
<b>Boulder</b>	-	-	-
<b>Broomfield</b>	-	-	-
<b>Chaffee</b>	1	-	-
<b>Cheyenne</b>	-	-	-
<b>Clear Creek</b>	-	-	-
<b>Conejos</b>	-	-	-
<b>Costilla</b>	2	-	-
<b>Crowley</b>	1	-	-
<b>Custer</b>	1	-	-
<b>Delta</b>	13	-	-
<b>Denver</b>	-	-	-
<b>Dolores</b>	17	-	-
<b>Douglas</b>	-	-	-
<b>Eagle</b>	9	-	-
<b>El Paso</b>	8	-	-
<b>Elbert</b>	-	-	-
<b>Fremont</b>	1	-	-
<b>Garfield</b>	98	-	5
<b>Gilpin</b>	-	-	-

County	Total Events	Deaths	Injuries
Grand	-	-	-
Gunnison	28	-	-
Hinsdale	2	-	-
Huerfano	1	-	-
Jackson	-	-	-
Jefferson	-	-	-
Kiowa	-	-	-
Kit Carson	-	-	-
La Plata	22	-	-
Lake	-	-	-
Larimer	3	1	-
Las Animas	-	-	-
Lincoln	-	-	-
Logan	-	-	-
Mesa	96	-	5
Mineral	-	-	-
Moffat	47	-	-
Montezuma	9	-	-
Montrose	35	-	-
Morgan	1	-	-
Otero	1	-	-
Ouray	1	-	-
Park	-	-	-
Phillips	-	-	-
Pitkin	9	-	-
Prowers	-	-	-
Pueblo	-	-	-
Rio Blanco	48	-	-
Rio Grande	-	-	-
Routt	47	-	-
Saguache	1	-	-
San Juan	1	-	-
San Miguel	17	-	-
Summit	-	-	-
Sedgwick	-	-	-
Teller	-	-	-
Washington	-	-	-
Weld	4	1	-
Yuma	14	3	-

Source: NOAA

## 8. FUTURE DEVELOPMENT

Dense fog will continue to remain an issue for the foreseeable future, and is not likely to change in the near future. Therefore, it is important to understand how the future population of Colorado will be affected by this hazard. To gauge fog, forecasting zones are used for different elevations and areas of the state, rather than counties. To account for this in the future exposure modeling, the forecast zones were superimposed on top of the counties using GIS, and the number of events per county were determined. Table 3-18 presents a summary of the dense fog exposure projections for the state.

TABLE 3-18 DENSE FOG FUTURE EXPOSURE PROJECTIONS

Dense Fog Exposure Projections					
		County Population Percent Change Projections, 2010 to 2030			
Combined Risk (Dense Fog)		-13% to 2%	3% to 17%	18% to 34%	35% to 89%
High ↑ Moderate	3	Moderate	High	Severe	Extreme
	2	Slight	Moderate	High	Severe
	0-1	Negligible	Slight	Moderate	High

The Combined Risk calculations are based on the methodology outlined in Table 3-19. Values (between zero and three) have been assigned the total number of dense fog events per County. Due to the low number of recorded incidents involving deaths and injuries, these were not included in the Combined Risk Methodology, as they do not accurately contribute to the actual risk. Instead, population and number of incidents were used in its place. The Jenks Natural Breaks algorithm was used to classify these historical data sets.

TABLE 3-19 COMBINED RISK METHODOLOGY

# of Storm Events (1950-2017)	Value
49-98	3
18-48	2
1-17	1
0	0

Exposure to dense fog is expected to intensify across the State of Colorado between 2010 and 2030 as population increases. The darker colors in the table below illustrate relative rates of increase in exposure between counties. Garfield County has the highest future exposure projection due to its high number of past dense fog events and high population change. La Plata, Routt, and Mesa Counties fall into the next tier of future exposure. Table 3-20 and Figure 3-6 present each county’s future exposure to dense fog.

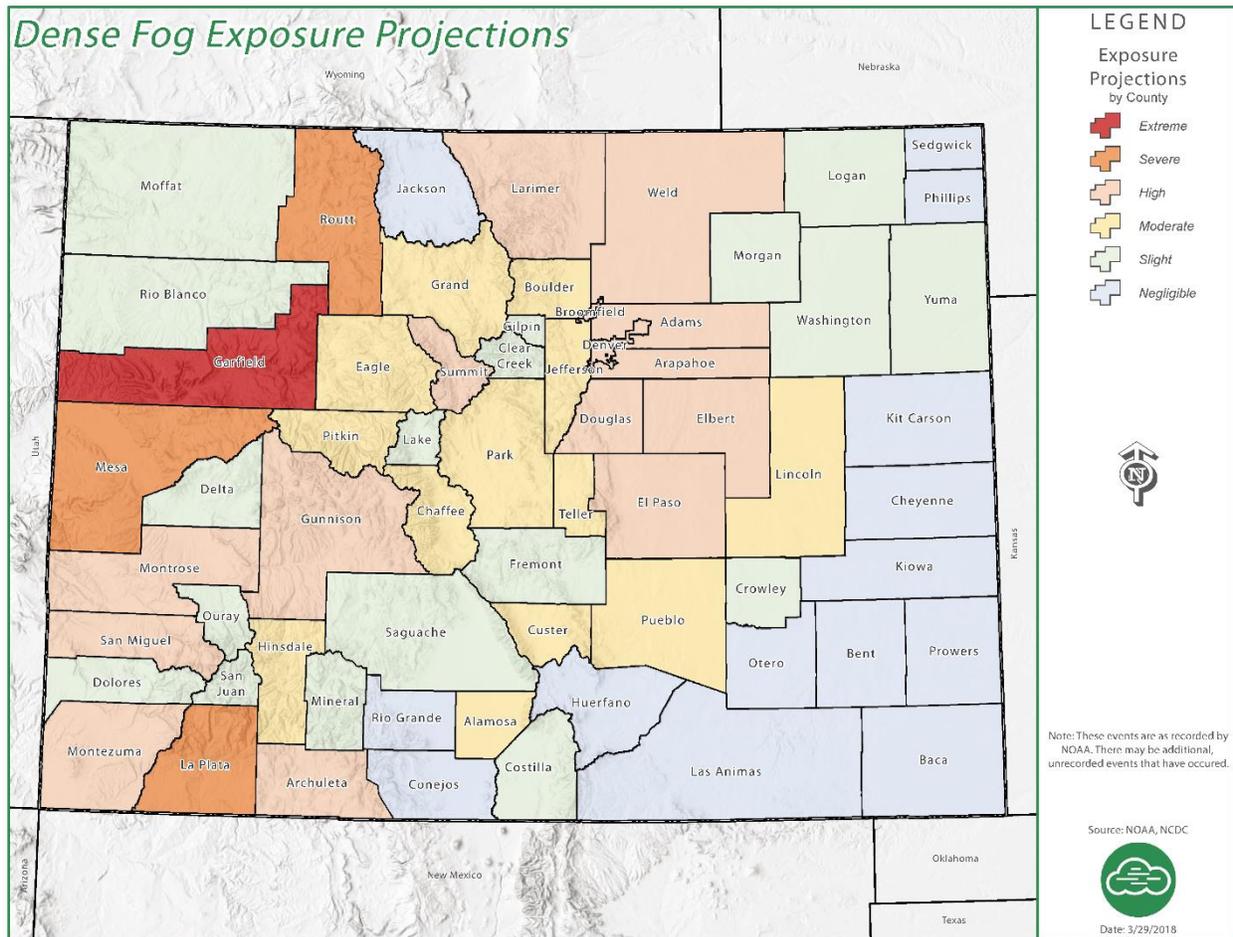
**TABLE 3-20 DENSE FOG EXPOSURE PROJECTIONS, 2010 TO 2030**

County	Number of Dense Fog Events	Population Change	Exposure Rating
Garfield	98	38%	Extreme
La Plata	22	42%	Severe
Routt	47	40%	Severe
Mesa	96	24%	Severe
Elbert	0	89%	High
Weld	4	81%	High
Broomfield	0	71%	High
San Miguel	17	59%	High
Adams	0	48%	High
Douglas	0	44%	High
Denver	0	42%	High
Larimer	3	42%	High
Summit	0	41%	High
Archuleta	11	40%	High
Montezuma	9	37%	High
El Paso	8	36%	High
Arapahoe	0	36%	High
Montrose	35	30%	High
Gunnison	28	26%	High
Park	0	34%	Moderate
Eagle	9	34%	Moderate
Grand	0	32%	Moderate
Hinsdale	2	29%	Moderate
Chaffee	1	29%	Moderate
Boulder	0	28%	Moderate
Teller	0	25%	Moderate
Alamosa	1	22%	Moderate
Lincoln	0	21%	Moderate
Jefferson	0	21%	Moderate
Pueblo	0	20%	Moderate
Custer	1	20%	Moderate
Pitkin	9	18%	Moderate

County	Number of Dense Fog Events	Population Change	Exposure Rating
Lake	0	17%	Slight
Ouray	1	17%	Slight
Mineral	0	16%	Slight
Morgan	1	16%	Slight
Logan	0	14%	Slight
Clear Creek	0	14%	Slight
Gilpin	0	13%	Slight
Saguache	1	9%	Slight
Delta	13	8%	Slight
Costilla	2	7%	Slight
Yuma	14	7%	Slight
Fremont	1	5%	Slight
Washington	0	5%	Slight
Dolores	17	5%	Slight
Crowley	1	5%	Slight
San Juan	1	5%	Slight
Rio Blanco	48	2%	Slight
Moffat	47	-3%	Slight
Cheyenne	0	2%	Negligible
Conejos	0	1%	Negligible
Kit Carson	0	-1%	Negligible
Huerfano	1	-1%	Negligible
Sedgwick	0	-3%	Negligible
Phillips	0	-3%	Negligible
Rio Grande	0	-5%	Negligible
Bent	0	-5%	Negligible
Prowers	0	-5%	Negligible
Otero	1	-7%	Negligible
Jackson	0	-7%	Negligible
Kiowa	0	-8%	Negligible
Las Animas	0	-9%	Negligible
Baca	0	-13%	Negligible

Source: NOAA, Colorado State Demography Office, 2017

FIGURE 3-6 DENSE FOG EXPOSURE PROJECTIONS, 2010 TO 2030



In review of local hazard mitigation plans, no information on future development trends were profiled for dense fog.

## 9. CLIMATE CHANGE

According to the best data available at the time of this plan update, the future impacts of climate change are not expected to influence future dense fog events (FEMA 2017; Garfin et al. 2013; Lukas et al. 2014, and Childress et al. 2015).

## 10. RISK TO STATE ASSETS

Dense Fog does not directly impact infrastructure. Any impacts are generally due to accidents resulting from limited visibility. If a vehicle were to damage power lines or a substation during an accident, power could be limited or shut down for critical facilities. These effects would be localized, and would not be of significant threat to multiple facilities. Since 2008, no state asset property losses have been reported due to dense fog.

Of fog's direct impacts on critical state assets, schools are likely to be the most impacted, as dense fog can cause delays or cancellations. Hospitals and police stations can also be affected, as 911 dispatchers may have trouble corresponding location data to first responders due to limited visibility. Response times can also be drastically inflated because of this.

## 11. RESOURCES

- Childress, A., Gordon, E., Jedd, T., Klein, R., Lukas, J., and McKeown, R. (2015). Colorado Climate Change Vulnerability Study.
- Colorado Department of Transportation (CDOT)
- Colorado Department of Transportation (CDOT) Emergency Operations Plan
- Federal Emergency Management Agency (FEMA). (2017). Assessing Future Conditions, Colorado.
- Federal Highway Administration (FHWA)
- Garfin, G., A. Jardine, R. Merideth, M. Black, and S. LeRoy, eds. (2013). Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment. A report by the Southwest Climate Alliance. Washington, DC: Island Press.
- Iowa Environmental Mesonet
- Lukas, J., Barsugli, J., Doesken, N., Rangwala, I., and Wolter, K. (2014). Climate Change in Colorado: A Synthesis to Support Water Resources Management and Adaptation.
- National Weather Service (NWS), Driving in Fog; <http://www.nws.noaa.gov/om/fog/driving.shtml>
- National Weather Service (NWS), Fog Safety; <http://www.nws.noaa.gov/om/fog/index.shtml>

# DROUGHT



## 1. DEFINITION

Portions of information included in this drought section are taken directly from the 2018 Colorado Drought Mitigation and Response Plan (Drought Plan). The Drought Plan provides an effective and systematic means for the State of Colorado to reduce the impacts of water shortages over the short and long term. Updated every five years, the Drought Plan outlines a mechanism for coordinated drought monitoring, impact assessment, response to emergency drought problems, and mitigation of long term drought impacts. The following chapter summarizes material presented in the 2018 update of the Drought Plan, contributing to the profile of the drought hazard in Colorado and analysis of the nature of impacts and probability of drought occurrence.

Due to the semiarid conditions, drought is a natural part of the Colorado climate. Given natural variations in climate and precipitation, nevertheless, 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. 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 different criteria, such as rainfall/runoff, amount of water in storage, or expected supply from a water wholesaler, to define their water supply conditions.

Drought is a complex and a gradual phenomenon in Colorado. Although droughts can be characterized as emergencies, they differ from other emergency events in that most natural disasters, such as floods or forest fires, occur relatively rapidly and afford little time for preparing for disaster response. Droughts typically occur slowly, over a multi-year period, and it is often not obvious or easy to quantify when a drought begins and ends. Drought can often be defined regionally based on its effects:

**Meteorological** drought is usually defined by a period of below average precipitation.

**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.

Table 3-21 below summarizes the characteristics that relate to the drought, namely location of the hazard, previous occurrence, probability (or likelihood) of it taking place, and extent (magnitude) of its effects.

TABLE 3-21 HAZARD PROFILE SUMMARY

Consideration	Impact	Description
<b>Location</b>	Regional	Mountains and plains both experience drought. Drought changes geographically from year to year and decade to decade. Drought in one area of the State may affect other regions.
<b>Previous Occurrence</b>	Seasonal	Past droughts have occurred at any time of the year and been short or long-term in development, duration, and ending.
<b>Probability</b>	Expected	Atmospheric conditions resulting in severe drought conditions are expected to occur as frequently in the future as in the past, though a changing (warming) climate may increase probability of occurrence. Short duration drought as defined by the three-month Standardized Precipitation Index (SPI) also occurs somewhere in Colorado in nearly nine out of every ten years.
<b>Extent</b>	Moderate	Limited property damage that does not threaten structural integrity is common; some deaths or injuries from indirect causes/effects possible; little or no impact to critical services or facilities expected. Drought may result in significant economic and water resource impacts. Droughts are projected to have a longer duration due to shifts in seasonal precipitation patterns, including dryer summers and less precipitation falling as snow in early spring/late fall.

## 2. LOCATION

No portion of the state of Colorado is immune from drought conditions. The effects of drought vary based on where in the state it occurs, when it happens, and how long the drought persists. For example, a drought in the plains of the state can greatly affect agricultural crops. A long-term drought is not needed to affect agricultural yields. Droughts of just a few weeks during critical periods of plant development can have disastrous effects on agriculture production. Droughts that occur in the mountainous regions of the state during winter months may have great effects on the ski and tourism industry. Additionally, drought in one area of the state may also impact other regions. Lack of winter snowfall in the mountains can eventually lead to agricultural impacts on the eastern plains due to decreased streamflows. Reduced reservoir storage from decreased runoff in the mountains leads to municipal and industrial water shortages on the Front Range. Droughts that occur in populated areas may not have direct effects to the residents, but may increase the threat of wildfire in the wildland urban interface (WUI) areas. In summary, drought is one of the few hazards with the potential to directly or indirectly impact the entire population of the state, be it from water restrictions, higher water and food prices, reduced air or water quality, or restricted access to recreational areas (McKee et. al., 1999).

### 3. EXTENT (MAGNITUDE/STRENGTH)

Drought in the United States is monitored by the National Integrated Drought Information System (NIDIS). A major component of this portal is the U.S. Drought Monitor. The Drought Monitor concept was developed jointly by NOAA’s Climate Prediction Center, NDMC, and the USDA’s Joint Agricultural Weather Facility in the late 1990s as a process that synthesizes multiple indices, outlooks, and local impacts into an assessment that best represents current drought conditions. The outcome of each Drought Monitor is a consensus of federal, state, and academic scientists who are intimately familiar with the conditions in their respective regions.

The United States Drought Monitor measures drought in five categories, from “abnormally dry” to “exceptional drought.” These categories are defined in Table 3-22 below. All counties across the state are vulnerable to all levels of drought, including exceptional drought. The duration of time that portions of Colorado experienced D4 conditions during the 2011 -2013 drought is discussed in the section on Previous Occurrences. Droughts are subject to global climate and precipitation trends, and wet and dry periods can persist for years.

TABLE 3-22 DROUGHT MONITOR CATEGORIZATION

Category	Description	Possible Impacts	Palmer Drought Severity Index (PDSI)	Standardized Precipitation Index (SPI)
D0	Abnormally Dry	Going into drought: Short-term dryness slowing planting, growth of crops, or pastures Coming out of drought: Some lingering water deficits Pastures or crops not fully recovered	-1.0 to -1.9	-0.5 to -0.7
D1	Moderate Drought	Some damage to crops, pastures Streams, reservoirs, or wells low Some water shortages developing or imminent Voluntary water-use restrictions requested	-2.0 to -2.9	-0.8 to -1.2
D2	Severe Drought	Crop or pasture losses likely Water shortages common Water restrictions imposed	-3.0 to -3.9	-1.3 to -1.5
D3	Extreme Drought	Major crop/pasture losses Widespread water shortages or restrictions	-4.0 to -4.9	-1.6 to -1.9
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses Shortages of water in reservoirs, streams, and wells creating water emergencies	-5.0 or less	-2.0 or less

Source: United States Drought Monitor

## 4. PROBABILITY

Historical analysis of precipitation shows that drought is a frequent occurrence in Colorado, and short duration droughts occur somewhere in Colorado nine of out ten years (McKee et al., 1999). However, severe, widespread multiyear droughts are much less common.

Up until the publishing of the 2004 Drought Water Supply Assessment (DWSA), there had been six recorded multi-year drought incidents which impacted the State of Colorado since 1893, during a span of 111 years (from 1893 to 2004). With the addition of the 2011-2013 drought, Colorado has been exposed to a total of seven major multi-year droughts in its recorded history. Based on this data and the Standardized Precipitation Index-derived formula, the probability of a drought occurring in any given year is 32.4 percent.

NOAA projects short term future probability of drought by releasing U.S. Seasonal Drought Outlook maps that forecast anticipated drought conditions three months out. The current (April 19 through July 2018) Outlook map shows that drought is expected to persist or intensify throughout most of Colorado's southwest. The southeast of the state is expected to see some drought remain but improving slightly, and small sections of the central-east might see actual drought removal conditions. Dry conditions are hence prevalent and expected in Colorado at some point and in some location year-round.

Increased duration and/or frequency of droughts may be foreseen in the future due to changing climatic conditions. The Climate Change section of this document highlights some potential drought effects and what they could mean for the state, if they become more common or last for longer periods. Some recent efforts regarding state plans geared to address and prepare for climate change are introduced. Overall, however, droughts are projected to have a longer duration due to shifts in seasonal precipitation patterns, including drier summers and less precipitation falling as snow in early spring/late fall. For more details about climate change and drought, please refer to Annex C Climate Change Implications within the 2018 update of the Colorado Drought Mitigation and Response Plan.

## 5. PREVIOUS OCCURRENCES

Several times since the late 1800s Colorado has experienced widespread, severe drought. The most dramatic event occurred in the 1930s and 1950s when many states, Colorado included, were affected for several years at a time. Table 3-23 shows seven multi-year droughts experienced in Colorado since 1893, based on McKee et al., 1999. The 2002 and 2011-2013 droughts occurred after the study was published, but the table has been modified and updated to reflect the most recent and intense droughts based on input from the Colorado Climate Center (CCC). Following this section is a short history of drought declarations in the state. Details on the more significant droughts, particularly the droughts of 2002 and 2011-2013, conclude the discussion of drought history. For additional details, please visit the updated 2018 Colorado Drought Plan.

TABLE 3-23 HISTORICAL DRY AND WET PERIODS IN COLORADO

Date	Dry	Wet	Duration (years)
1893-1905	X		12
1905-1931		X	26
1931-1941	X		10
1941-1951		X	10
1951-1957	X		6
1957-1959		X	2
1963-1965	X		2
1965-1975		X	10
1975-1978	X		3
1979-1999*		X	20
2000-2006*	X		6
2007-2010*		X	3
2010-2013*	X		2

Source: McKee, et. al 1999.

\*modified for 2018 Drought Plan based on input from the CCC

The following is a shortened summary on major droughts that have affected Colorado. More details are available in the 2018 Drought Plan update.

**The 1930’s Drought** – The Dust Bowl drought severely affected much of the United States during the 1930s. The drought came in three waves, 1934, 1936, and 1939-1940, but some regions of the High Plains experienced drought conditions for as many as eight consecutive years. The soil, depleted of moisture, was lifted by the wind into great clouds of dust and sand which were so thick they concealed the sun for several days at a time (referred to as “black blizzards”). The Dust Bowl drought worsened the already severe economic crises that many Great Plains farmers faced. Many farmers were forced off their land. Many factors contributed to the severe impact of this drought, and in its aftermath a better understanding of the interactions between the natural elements (e.g., climate, plants, and soil) and human-related elements (e.g., agricultural practices, economics, and social conditions) of the Great Plains developed. As a result, farmers adopted new cultivation methods to help control soil erosion in dry land ecosystems; consequently, following droughts in the region were not as impactful.

**The 1950s Drought** –The drought was characterized by both decreased rainfall and excessively high temperatures. The Texas panhandle to central and eastern Colorado, western Kansas, and central Nebraska areas experienced severe drought conditions, reaching a peak in 1956. The drought devastated the region's agriculture, with crop yields in some areas decreased as much as 50%. By the time the drought subsided in 1957, many counties across the region were declared federal drought disaster areas.

**The 1977 Drought** – During 1976 and 1977, the state experienced record-low streamflows at two-thirds of the major stream gages, records that held until the 2002 drought. In addition, the Colorado ski industry estimated revenue losses at \$78.6 million; agriculture producers had to

incur higher crop production costs due to short water supplies, and numerous municipalities were forced to impose water use restrictions on their customers. The state's agriculture producers and municipalities received over \$110 million in federal drought aid as a result of the 1976-1977 drought.

**1980-1981 Drought** – Although short-lived, beginning in the fall of 1980 and lasting until the summer of 1981, this drought generated costly impacts to the ski industry and initiated a huge investment in snow making equipment; it motivated the writing of the Colorado Drought Response Plan, one of the first plans of its type in the nation, and the formation of the Water Availability Task Force.

**1994 Drought** – On August 1, in response to extremely arid conditions, the Governor activated, by memorandum, several Task Forces to assess impacts: Agriculture (blowing soils), Wildlife, Wildfire, Commerce/Tourism, and Review and Reporting. Significant impacts reported included an increase in wildfires statewide, loss to the winter wheat crops, difficulties with livestock feeding, and impacts to the state's fisheries.

**1996 Drought** – July 29, the Governor issued an Executive Order proclaiming a Drought Disaster Emergency Declaration. Fifteen counties were included in a request for USDA assistance. The directive activated the Water Availability, Agriculture, Wildfire, Tourism, Municipal Water, and Review and Reporting Task Forces to monitor the situation, and evaluate impacts to potable water supplies in the southwest and northwest portions of the state.

**2002 Drought** – On a statewide basis, 2002 was the most intense single year of drought in Colorado's history (Pielke and Doesken, 2003). This was an extremely dry year embedded in a longer dry period (2000-2006), similar to 1934 being an extremely dry year within a period of longer drought (1931-1939). These conditions were rated "exceptional" by the U.S. Drought Monitor and were the most severe drought experienced in the region since the Dust Bowl (Tronstad and Feuz, 2002). Indeed, based on studies of tree rings and archaeological evidence from aboriginal cultures, the 2002 drought was arguably the most severe single-year event in the recorded history of the state (Pielke and Doesken, 2003) at that point in time.

Many municipalities implemented strict water conservation restrictions. Other forest fires erupted and each new blaze seemed to spread faster than the one before. Winter wheat crop conditions continued rapid deterioration, and ranchers quickly sold or relocated their herds in response to the poor range conditions and high cost of feed. The most severe fires of the season erupted in June, including the Hayman fire southwest of Denver which quickly grew to be the largest documented forest fire in Colorado (217 mi<sup>2</sup>) on record.

**2011-2013 Drought** – Even though 2011 was very wet across northern Colorado, the extreme drought during this time in Texas, New Mexico, and Oklahoma was also felt in the Rio Grande and Arkansas Basins in Colorado. Based on the U.S. Drought Monitor, approximately 50% of Colorado was already under drought conditions at the beginning of 2012. The entire State was under drought conditions by the end of May 2012, causing concern as it included the regions

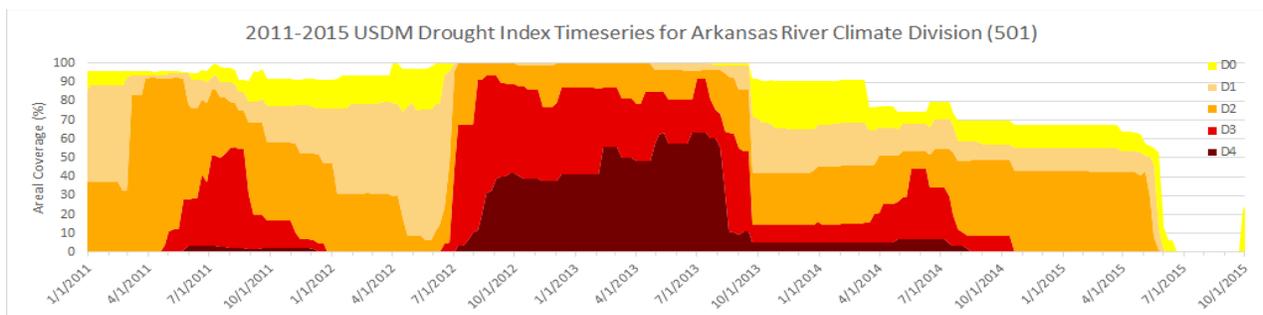
where 80 percent of the State’s water supply originates. Streamflows measured only slightly better compared to the extreme drought years of 1934, 1954, 1977, and 2002 (Ryan and Doesken, 2013).

Agriculture was highly impacted. Soil moisture was low on the plains during the spring planting season and temperatures were high, giving crops little chance to establish and survive the summer. This was compounded by less water availability for summer irrigation diversions due to low snowpack and runoff. The multi-year drought in 2011-2013 also deteriorated vegetative cover across the state’s Eastern Plains. The exposed soil, combined with heavy winds, created dust storms similar to those of the devastating 1930’s Dust Bowl. Some farmers lost entire crops with one storm, causing immense financial strain and emotional hardship.

Drought conditions and a period of extremely hot temperatures in June 2012 also contributed to very dry forests, leading to wildfires such as the High Park fire in northern Colorado, the Waldo Canyon fire near Colorado Springs (The Gazette, 2012), and even the Royal Gorge and Black Forest fires in 2013. These wildfires prompted Presidential Disaster Declarations.

Other impacts seen during the 2011-2013 drought were decreased rafting numbers in 2012 due to low streamflows and wildfire conditions making some river reaches inaccessible. Colorado’s ski industry experienced an 11.9 percent decrease in visits for the 2011-2012 season as compared to the five-year average. Both of these industries have developed marketing and operations strategies in recent years to mitigate economic impacts due to drought. In the agriculture sector, the Arkansas Basin lost approximately 1,300 jobs and \$105 million in economic activity (Gunter et al., 2012). Figure 3-7 presents a time series graph beginning in January 2011 and ending in October of 2015, as a visual representation of the severity of this major multi-year drought in Colorado.

**FIGURE 3-7 DROUGHT TIME SERIES WITH BEFORE AND AFTER DROUGHT CONDITIONS: JANUARY 2011-OCTOBER 2015**



Source: NIDIS U.S. Drought Portal

## 6. IMPACT ANALYSIS

Drought impacts are wide-reaching and may come in different forms, such as 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 effects. Drought conditions can also cause soil to compact, decreasing its ability to absorb water, 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 more potent fuel sources for wildfires. Drought may additionally weaken trees in areas already affected by mountain pine beetle infestations, causing more extensive damage and increasing wildfire risk, at least temporarily. An ongoing drought which severely inhibits natural plant growth cycles may impact critical wildlife habitats. Drought impacts increase with the length of a drought, as carry-over supplies in reservoirs are depleted and water levels in groundwater basins decline.

Colorado’s Drought Mitigation and Response Plan contains an in-depth risk assessment section, which includes a detailed multi-sector vulnerability assessment. According to FEMA’s risk assessment guidance, vulnerability is defined as being open to damage or attack, and risk is defined as the possibility of loss or injury. For the Drought Plan’s assessment, the vulnerability of a county is approximated by looking at previous impacts due to drought and identifying existing conditions, or “metrics,” that would cause a county to be more or less impacted during future droughts. These metrics are determined on a sector-by-sector basis. In an attempt to expand upon previous vulnerability assessments for the State of Colorado’s Drought Plan, the scope has been widened to include six private economic sectors and one public sector in total. The private sectors are as follows: Agriculture, Energy, Environment, Municipal and Industrial (M&I), Recreation/Tourism, and Socioeconomic. The public sector is State Assets, which accounts for state-owned facilities and lands.

In addition to the FEMA requirements, the Emergency Management Accreditation Program, or EMAP risk assessment standards, require a consequence-based analysis. Figure 3-26 below outlines the detrimental impacts that drought can have on various subject areas as designated by EMAP.

**TABLE 3-24 DROUGHT EMAP IMPACT SUMMARY**

Consideration	Description
<b>Health and Safety of the Public</b>	Water supply disruptions may adversely affect people. Reduced water quantity and quality could impact delivery of potable water, particularly in rural areas. Reduced air quality associated with blowing dust could have detrimental impacts. Mental health issues may be associated with loss of farm income and heavily impacted lifestyles in agricultural areas. See the Socioeconomic Sector analysis of the Drought Plan for a detailed impact discussion.
<b>Health and Safety of Personnel Responding to the Incident</b>	Nature of hazard expected to have minor impacts to properly equipped and trained personnel, though dust storms may require special equipment.

Consideration	Description
<b>Continuity of Operations Including Delivery of Services</b>	Slow onset and nature of drought makes it unlikely to have an impact on continuity of operations. Nature of hazard not expected to impact delivery of government services, except for moderate impact on water utilities. In extreme cases, municipal water delivery may be interrupted. Ability to deliver recreational services may be impacted at the local level. Food supply and delivery could be disrupted, with an associated increase in food prices.
<b>Property, Facilities, and Infrastructure</b>	Buildings: Nature of hazard expected to have minimal impact. Landscaping can be damaged or lost in events of severe municipal water restrictions or water rights out of priority. Increased risk of wildfire can threaten catastrophic loss of buildings. Critical infrastructure (e.g., dams, transmountain ditches, irrigation ditches): Infrastructure can be damaged by excessively dry expansive soil as it contracts. Dams and ditches can experience structural damage due to decreased pore water pressure, damage caused by high sediment loads when pulling water from the bottom of reservoirs, and damage caused by debris flows and flooding following wildfires. state lands: Environmental quality of land can be impacted by overgrazing during drought conditions. See the State Assets Sector analysis of the Drought Plan for a detailed impact discussion.
<b>The Environment</b>	May cause disruptions in wildlife habitat, resulting in an increasing interface with people, and reduction in numbers of animals. Land quality can be negatively impacted by overgrazing during drought. Water quality can become degraded to the point of causing localized fish kills. See the Environment Sector analysis of the Drought Plan for a detailed impact discussion. Low streamflows will have negative impacts on riparian habitats and aquatic species.
<b>Economic Condition</b>	Local economy and finances dependent on abundant water supply or precipitation (e.g., snow at ski areas) adversely affected for duration of drought. Agricultural economies adversely affected if drought results in widespread loss of crops or yield reductions. Increased expenses possible among M&I providers. See sector analyses of the Drought Plan for Recreation and Tourism, Agriculture, State Assets, Energy, M&I, and Socioeconomic.
<b>Regulatory and Contractual Obligations</b>	Water trading between municipalities expected to occur on a voluntary rather than obligatory basis. Drought reservations or instream flows may be invoked to allow a reduction in bypass requirements and an interruption to agricultural leases (see the M&I Sector analysis). Interstate compact obligations could become stressed if long term or severe decreases in availability occurs. Recreational in-channel diversions and instream flow rights are subject to water rights priority system and may become out-of-priority in a drought (see Recreation and Tourism and State Assets analyses of the Drought Plan).
<b>Public confidence in the jurisdiction's governance</b>	Ability to respond and recover may be questioned and challenged if planning, response, and recovery efforts are not timely and effective. State must balance <i>over</i> and <i>under</i> responses to the drought hazard.

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

The 2018 Drought Plan includes a detailed vulnerability assessment that discusses the past and potential impacts to Colorado’s economy, environment, state assets, and water providers on a county-by-county basis (except for the M&I sector, which was assessed at a basin-wide level for the seven major river basins in the state). The updated vulnerability assessment, rankings, and derived results are covered in detail in Annex B of the Drought Plan. Main highlights of this analysis are summarized below in Table 3-25, but referring to the 2018 Colorado Drought Mitigation and Response Plan for more information is encouraged.

**TABLE 3-25 SUMMARY OF THE 2018 DROUGHT PLAN VULNERABILITY ASSESSMENT, BY SECTOR**

Sector	Vulnerability Summary
<b>State Assets</b>	<ul style="list-style-type: none"> <li>• With growing populations and demands across agencies to serve Colorado this sector may be more heavily affected by increased management costs of state structures, coupled with decreased revenue during times of drought (related to lower state park visitation numbers, etc.). Apart from state-owned structures, other variables used in the vulnerability calculation include: state park visitation data, instream flow rights, fish hatcheries, and protected lands.</li> <li>• Vulnerable counties include many in the eastern plains (Kit Carson, Sedgwick, Phillips, Kiowa), and west (Mesa, Montrose).</li> </ul>
<b>Agriculture</b>	<ul style="list-style-type: none"> <li>• Impact metrics include crop indemnities due to drought, indemnity allotments, herd reduction statistics, and number of green industry producers.</li> <li>• Most vulnerable counties include those on the eastern plains (Yuma, Kiowa, Baca, Kit Carson, Lincoln) and Adams County, in part due to high amounts of acreage used for agriculture.</li> </ul>
<b>Energy</b>	<ul style="list-style-type: none"> <li>• Variables used to calculate vulnerability include: power generation capacity, number of mining jobs, water use and source (i.e., ground vs. surface), and renewable energy development opportunities.</li> <li>• Most vulnerable counties include those heavily reliant on water for energy production and mining operations, including Routt, Moffat, Cheyenne, Washington, and Fremont counties.</li> </ul>
<b>Environment</b>	<ul style="list-style-type: none"> <li>• Variables used to calculate vulnerability include: land stewardship acreage, impaired waters from an EPA database, bark beetle infestation areas, wildfire threat areas, and riparian habitat areas. An updated instream flow rights dataset for 2017 was used as a quantitative adaptive capacity metric for this sector, reflecting increases in the number of instream flow rights since 2013; ensuring minimum flows for environmental preservation purposes as an adaptation measure has resulted in lowered vulnerability scores in certain counties that gained additional instream flows.</li> <li>• Most vulnerable counties in this sector include Larimer, Weld, Chaffee, Custer, Denver, and Lake.</li> </ul>
<b>Municipal and Industrial (M&amp;I)</b>	<ul style="list-style-type: none"> <li>• Vulnerability of this sector to drought can vary greatly based on: water supply, water distribution, water demand, adaptive capacities.</li> <li>• The state’s municipal diversions total 970,000 acre-feet per year. 2050 projections range from 1.5 million AF/yr to more than 1.8 million AF/yr, depending on growth and climate.</li> </ul>

Sector	Vulnerability Summary
<b>Recreation / Tourism</b>	<ul style="list-style-type: none"> <li>• Diversification of recreational offerings is a way to buffer against drought impacts, but all assessed subsectors (skiing, wildlife viewing, hunting/fishing/camping, golfing, boating, and rafting) are at some risk of drought due to reliance on healthy water resources and/or colder conditions.</li> <li>• Vulnerable counties include Moffat, Routt, Larimer, Mesa, Garfield, Fremont, and Pueblo, due to the presence of water-based parks and other water-reliant recreation and tourism activities.</li> </ul>
<b>Socioeconomic</b>	<ul style="list-style-type: none"> <li>• Social vulnerability index metrics integrated to account for population specific risk (e.g., aging populations). Other variables used in the vulnerability calculation are economic diversity and estimated population growth/change.</li> <li>• Counties with the largest rates of growing populations coupled with lack of economic diversification are most vulnerable during drought. The most vulnerable county is Routt, followed by mountain counties such as Eagle, Pitkin, Summit, and Grand, and others throughout the state.</li> </ul>

Source: 2018 CO Drought Mitigation and Response Plan Update vulnerability analysis update.

The following text introduces the table and figure below, which provide a summary of drought hazard significance based upon a 2018 review of local hazard mitigation plans.

Most counties across Colorado have rated drought as a high significance hazard in their plans, with the second majority rating it as medium. Only Garfield and Larimer do not include drought in their local plans, while San Juan, Jackson, and Moffat have not rated the hazard due to a lack of a mitigation plan. The cities of Boulder, Thornton/Federal Heights/Northglenn and Westminster as well as the Ute Mountain Ute Tribe have all rated drought as a highly impactful hazard, while Aurora, Colorado Springs, Manitou Springs, and the Southern Ute Indian Tribe rate it as a medium hazard. Drought is considered the top hazard in fifteen communities in the state, with areas of El Paso County having the most potential quantified losses from this hazard, followed by the counties of Eagle, Grand, Fremont, La Plata, and areas of unincorporated land in Montrose. Using information taken from local hazard mitigation plans, Figure 3-8 drought hazard rating in local hazard mitigation plans shows how jurisdictions ranked drought in local hazard mitigation plans and Table 3-26 identifies total loss estimations based on crop insurance indemnities, for the counties that include drought in the top four highest risk hazards.

FIGURE 3-8 DROUGHT HAZARD RATING IN LOCAL HAZARD MITIGATION PLANS

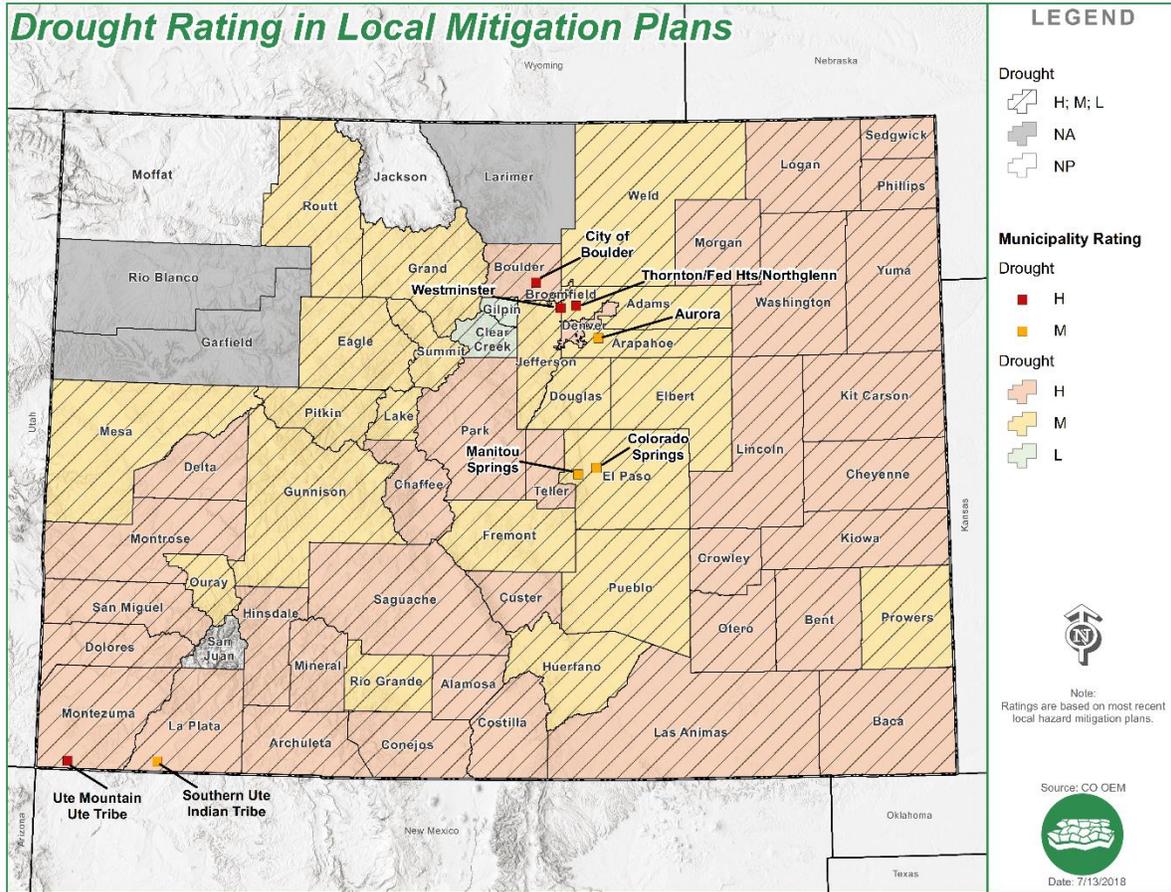


TABLE 3-26 DROUGHT VULNERABILITY FOR COUNTIES WITH HIGH RISK IN LOCAL PLANS

County or Jurisdiction (city/town)	Crop Insurance-Based Loss Estimate
<b>Baca County</b>	\$2,290,000
<b>Bent County</b>	\$340,000
<b>Cheyenne County</b>	\$3,200,000
<b>Crowley County</b>	\$46,550
<b>Dolores County</b>	\$221,928
<b>Eagle County</b>	\$17,690,474,350
<b>El Paso County (Unincorporated areas)</b>	\$31,747,752,419
<b>Fremont County</b>	\$5,744,537,170
<b>Gilpin County</b>	\$175,901,000
<b>Grand County</b>	\$7,689,125,055
<b>Jefferson County</b>	\$6,518,232
<b>Kiowa County</b>	\$1,470,000

County or Jurisdiction (city/town)	Crop Insurance-Based Loss Estimate
Kit Carson County	\$5,600,000
La Plata County	\$3,201,830,000
Lake County	\$1,155
Lincoln County	\$8,474,910
Logan County	\$1,600,000
Manitou Springs (El Paso County)	\$264,075,512
Montrose County (Unincorporated areas)	\$2,342,787,330
Morgan County	\$1,500,000
Otero County	\$227,000
Ouray County	\$930,044,845
Phillips County	\$1,755,331
Pitkin County	\$14,600,000
Sedgwick County	\$711,934
Southern Ute Indian Tribe (La Plata County)	\$255,372,931
Ute Mountain Ute (Montezuma County)	\$46,312,000
Washington County	\$2,201,639
Weld County	\$472,916,287
Yuma County	\$2,566,890

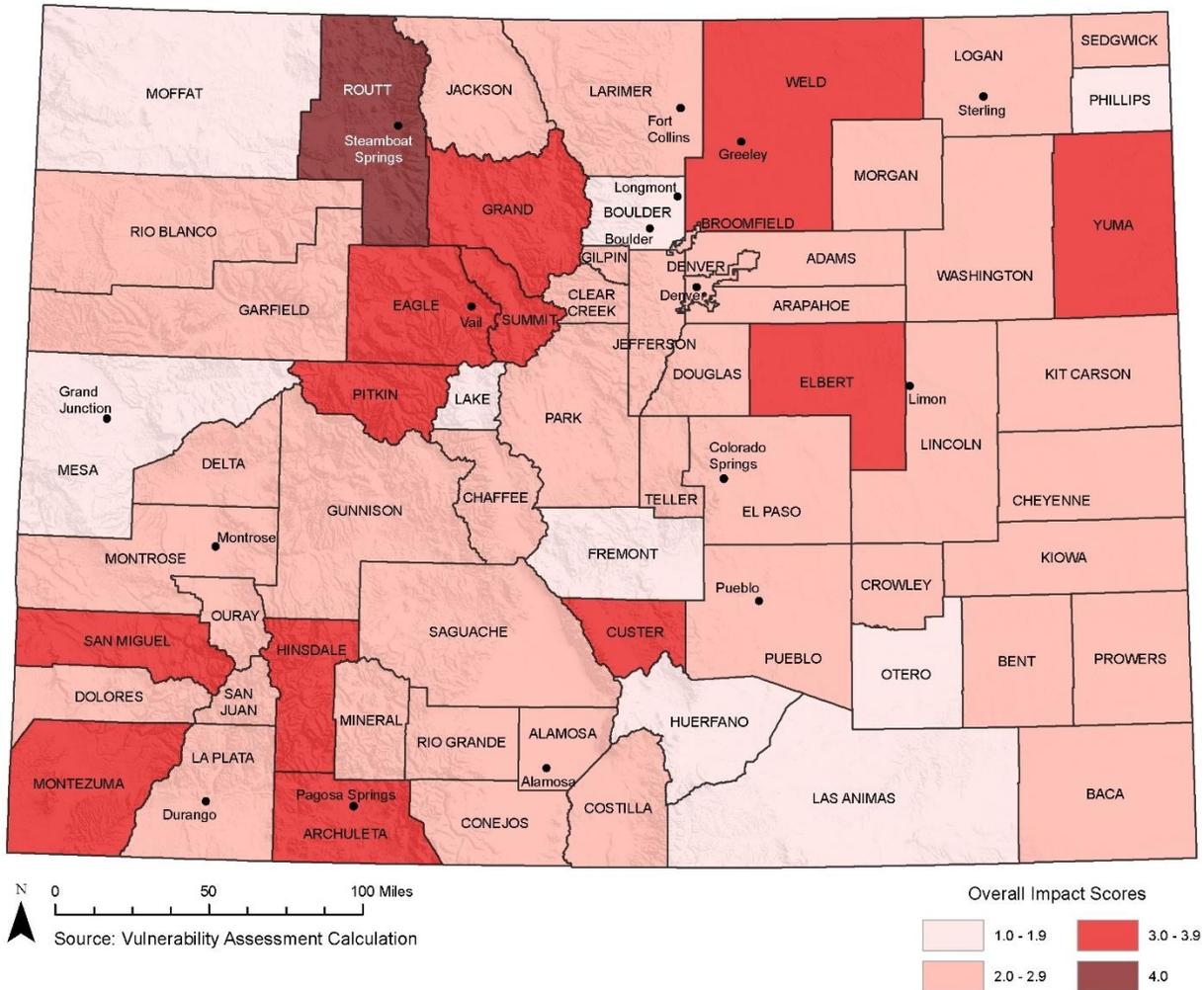
## 8. FUTURE DEVELOPMENT

Drought vulnerability will generally increase with future development, since there will be increased demands for limited water resources. As Colorado’s population continues to grow and the need for water increases, more people and property may be affected by drought conditions. As part of the Drought Plan update vulnerability assessment for the Socioeconomic sector, projected population growth/change was incorporated as an impact metric used to estimate how demographic changes, by county, could increase susceptibility and subsequently risk to jurisdictions in times of drought (based on expectations of increased water demands, resources, etc.).

For the Drought Plan vulnerability assessment update, population projections for 2030 were obtained from the State Demographer’s Office, and the percentage increase (or decrease) from the 2010 population was calculated. In addition, economic diversity and social vulnerability were taken into account to arrive at the final vulnerability scores for the sector. Counties received scores from 1 to 4 based on overall socioeconomic vulnerability to drought, where a 1 is the lowest susceptibility, 2 is medium, 3 is high, and 4 is the highest vulnerability. The results of the vulnerability assessment tool for this sector by county are displayed in Figure 3-9 below. For more details on the metrics related to the Socioeconomic sector, and more thorough

explanations of the general vulnerability assessment process and results, refer to the 2018 Drought Plan update.

**FIGURE 3-9 OVERALL SOCIOECONOMIC SECTOR VULNERABILITY, BY COUNTY (FROM 2018 DROUGHT PLAN)**



Source: Colorado Drought Mitigation and Response Plan 2018

Based on this analysis, which again summarizes how population growth and other variables affect the Socioeconomic sector in Colorado in terms of drought vulnerability, many counties in the state have high ranks. Only Routt receives a very high rank of 4, meaning it is the most vulnerable in this sector. Examples of high score receiving counties are Pitkin, Eagle, Summit and Grand in the mountains (likely due to a lack of diversity in their economies), and some in the southwestern parts of Colorado such as San Miguel, Montezuma, Archuleta and Hinsdale. Others such as Custer, Elbert, Weld, and Yuma also are highly susceptible to drought in this sector. High projected population growth accounts for some of these high scores, while other counties receive a 3 due to containing people with high social vulnerability (e.g., aging adults, disabled populations). On the other side of the spectrum, counties with very low socioeconomic

vulnerability as shown in their final rankings include Las Animas, Otero, and Huerfano, among others, due to negative population growth (i.e., decreasing population). The Colorado Drought Plan update has more information on the Socioeconomic sector’s vulnerability assessment and how future development can affect counties’ risk to drought.

## 9. CLIMATE CHANGE

Colorado’s hydrology and water resources, and hence its economy, are extremely sensitive to climate. Climate change researchers around the world have recognized mountain systems as sensitive bellwethers of regional change. The interannual variability of the snow resource, the impacts of rapidly emerging factors such as dust-on-snow, and the possibility that climate change could cause substantial long-term reductions in Colorado's seasonal snow cover highlight the vulnerability of the state's mountain snowpack and the economies that depend on the predictable storage and release of the water supply from snowmelt.

According to the best data available at the time of this plan update, the future impacts of climate change are expected to influence future drought events. The following Table 3-27 presents a breakdown of these projected changes in terms of the hazard’s location, extent/intensity, frequency, and duration.

**TABLE 3-27 CLIMATE CHANGE IMPACTS**

<b>Location</b>	Mountains and plains both experience drought. Drought changes geographically from year to year and decade to decade. Location is not projected to change.
<b>Extent / Intensity</b>	Property damage that does not threaten structural integrity is common. Little or no impact to critical services or facilities expected. Economic and water resource impacts foreseen. Extent is not projected to change.
<b>Frequency</b>	Droughts are projected to increase in frequency due to shifts in seasonal precipitation patterns, including dryer summers and less precipitation falling as snow in early spring/late fall.
<b>Duration</b>	Droughts are projected to have a longer duration due to a changing climate, e.g. shifts in seasonal precipitation patterns, including drier summers and less precipitation falling as snow in early spring/late fall.

For more details on projected climate change impacts refer to the 2018 Drought Plan.

## 10. RISK TO STATE ASSETS

Vulnerability to state facilities and other assets from drought varies depending on the asset. For state-owned or operated facilities (e.g., buildings, dams, ditches) the primary vulnerability is to catastrophic loss due to wildfires that can be made more severe by drought conditions. These facilities can be damaged due to prolonged droughts. For example, a building can be in an area with mandatory municipal watering restrictions, and as a consequence landscaping can be

damaged or lost, incurring costs to the state. Dams and ditches, which are built to hold water, can become weakened if left dry for extended periods of time. The at-risk state assets and their impacts are shown in Table 1-7, based on information from the State Assets section of Appendix B in the 2018 Drought Plan.

Drought-vulnerable infrastructure includes dams, trans-mountain ditches, and irrigation ditches. Instream flow rights are non-consumptive ‘in-channel’ or ‘in-lake’ water rights that can only be held by the Colorado Water Conservation Board. These rights designate minimum flows between specific points on a stream, or water levels in natural lakes, to ensure environmental health and maintain aquatic and riparian species and habitat. Table 3-28 lists some key impacts to sub-sectors that were identified during the literature review and interview portion of the updated Drought Plan State Assets vulnerability assessment.

**TABLE 3-28 STATE ASSETS KEY IMPACTS FROM DROUGHT**

State Assets at Risk	Key Impacts
<b>State-owned or operated buildings</b>	Increased exposure to wildfires, increased wear and tear on building exterior and HVAC systems due to degraded air quality, and water shortages due to out-of-priority rights or restrictions imposed by municipality, landscaping loss.
<b>Critical infrastructure</b>	Decreased water levels in dams can cause structural damage, dry ditches can be damaged by animal holes and general exposure, and increased vegetative growth and high sediment loading resulting from low reservoir levels or wildfire debris can damage structures. Drought causes extensive damages to state rights of way through accumulation of dust and dirt on right of way fences and stormwater diversion utilities.
<b>State Land Board</b>	Decreased forage and crop yields on leased lands, negative impacts to lands if lessees do not appropriately adjust grazing allowances, and decreased mining activity if water is not available for production.
<b>State Parks and CPW</b>	Low reservoir and stream levels can deter visitors and prevent water-based recreation, park closures and campfire restrictions can result from severe wildfires, negative media portrayal is possible, and visitation decline results in lower operating budget. Revenue from licenses, water activities, tourism, park visitation, biological loss – State Forest and park land trees – dead trees, beetle activity, wildfires, impacts to tourism and recreation sectors.
<b>Aquatic habitat</b>	Impacts to flow levels, water quality, habitats, and fish populations, including increased management requirements and protection programs.
<b>Instream flow rights</b>	Junior water rights associated with most instream flows leave them vulnerable to over appropriation during severe drought, possibly leading to economic and biological losses.

Source: Colorado Drought Mitigation and Response Plan 2018

One way to estimate potential losses due to drought is to look at previously reported losses and existing economic exposure of state assets. Table 3-29 summarizes losses from recent droughts, and tabulates economic exposure of at-risk state assets.

TABLE 3-29 POTENTIAL DROUGHT LOSSES BASED ON HISTORIC ECONOMIC IMPACTS

Potential Economic Impacts to State Facilities	Where Potential Losses and Effects Could be Exhibited	State Economic Exposure and/or Past Drought Impacts
<b>Costs and losses to agricultural and livestock producers</b>	State lands leased for crops to crop producers, for farming and livestock producers for grazing. Grazing, recreation, and forestry uses of Colorado State Forests	Accounting for the last eight years, the State Land Board has generated \$12-19 million annually in revenues from leases and royalties in land leased for ranching/grazing, farming, and recreation alone (not counting mineral leases or commercial building leases). However, for past drought years, these revenues have been shown to decrease when compared with non-drought years (e.g., Fiscal Year 2011-2012 vs. FY 2013-2014) (Colorado State Land Board Commissioners, 2014). While it is difficult to attribute all revenue differences directly to drought, it is expected that it may be a part of the reason revenues are reduced during dry years.
<b>Loss from fishery production</b>	State-owned fish propagation and restoration facilities. Fishing license sales. Fish in streams throughout the state (since all wildlife is “owned” by the state). Angler visitation and spending	CPW estimates that fishing activities and angler-based spending contributed 1.9 billion to the Colorado economy, both directly and indirectly, for the 2015-2016 fiscal year. CPW operates 15 fish propagation facilities, including the Roaring Judy Hatchery for the propagation of endangered Colorado River fish, which may be affected in times of drought due to reduced revenues and/or water resources. In 2002, fishing license sales declined by about 15% from 2001, and there was a 13.4% decline in fishing recreation days from 2001 to 2002. Salmon runs were impacted by the 2012 (latest) major drought in Colorado (The Journal, 2012). The drought prevented the annual run due to low water levels in the Dolores River, which created a shallow, delta-like area of sediment that blocked the salmon from migrating. Kokanee eggs placed on the Dolores River by CPW to bolster the adult fish stocks in the McPhee Reservoir were not able to reach upstream spawning waters.
<b>Losses to wildlife</b>	Hunting license sales, wildlife throughout the state, management costs	CPW estimates that hunting (big and small game) generated \$292.6 million in direct visitor expenditures for the 2011-2012 fiscal year. This revenue helped support over 900 full time CPW employees. While CPW license sales have generally increased over time, reductions in total sales were apparent during the 2012 and 2013 years (CPW 2015). A possible/partial explanation of the decrease in sales could be drought conditions and negative public perception of the health of State Parks, natural resources, and wildlife. The number of full time CPW employees has reduced slightly since 2011-2012, down to 886, likely due to changes in spending and budgets.
<b>Costs and losses to state parks</b>	Revenues, damage to parks themselves	For the 2015-2016 fiscal year, Colorado’s state parks had over 13.6 million visitors. Visitors to Colorado state parks contribute over \$6 billion annually to local economies, directly and indirectly. Back in 2002, state parks experienced a 3% decline in visitation.

Potential Economic Impacts to State Facilities	Where Potential Losses and Effects Could be Exhibited	State Economic Exposure and/or Past Drought Impacts
<b>Losses due to hydrological effects</b>	State-owned instream flows	CWCB has appropriated instream flow water rights on over 1,800 stream segments covering 10,332 miles of streams (as of 2018). Instream flow impacts during the 2002 drought were mitigated somewhat by downstream senior water rights calls. While acquisition of instream flows can benefit state-owned environmental assets, extensive junior rights can prove limiting in times of water scarcity and drought.

Source: Colorado Drought Mitigation and Response Plan 2018

Many state assets are conservation areas or protected wildlife that cannot be adequately evaluated based on the revenue they generate. Colorado is renowned for its wilderness areas and outdoor recreation activities, and the value of these areas goes far beyond any revenue stream. Still, economic consideration is important because the revenues generated by state assets help to maintain protected areas. For a more thorough discussion of state assets (e.g., buildings, dam storage), economic values, and specific vulnerability to drought for each county in the state, among other topics related to these Colorado assets, please visit the 2018 update to the Colorado Drought Mitigation and Response Plan documents, including the Risk Assessment chapter, Chapters 1-4 Drought Vulnerability Assessment Technical Information, and the Annex B – State Assets document.

## 11. RESOURCES

- Colorado Climate Plan. 2018.
- Colorado Drought Mitigation and Response Plan, 2013 and 2018 updates.
- Drought Water Supply Assessment (DWSA). 2004.
- Colorado Parks and Wildlife. 2015. License Revenue History.
- Colorado State Land Board Commissioners. 2014. Income and Inventory Report – Fiscal Year 2013-2014 – Annual Review of Income Generated by State Trust Lands.
- Colorado Water Conservation Board (CWCB). 2014. Climate Change in Colorado – A Synthesis to Support Water Resources Management and Adaptation.
- CWCB. 2017. Colorado’s Water Supply Future – Water Supply Reserve Fund Annual Report.
- Gunter, Allison, Goemans, Christopher, Pritchett, James, and Dawn Thilmany. 2012. *The economic impact of the 2011 drought on southern Colorado: A combined input-output and EDMP analysis*. Department of Agricultural and Resource Economics, Colorado State University.
- International Panel on Climate Change (IPCC). 2014. Fifth Assessment Reports. 2018

- McKee, Thomas B, Nolan J. Doesken, and John Kleist. 1999. Historical Dry and Wet Periods in Colorado, *Climatology Report 99-1, Part A: Technical Report, Part B: Appendices*, Dept. of Atmos. Sci., CSU, Fort Collins, CO, July 1999.
- National Drought Mitigation Center. 2018. Drought Impact Reporter.
- National Drought Mitigation Center. 2018. U.S. Drought Monitor.
- National Oceanic and Atmospheric Administration (NOAA). 2010. U.S. Standardized Precipitation Index.
- Pielke, Sr, R. A., Doesken, N. & Bliss, O. 2003. Climate of Colorado. *Climatology Report 60*, Department of Atmospheric Science, Colorado State University, Fort Collins, CO.
- Ryan, Wendy, and Doesken, Nolan. 2013. Drought of 2012 in Colorado. *Climatology Report 13-01*. Dept. of Atmos. Sci., CSU, Fort Collins, CO. June 2013.
- The Gazette. 2012. Waldo Canyon Fire: Tally of Destruction Remains Imprecise. <http://gazette.com/waldo-canyon-fire-tally-of-destruction-remains-imprecise/article/144967>
- The Journal. 2012. Drought Impacts Salmon Run. <https://the-journal.com/articles/2294>
- Tronstad, R. & Feuz, D. 2002. Impacts of the 2002 Drought on Western Ranches and Public Land Policies. *Western Economics Forum*, 1, pp. 19–24.

# EXTREME HEAT



## 1. DEFINITION

Extreme heat can pose severe and life-threatening problems for Colorado’s citizens. Extreme heat is defined as temperatures over 90 degrees for an extended period of time, or that hover 10 degrees or more above the average high temperature for the region and last for multiple consecutive days. Humid or muggy conditions, which add to the discomfort of high temperatures, occur when a "dome" of high atmospheric pressure traps hazy, damp air near the ground. Excessively dry and hot conditions can provoke dust storms and low visibility. Droughts occur when a long period passes without substantial rainfall. A heat wave combined with a drought is a very dangerous situation.

Many parts of the State of Colorado, including much of the eastern and flat-lying areas on the Western Slope, experience extreme temperature variations, and much of the state is high desert and subject to very dry and hot conditions and frequent droughts. Humidity levels are also usually low, averaging less than 37 degrees for mean dew point temperature throughout the state. Table 3-30 summarizes extreme heat profile results.

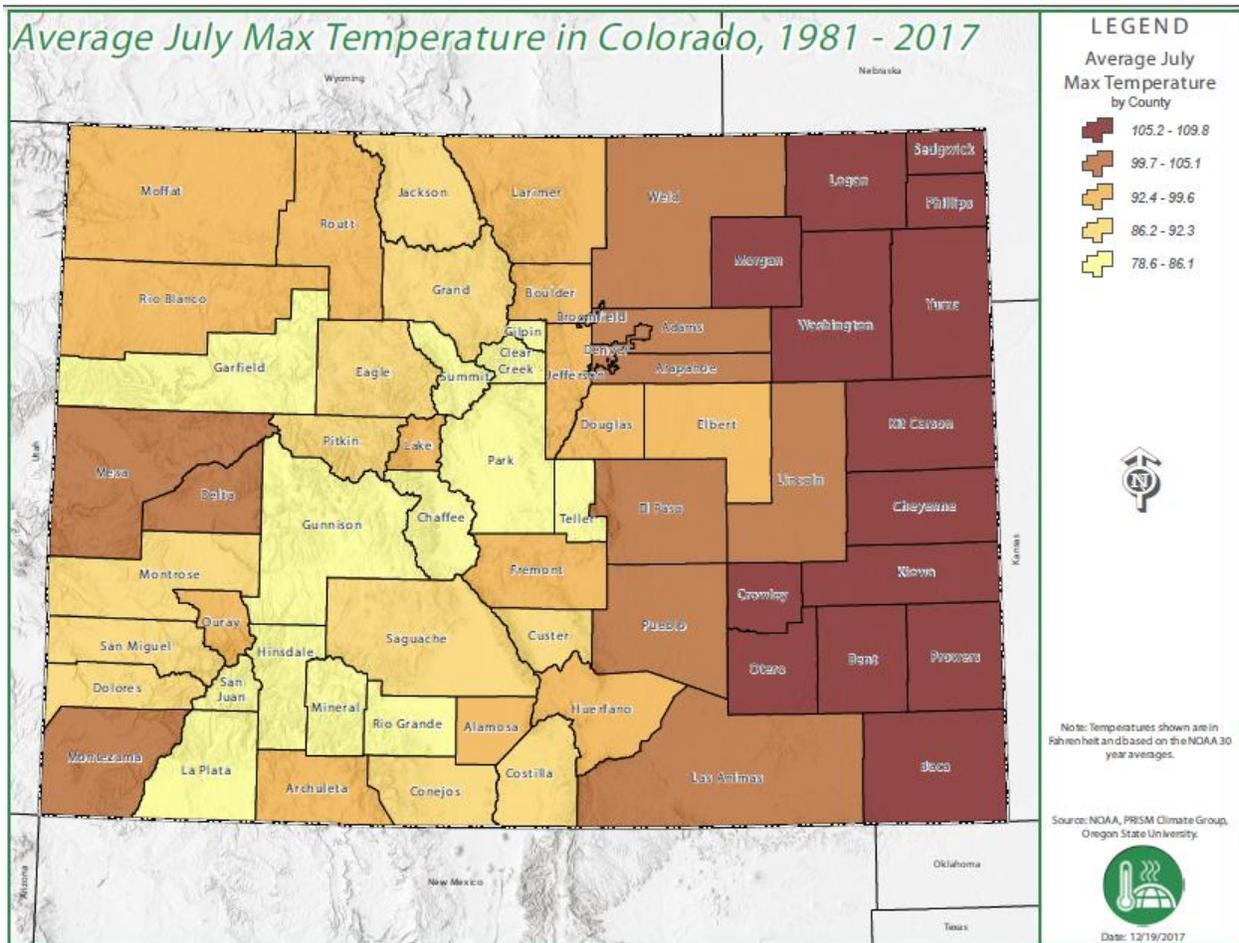
TABLE 3-30 HAZARD PROFILE SUMMARY

Consideration	Impact	Description
<b>Location</b>	Regional	Areas of the state with highest temperatures are concentrated along the Front Range and Eastern Plains, the Grand Valley, and extreme southwest.
<b>Previous Occurrences</b>	Seasonal	Every few years in high temperature prone areas of the state, average temperatures will be at extreme highs for one to three weeks.
<b>Probability</b>	Occasional	Each year, any number of days with extreme heat exceeds normal high temperatures around the state. High temperature events of prolonged duration are not frequent.
<b>Extent</b>	Moderate	Limited property damage that does not threaten structural integrity; minor injuries; minor impacts to critical services or facilities.

## 2. LOCATION

Average temperatures across Colorado vary by area and with changes in elevation, as shown in Figure 3-10, which identifies average maximum temperatures between 1981 and 2017. The Eastern Plains and Western Slope of the state experience average temperatures in July between 70 and 80 degrees. At higher elevations, these temperatures tend to be lower with highs reaching into the 60s (Climate.gov “Data Snapshots”, accessed December 2017).

FIGURE 3-10 AVERAGE HIGHEST TEMPERATURES IN JULY



Highest recorded temperatures by county tend to be in the eastern to southeastern part of the state. Colorado’s far eastern counties of Bent, Baca, Cheyenne, Crowley, Kiowa, Kit Carson, Logan, Morgan, Otero, Phillips, Prowers, Pueblo, Sedgwick, Washington, and Yuma all have reported record temperatures over 105 degrees. All of these counties also, on average, experience more than five days over 90 degrees each year.

Colorado’s far eastern side also experiences the highest humidity levels throughout the year, adding to the feel and relative health danger of extreme heat events. During the month of August (over the 30-year period between 1981 and 2010 which is the best available 30-year average), when humidity levels are typically highest, the far eastern portion of the state’s average dew point temperature is 55 to 59 degrees. This is relatively low humidity compared to much of the nation, and is generally not high enough to greatly alter risk to human health during extreme heat events. Humidity levels decrease gradually moving west across the state.

Another locational factor in temperatures are localized ground conditions and shade cover. An effect known as the urban heat island causes metropolitan areas to regularly experience higher

temperatures than surrounding more rural areas. The temperature difference usually is larger at night than during the day, and is most apparent when winds are weak. The main cause of the urban heat island effect is from the modification of land surfaces from soil and vegetation to human materials which store more heat. On a hot, sunny summer day, roof and pavement surface temperatures can be 50–90°F (27–50°C) hotter than the air, while shaded or moist surfaces - often in more rural surroundings - remain close to air temperatures (EPA, “Heat Island Impacts”, accessed December 2017).

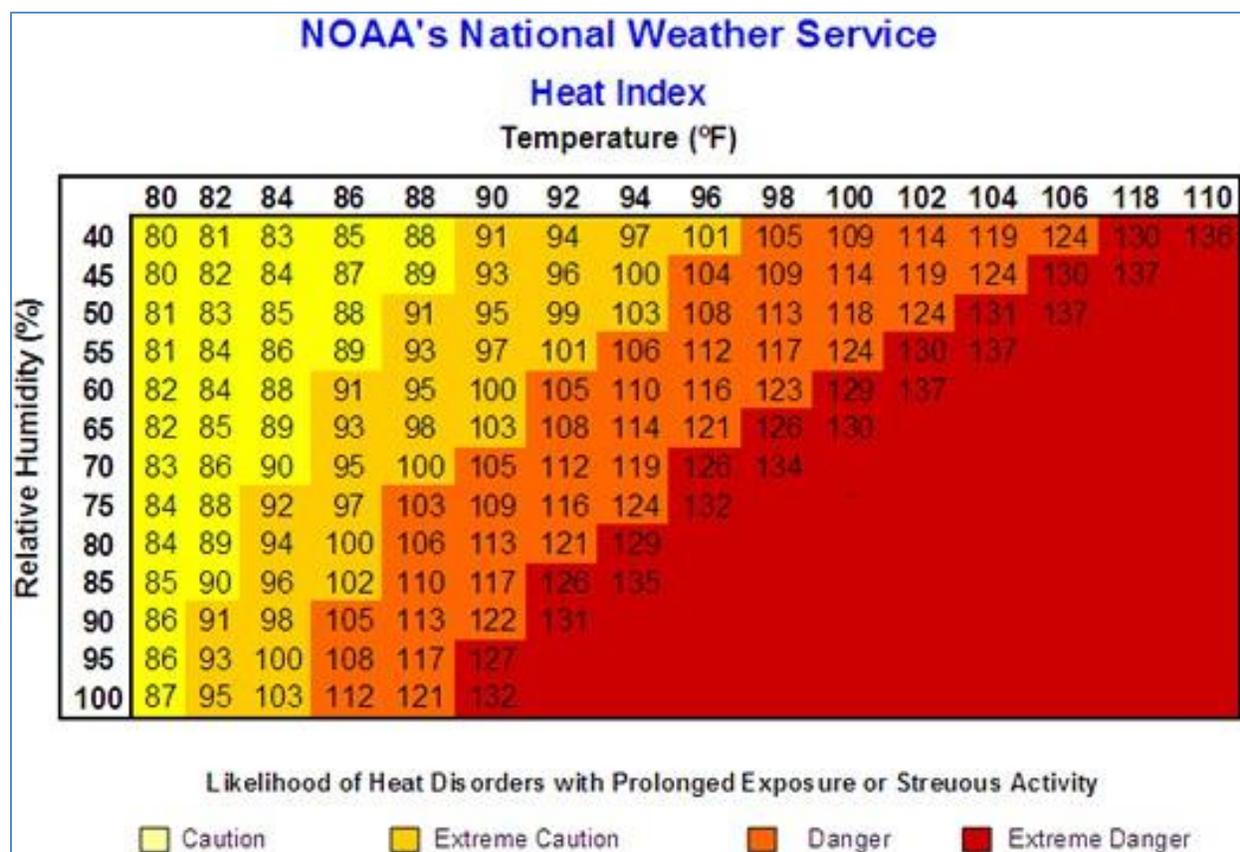
These surface urban heat islands, particularly during the summer, have multiple impacts and contribute to atmospheric urban heat islands. Air temperatures in cities, particularly after sunset, can be as much as 15 degrees to 27 degrees warmer than the air in neighboring, less developed regions. As a population center grows, it tends to expand its area and increase its average temperature. In addition to raising average daytime temperatures and reducing night-time cooling effects, heat islands can also exacerbate the impact of extreme heat events. Although trees and foliage can moderate impacts for local areas, the urban heat island effect usually encompasses a broader area. Due to the heat island effect, the major urban areas of the state, including the Denver Metro area, Fort Collins Metro area, and Colorado Springs are likely to experience more extreme heat events than their respective regions as a whole. The effects of urban heat islands may not be reliably documented in countywide averages of temperatures used throughout this section, since the weather stations used to provide official temperature records are frequently outside core metro areas. Consequently, it is assumed that cities will experience temperatures up to 20 degrees hotter than the county averages.

### **3. EXTENT (MAGNITUDE/STRENGTH)**

According to the Centers for Disease Control and Prevention (CDC), temperatures of 90 degrees and above can cause major health impacts, depending on individuals’ exposure and humidity, while temperatures over 100 degrees can also cause strain or degrade infrastructure. High temperatures are a higher risk to human health when combined with high humidity. Figure 3-11 shows NOAA’s National Weather Service Heat Index which indicates the way that temperature, humidity, and wind speed feels to the human body. Because daytime relative humidity throughout Colorado rarely exceeds 40 percent, humidity is not considered a major factor in determining extreme heat risks in Colorado’s counties. Although the heat index provides a generalized expression about the “feel” of the weather in terms of a temperature equivalent, conditions for each individual will still vary with the duration and type of weather exposure, personal health, extent of acclimation, and the type of clothing worn. For example, exposure to full sunshine can increase heat index values by up to 15 percent. Also, cooler air holds less moisture, and dryer air readily allows the cooling evaporation of perspiration from skin. In other words, the heat index and wind chill index only involve a consideration of two important factors, but they are still more useful than a consideration of temperature alone. The Heat Index table assumes shady conditions with a light wind. Actual indoor conditions may vary, trapping heat and /or humidity in some locations and making them potentially much more

dangerous. Prolonged exposure, physical activity, and age all tend to increase the risks associated with heat. Conditions that might cause heat cramps in a teenager could be experienced as heat exhaustion by a middle-aged person and as heat stroke by a senior citizen. Young infants are also vulnerable to heat effects.

FIGURE 3-11 HEAT INDEX TABLE



Source: NOAA

Similarly, temperatures over 90 degrees can also impact roads, bridges, railways, and airports. Road materials have a limited range of heat tolerance, and road buckling occurs with sustained temperatures above 90 degrees. Bridges are particularly vulnerable to extended high temperatures, which stress bridge integrity. Extended periods of extreme heat shorten pavement life and cause bridges to expand, with negative economic impacts.

For the purposes of this Plan, potential risk from extreme heat is considered moderate with temperatures over 90 degrees, high with temperatures over 95 degrees, and extreme with temperatures over 100 degrees, as summarized in Table 3-31. The scale assumes a relative humidity of less than 50% which is predominant in the state.

TABLE 3-31 HEAT INDEX TABLE

Max Daily Temperature	Type of Damage Possible
90°F-94.9°F	<b>Moderate:</b> Possible health risks for vulnerable populations including the elderly, infants, those with compromised heart or cardiovascular function, or those without shelter or shade. Increased wear on roads and bridges over extended durations.
95°F-99.9°F	<b>High:</b> Potential health risks for all populations if exposed over several days and for those without access to reliable transportation or shelter without effective insulation or air conditioning. Asphalt roads soften causing increased wear on roads and bridges. Increased strain on electricity grid. Livestock and crops stressed.
>100°F	<b>Extreme:</b> Life-endangering for all populations if exposed for more than several hours and without access to reliable transportation or shelter without effective insulation or air conditioning. Increased wear on roads and bridges and possibility of road buckling; train rails develop sun kinks and distort. Stress on automobile cooling systems, diesel trucks, and railroad locomotives. Possible disruption of airport operations. Major strains on electricity grid up to 6% above normal, power lines sag, and possible brown-outs or black-outs. Livestock, such as rabbits and poultry, are severely impacted.

A heat wave, defined as a heat event where temperatures are above 90 degrees for five or more consecutive days, poses a greater danger than five high heat days spread out over time, due to latent heat retention and stress on energy and water systems.

High temperatures in comparison to the area’s average temperatures are also important, since communities’ infrastructure and systems to deal with heat, such as air conditioning, insulation, and shade, are usually installed and built to specifications to reflect typical climate conditions. For example, temperatures of over 100 degrees in Boulder County, with typical summer temperatures in the high 60s, may pose greater risks than 100 degree days in Yuma County, where such high heat days are more common and homes typically have greater insulation and air conditioning.

#### 4. PROBABILITY

Temperature, taken together with other key climate factors such as humidity and precipitation, is typically described statistically in aggregate over 30 years or more to determine probabilities. Since temperatures vary significantly by day, season, and year, aggregate data is necessary to understand current and future probability of extreme heat events.

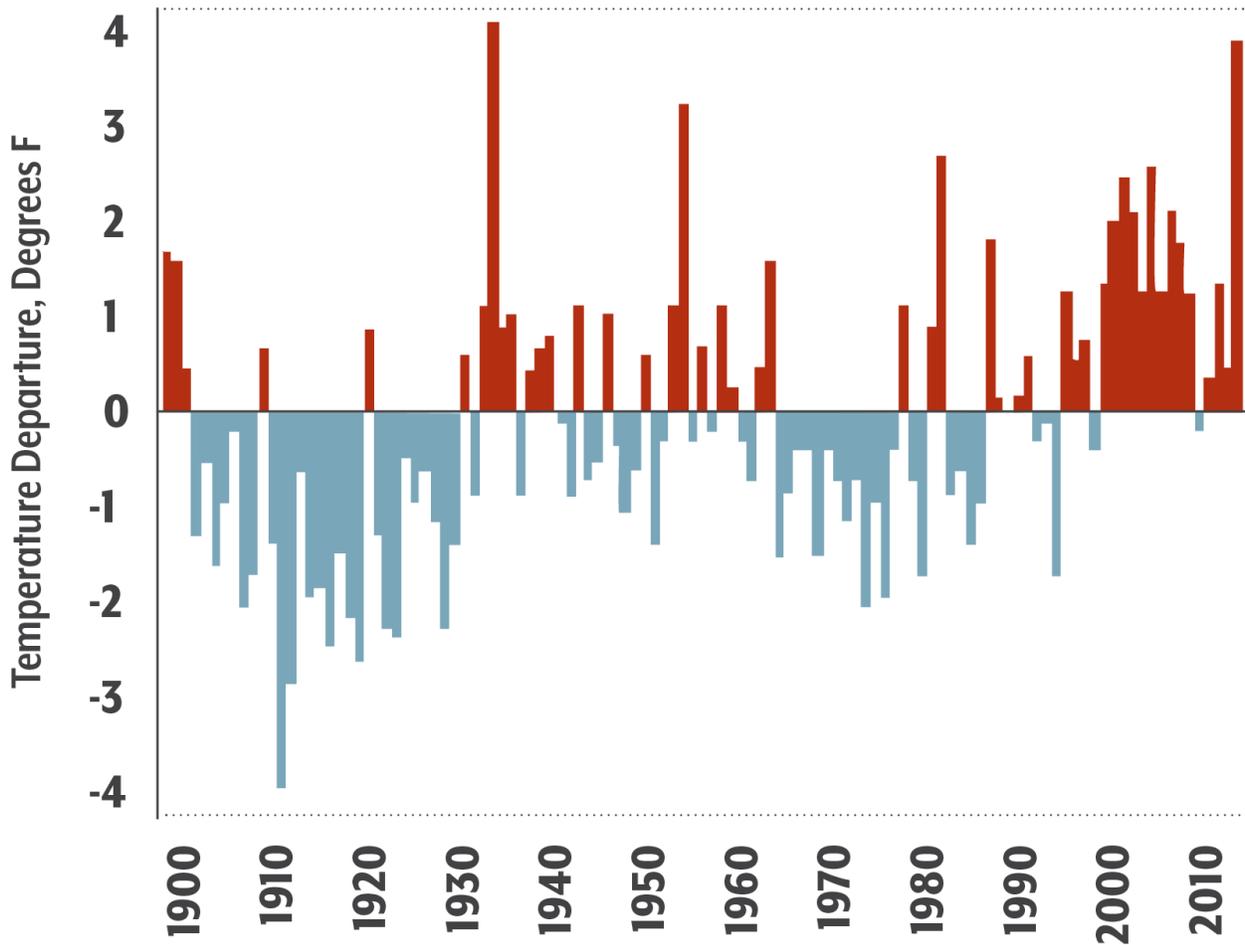
Colorado’s average temperature over the 30-year period from 1981-2010 was 50.7 degrees (Colorado Health Institute, July 2017). Average summer temperatures in the state range from 60 degrees to just over 80 degrees. Record high temperatures in Colorado tend to peak between

105 and 110 degrees, with 26 counties experiencing record highs above 100 degrees and 45 counties experiencing record highs above 90 degrees (Prism Climate Group, accessed December 2017).

In Denver, eight of the last 13 years have had between 50 and 73 days with temperatures of at least 90 degrees. Similarly, a 2016 Climate Central report indicates that Greeley ranks in the top 10 cities in the nation with the biggest increase in the number of average days above 100 degrees each year since the 1970s. Fort Collins is on the list of top 25 cities with the biggest increase in days where the temperature climbed above 90 degrees each year since the 1970s. Northeastern counties show similarly dramatic temperature increases, with Yuma seeing a 18% jump in days over 95 degrees in July since 1981, according to NOAA data reports. These are just examples, as these trends extend across the warmer locations in the state; while the exact shifts in overall temperature over the last decade varies based on elevation, geography, and urban development, the trend across all counties is higher average temperatures by 2 degrees and more high heat days.

The average fluctuates year over year by as much as four degrees up or down. Figure 3-12 plots the annual average temperature relative to that average from 1900 to 2012, which is the best available graphic denoting these trends. The blue bars represent years when the average temperature was below the 30-year baseline. Red bars mark years when the average temperature rose above the baseline.

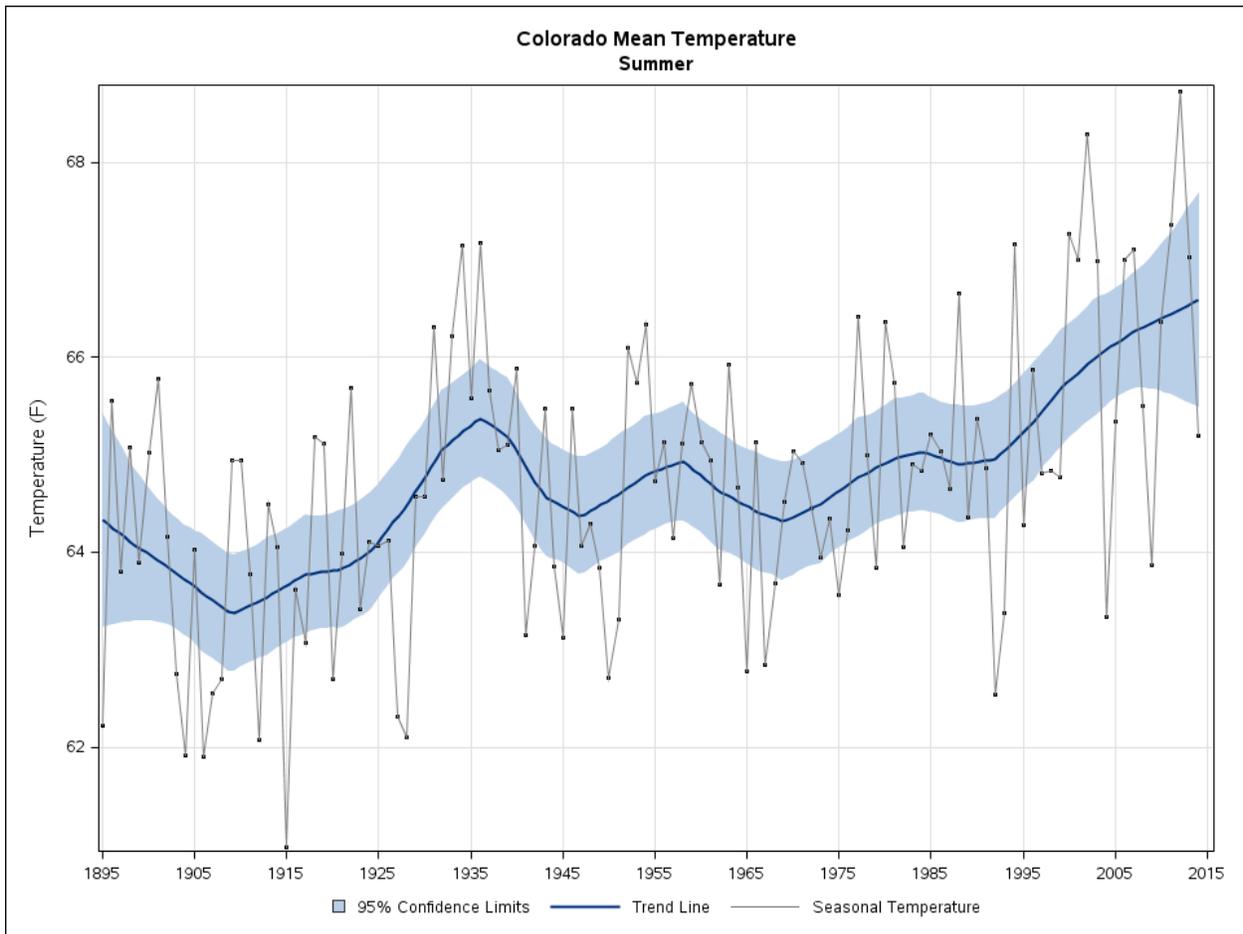
FIGURE 3-12 COLORADO TEMPERATURE TRENDS, 1900 TO 2012



Source: Colorado Health Institute, Colorado’s Climate and Colorado’s Health, June 2017

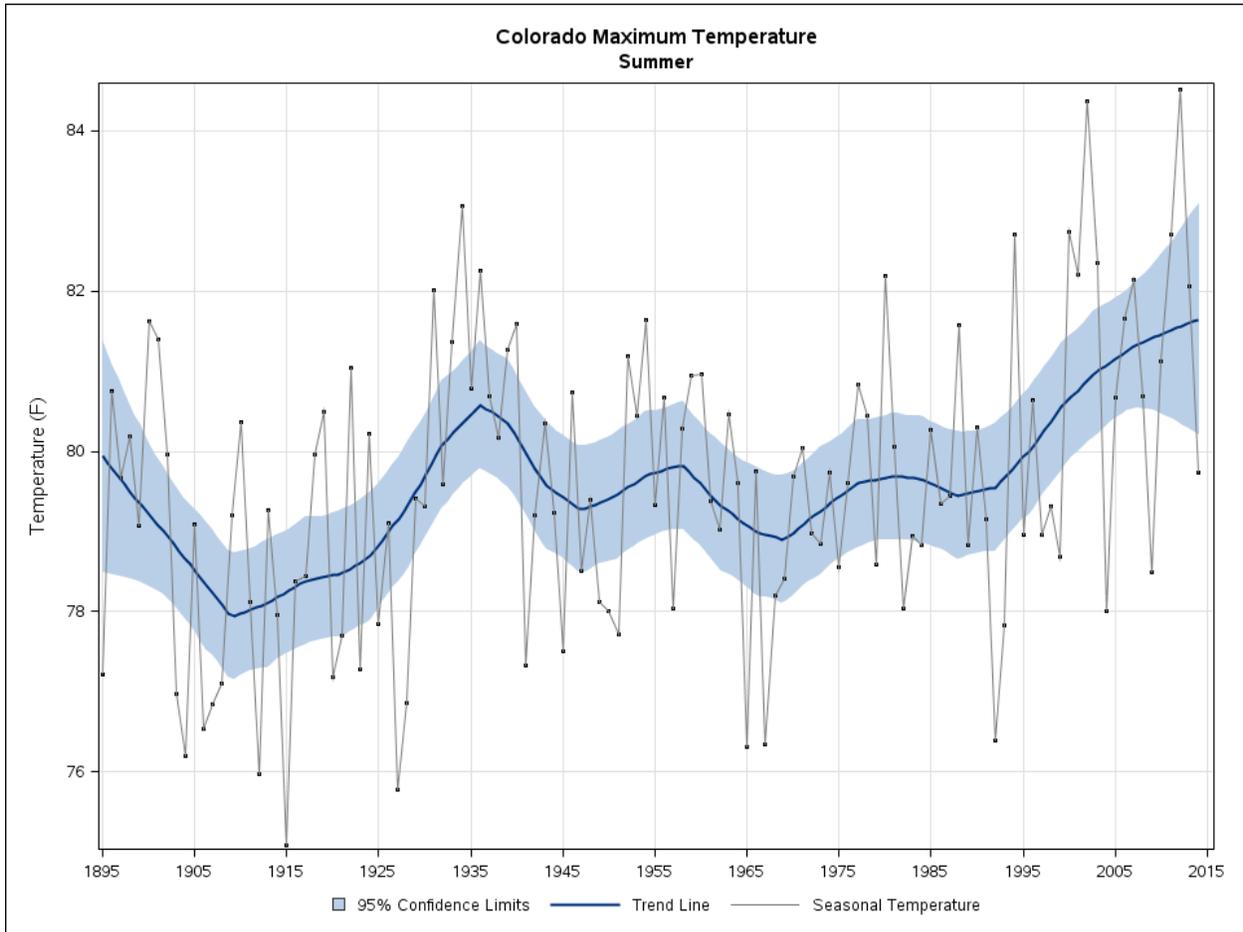
Average temperatures are also trending upward according to NOAA. Figure 3-13 shows annual average temperatures in summer over the last 120 years, illustrating the upward trend from roughly 64 degrees in 1895 to close to 67 degrees in 2015. Figure 3-14 shows the average maximum temperatures during the hottest months of summer, which by 2015 had a trend of close to 82 degrees, with spikes above 84 degrees in recent years. The state’s average temperature has risen by two degrees Fahrenheit in the past 30 years, an increase that ranks Colorado as the 20th fastest-warming state since 1970.

FIGURE 3-13 COLORADO TEMPERATURE TRENDS



Source: NOAA State Annual and Seasonal Time Series, accessed December 2017

FIGURE 3-14 COLORADO TEMPERATURE TRENDS



Source: NOAA State Annual and Seasonal Time Series, accessed December 2017

According to NOAA, in 2016 the contiguous United States average temperature was 54.9°F, 2.9°F above the 20th century average. This was the second warmest year for the nation (excluding Alaska), behind 2012 when the annual average temperature was 55.3°F. This marks the 20th consecutive year that the annual average temperature was above the 20th century average. The number of hottest record days and extreme events are also increasing as annual averages increase.

This data supports a globally documented shift towards a warmer climate with an increase in extreme high temperatures and a reduction in extreme low temperatures as a result of human-caused climate change.

## 5. PREVIOUS OCCURENCES

Extreme high temperatures recorded in Colorado counties are shown in Table 3-32. Although viewing record highs does not necessarily equate to prolonged extreme heat events, the table provides an indication of potential temperature extremes across the state. Figure 3-15 provides

a heat map based on the number of total extreme events by county that have occurred between 1981 and 2017.

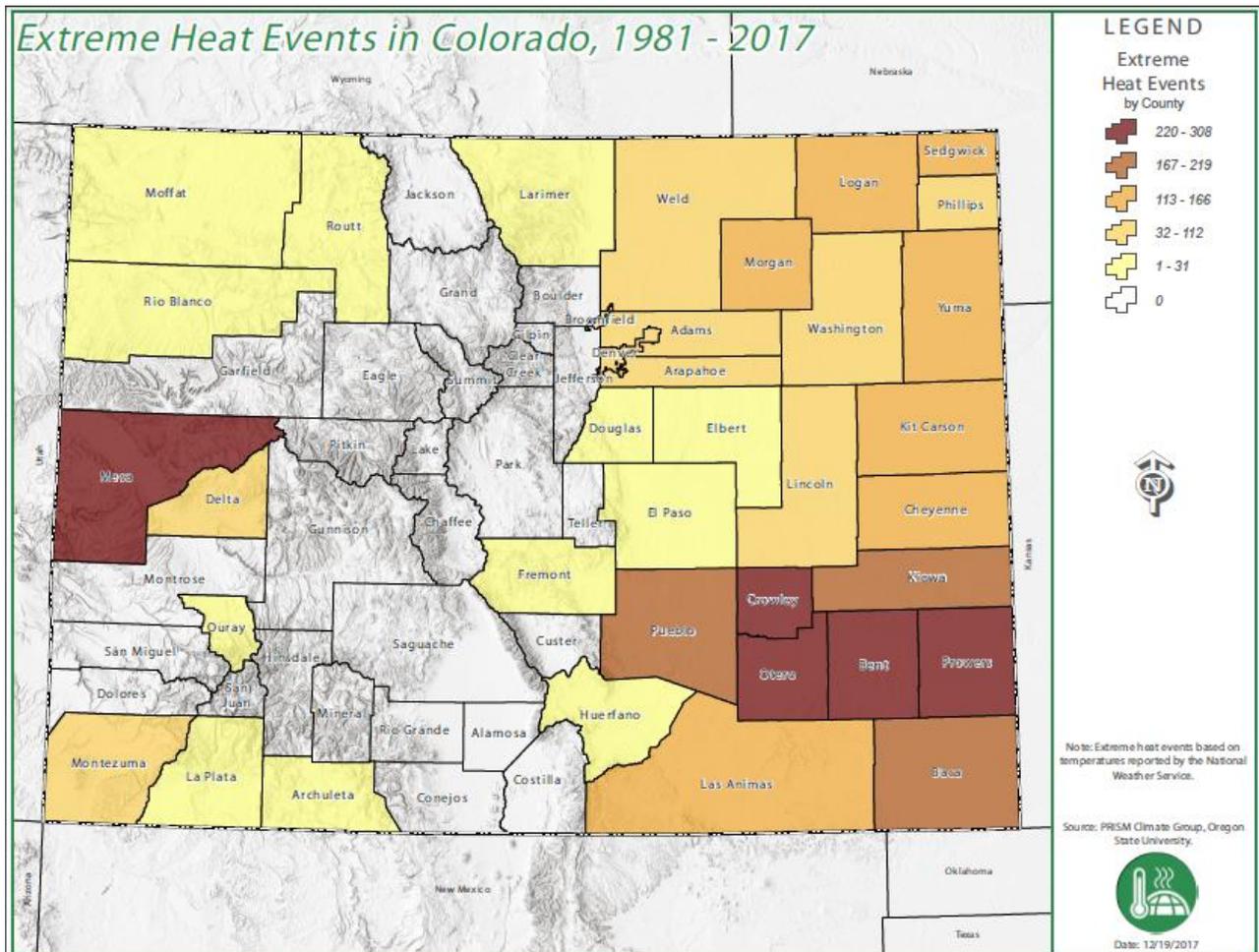
**TABLE 3-32 SUMMARY OF EXTREME HIGH TEMPERATURES IN COLORADO BY COUNTY, 1981-2017**

<b>County</b>	<b>Days over 90°F</b>	<b>Days over 95 °F</b>	<b>Days over 100 °F</b>	<b>Heat Waves</b>
<b>Adams</b>	1,406	426	46	99
<b>Alamosa</b>	38	0	0	0
<b>Arapahoe</b>	1,035	248	15	70
<b>Archuleta</b>	108	3	0	7
<b>Baca</b>	2,090	957	144	217
<b>Bent</b>	2,700	1,511	480	308
<b>Boulder</b>	34	0	0	0
<b>Broomfield</b>	1,315	385	42	102
<b>Chaffee</b>	0	0	0	0
<b>Cheyenne</b>	1,801	769	121	164
<b>Clear Creek</b>	0	0	0	0
<b>Conejos</b>	0	0	0	0
<b>Costilla</b>	12	0	0	0
<b>Crowley</b>	2,386	1,221	305	266
<b>Custer</b>	0	0	0	0
<b>Delta</b>	1,093	215	16	102
<b>Denver</b>	1,220	343	34	80
<b>Dolores</b>	5	0	0	0
<b>Douglas</b>	453	42	0	22
<b>Eagle</b>	0	0	0	0
<b>Elbert</b>	580	76	3	31
<b>El Paso</b>	256	18	0	11
<b>Fremont</b>	345	25	0	19
<b>Garfield</b>	0	0	0	0
<b>Gilpin</b>	0	0	0	0
<b>Grand</b>	0	0	0	0
<b>Gunnison</b>	0	0	0	0
<b>Hinsdale</b>	0	0	0	0
<b>Huerfano</b>	240	13	0	10
<b>Jackson</b>	2	0	0	0
<b>Jefferson</b>	30	0	0	0
<b>Kiowa</b>	2,224	1,116	247	219
<b>Kit Carson</b>	1,627	659	100	136
<b>Lake</b>	0	0	0	0
<b>La Plata</b>	129	3	0	7
<b>Larimer</b>	39	1	0	1
<b>Las Animas</b>	1,637	466	25	166

County	Days over 90°F	Days over 95 °F	Days over 100 °F	Heat Waves
Lincoln	1,201	322	20	85
Logan	1,877	881	196	157
Mesa	2,104	835	128	259
Mineral	0	0	0	0
Moffat	251	10	0	14
Montezuma	996	183	5	105
Montrose	9	0	0	0
Morgan	1735	718	129	143
Otero	2544	1342	334	282
Ouray	149	6	0	12
Park	0	0	0	0
Phillips	1341	498	82	89
Pitkin	0	0	0	0
Prowers	2483	1337	370	264
Pueblo	1970	778	103	196
Rio Blanco	429	61	0	28
Rio Grande	0	0	0	0
Routt	106	3	0	5
Saguache	0	0	0	0
San Juan	0	0	0	0
San Miguel	1	0	0	0
Sedgwick	1581	693	136	132
Summit	0	0	0	0
Teller	0	0	0	0
Washington	1351	477	59	102
Weld	1492	529	67	112
Yuma	1724	767	172	147

Source: PRISM Climate Group, Oregon State University, <http://prism.oregonstate.edu>. Visited December 2017

FIGURE 3-15 HISTORIC EXTREME HEAT EVENTS (1981-2017)



The state has experienced major, widespread heat waves during the Dust Bowl in the 1930s and the La Nina event in the mid-1950's. During July 2008, temperature records for the number of consecutive days above 90 degrees was broken. The new record (24 days) surpassed the previous record by almost a week and was then equaled again in 2012. In 2012, Colorado was 6.4 degrees warmer than average, making Colorado the warmest state in the union for the month of July. That year, the state broke eight heat records and tied 15. Eastern state counties including Prowers and Bent recorded repeated unofficial highs over 110 degrees.

Excessive heat events, or abrupt and dramatic temperature increases, are particularly dangerous and can result in above-average rates of mortality. The Centers for Disease Control and Prevention estimates that from 1979 to 2003, excessive heat exposure contributed to more than 8,000 premature deaths in the United States. Fortunately, no heat-related deaths have been recorded in Colorado.

## 6. IMPACT ANALYSIS

Impacts from extreme heat and heat wave events can impact multiple aspects of Colorado populations and normal functions. Overall consequences are summarized in Table 3-33.

TABLE 3-33 EXTREME HEAT EMAP IMPACT SUMMARY

Consideration	Description
<b>General Public</b>	Affect human health by contributing to general discomfort, respiratory difficulties, heat cramps and exhaustion, non-fatal heat stroke, and heat-related mortality. People engaged in vigorous outdoor exercise are at most risk.
<b>Health Compromised Population</b>	Trigger life-threatening health impacts for children, older adults, or chronically infirm, and especially those with diabetes, cardiovascular disease, and other health conditions that weaken bodily temperature control/regulation and breathing.
<b>Economically Vulnerable Population</b>	Impacted ability to comfortably or safely withstand high heat events and to access and use disaster resources. Economic and social characteristics include homelessness, poverty, individuals who are socially isolated, those without adequate home cooling, and individuals without vehicle access.
<b>Facilities and Infrastructure</b>	Increased wear on roads and bridges and possibility of road buckling; train rails develop sun kinks and distort. Possible disruption of airport operations. Major strains on electricity grid, power lines sag, and possible brown-outs or black-outs.
<b>Economic</b>	Potential loss of facilities or infrastructure function or accessibility and uninsured damages. Impact to transportation sector and movement of goods. Historic events in Colorado have impacted community business districts where a majority of businesses are lost.
<b>Environment</b>	Significant impact related to natural ecosystems. Extended periods of extreme heat can stress both flora and fauna species while altering local habitat.
<b>Continuity of Government and Services</b>	Loss of facilities or infrastructure function or accessibility or ability to provide services. Power interruption is likely if not adequately equipped with backup generation.
<b>Confidence in Government</b>	Public holds high expectations of government capabilities for warning, public information, and response related to extreme heat events.
<b>Critical Assets</b>	Potential impacts relate to water scarcity and electrical grid stress. Interruption of rail and airport operations, and damages to road, bridge, and power infrastructure.

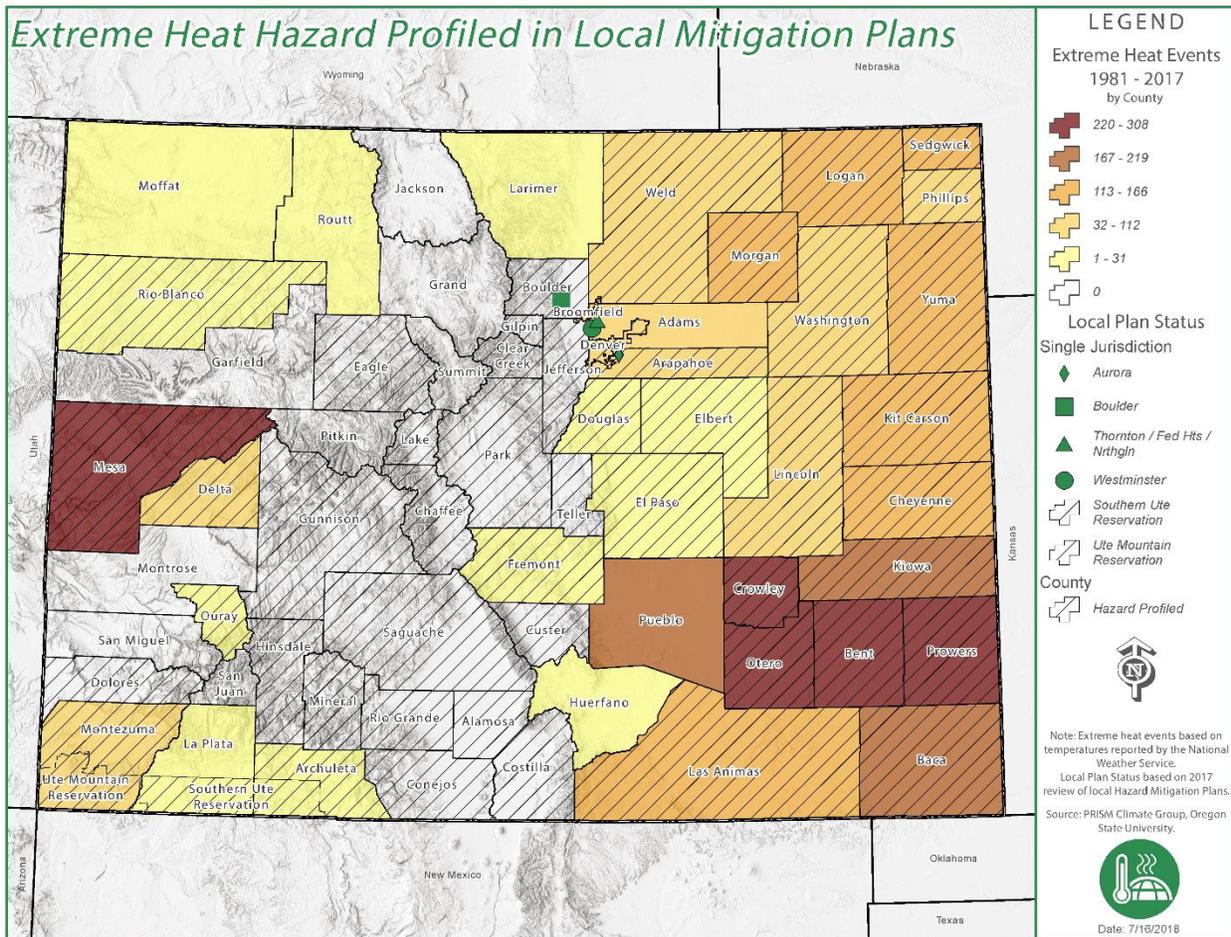
## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

The population of Colorado has become less sensitive to the impacts of excessive heat events over the course of the past 30 to 40 years despite rising urban temperatures. This is a trend common to most major cities across the United States as a result of increased availability and use of air conditioning and the implementation of social programs aimed at caring for high-risk individuals.

For nearly all cities, including Denver, the number of heat-related deaths is declining - meaning that the population has become better adapted to heat waves. This adaptation is most likely a result of improvements in medical technology, access to air-conditioned homes, cars, and offices, increased public awareness of potentially dangerous weather situations, and proactive responses by municipalities during extreme weather events.

Various adaptations, health impacts, and infrastructural damages continue to occur from the escalating numbers of extreme temperature events occurring within Colorado's local jurisdictions. Based upon a recent (2017) review of local mitigation plans, Figure 3-16 illustrates whether extreme heat risks are considered in the local mitigation plans of each county and each major municipality. Most counties across Colorado and several major municipalities along the Front Range have profiled extreme heat in their local hazard mitigation plans. All counties with a high amount of historical extreme heat events (noted red and dark orange on the map) have profiled extreme heat risks.

FIGURE 3-16 EXTREME HEAT HAZARD IN LOCAL MITIGATION PLANS



Based on review of local hazard mitigation plans, only Arapahoe County has identified extreme heat as one of their top four hazard, however, no loss information was provided.

## 8. FUTURE DEVELOPMENT

Population growth and development contribute to increased exposure of people and infrastructure to extreme heat events and their related impacts, and will continue to amplify the effects of extreme heat events on critical systems, services, and infrastructure. Understanding changes in hazard exposure over time is an important element of comprehensive hazard mitigation planning. Among other things, increased population and development elevate exposure levels of property and people to the impacts of extreme heat.

Colorado continues to experience some of the largest population growth in the country and future projections seem to indicate a similar trend should be expected. Table 3-34 presents the projected percent change in housing on a county scale from 2010 - 2030. As shown, five of the counties with the highest percent change in housing also have, on average, one or more extreme heat days a year, and several, including Adams, Broomfield, and Weld have had 99 or

more heat waves since 1981. Additionally, three counties with high housing growth, Crowley, Mesa, and Pueblo have more than five extreme heat days, on average, per year.

TABLE 3-34 HOUSING PROJECTIONS (2010 TO 2030) AND HISTORICAL EVENTS

County	Historical Extreme Heat Days	Historical Heat Waves	Housing Percent Change	Growth Rating
Weld	5.7	112	93%	Highest
Adams	5.1	99	60%	Highest
Broomfield	4.8	102	78%	Highest
Arapahoe	3.6	70	52%	Highest
Elbert	1.8	31	120%	Highest
Douglas	1.4	22	67%	Highest
La Plata	0.4	7	50%	Highest
Archuleta	0.3	7	61%	Highest
Routt	0.3	5	46%	Highest
Larimer	0.1	1	47%	Highest
Park	0	0	65%	Highest
San Miguel	0	0	64%	Highest
Montrose	0	0	61%	Highest
Eagle	0	0	56%	Highest
Garfield	0	0	51%	Highest
Summit	0	0	49%	Highest
Crowley	10.7	266	26%	High
Mesa	8.4	259	38%	High
Pueblo	7.8	196	26%	High
Denver	4.4	80	37%	High
Lincoln	4.2	85	26%	High
Delta	3.6	102	35%	High
Montezuma	3.2	105	37%	High
Fremont	1	19	28%	High
El Paso	0.8	11	40%	High
Boulder	0.1	0	37%	High
Jefferson	0.1	0	30%	High
Grand	0	0	44%	High
Custer	0	0	41%	High
Chaffee	0	0	38%	High
Pitkin	0	0	34%	High
Gunnison	0	0	28%	High
Kiowa	9.8	219	12%	Moderate
Logan	8.1	157	21%	Moderate

County	Historical Extreme Heat Days	Historical Heat Waves	Housing Percent Change	Growth Rating
Yuma	7.3	147	17%	Moderate
Morgan	7.1	143	26%	Moderate
Kit Carson	6.5	136	20%	Moderate
Las Animas	5.8	166	23%	Moderate
Huerfano	0.7	10	13%	Moderate
Ouray	0.4	12	13%	Moderate
Alamosa	0.1	0	25%	Moderate
Teller	0	0	23%	Moderate
Lake	0	0	21%	Moderate
Clear Creek	0	0	20%	Moderate
Hinsdale	0	0	19%	Moderate
Saguache	0	0	17%	Moderate
Conejos	0	0	14%	Moderate
Gilpin	0	0	12%	Moderate
Bent	12.9	308	7%	Low
Otero	11.6	282	6%	Low
Prowers	11.5	264	3%	Low
Baca	8.7	217	-6%	Low
Cheyenne	7.4	164	11%	Low
Sedgwick	6.6	132	1%	Low
Phillips	5.3	89	1%	Low
Washington	5.2	102	8%	Low
Rio Blanco	1.3	28	10%	Low
Moffat	0.7	14	7%	Low
Costilla	0	0	10%	Low
Mineral	0	0	10%	Low
San Juan	0	0	10%	Low
Jackson	0	0	9%	Low
Rio Grande	0	0	7%	Low
Dolores	0	0	4%	Low

Source: NOAA, Colorado State Demography Office, 2017

The following section provides county-scale extreme heat exposure projections by comparing current extreme heat event risk with projected population data. Combined Risk calculations are based on the methodology outlined in Table 3-36. Values (between zero and three) have been assigned to total number of historic high heat days, and also have been assigned to heat waves for each county, as shown in Table 3-35. The Jenks Natural Breaks algorithm was used to classify these historical data sets into the four value categories (zero, one, two, and three). For

each county, the assigned high heat value and heat wave value are summed to arrive at a number between zero and six that represents the Combined Risk for that county.

**TABLE 3-35 COMBINED RISK METHODOLOGY**

# of Historical Extreme Heat Days	Value	# of Historical Heat Waves	Value
>2,850	3	>195	3
1,185-2,850	2	70-195	2
1-1,184	1	1-69	1
0	0	0	0

**TABLE 3-36 EXTREME HEAT EXPOSURE PROJECTIONS**

Future Extreme Heat Change in Exposure from Projected Growth					
		County Population Percent Change Projections, 2010 to 2030			
Combined Risk (Extreme Heat)		-13% to 2%	3% to 17%	18% to 34%	35% to 89%
<b>High</b>  <b>Moderate</b>	5-6	Moderate	High	Severe	Extreme
	3-4	Slight	Moderate	High	Severe
	0-2	Negligible	Slight	Moderate	High

Through this analysis, Weld, Broomfield, Adams, Denver, Montezuma, Arapahoe, Mesa, and Pueblo Counties show the highest risk with respect to future development, as shown in Table 3-37. The combination of a growing population and combined extreme heat risk results in increasing exposure over that of today. Thirteen additional counties will also have significantly increased exposure by 2030. Figure 3-17 visualizes this data on the Colorado map.

**TABLE 3-37 EXTREME HEAT EXPOSURE PROJECTIONS, 2010 TO 2030**

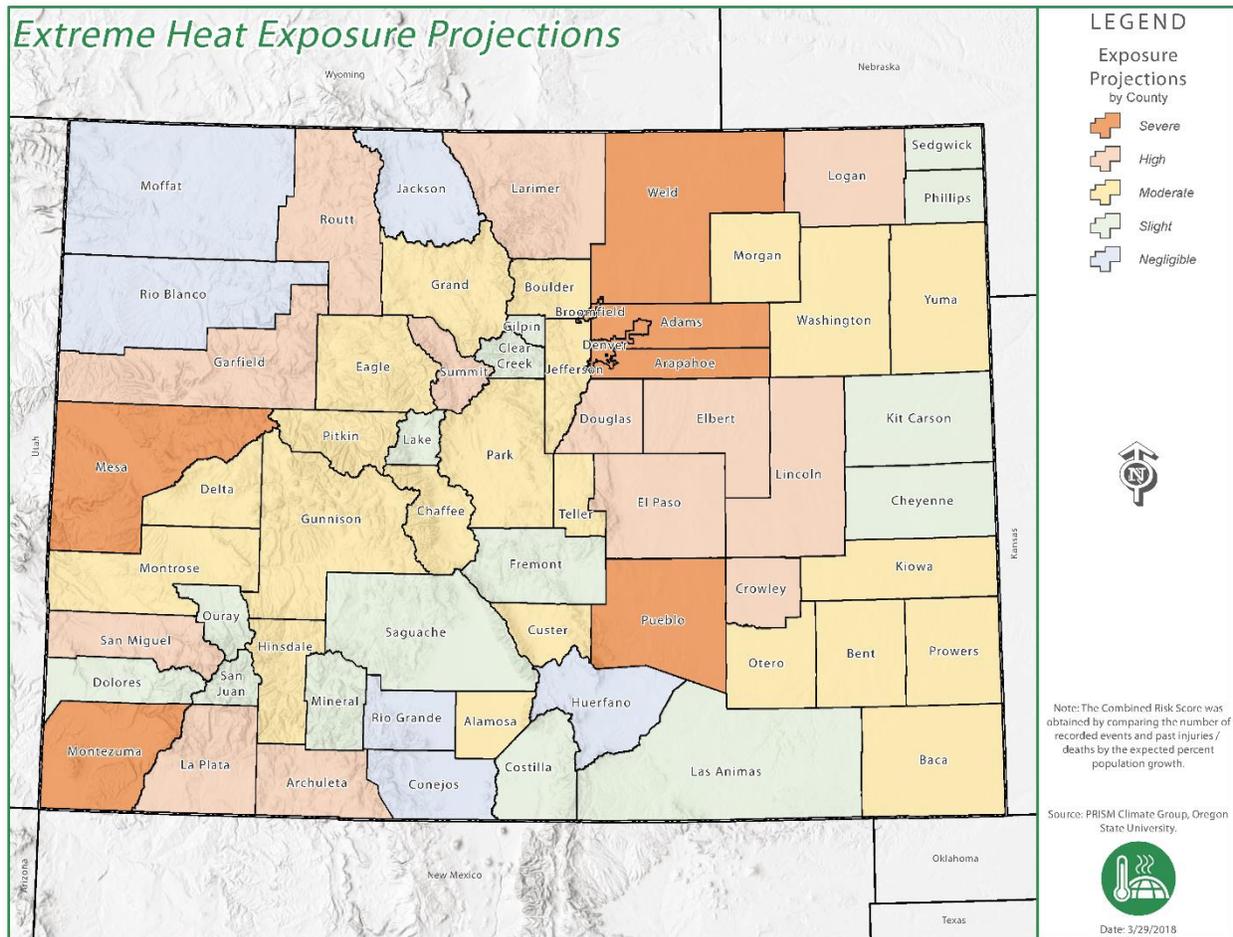
County	Combined Risk	Population Change	Exposure Rating
<b>Weld</b>	4	81%	<b>Severe</b>
<b>Broomfield</b>	4	71%	<b>Severe</b>
<b>Adams</b>	4	48%	<b>Severe</b>
<b>Denver</b>	4	42%	<b>Severe</b>
<b>Montezuma</b>	4	37%	<b>Severe</b>
<b>Arapahoe</b>	4	36%	<b>Severe</b>
<b>Mesa</b>	6	24%	<b>Severe</b>

County	Combined Risk	Population Change	Exposure Rating
Pueblo	6	20%	Severe
Elbert	2	89%	High
San Miguel	1	59%	High
Douglas	2	44%	High
La Plata	2	42%	High
Larimer	2	42%	High
Summit	0	41%	High
Routt	2	40%	High
Archuleta	2	40%	High
Garfield	0	38%	High
El Paso	2	36%	High
Lincoln	4	21%	High
Logan	5	14%	High
Crowley	6	5%	High
Park	0	34%	Moderate
Eagle	0	34%	Moderate
Grand	0	32%	Moderate
Montrose	1	30%	Moderate
Hinsdale	0	29%	Moderate
Chaffee	0	29%	Moderate
Boulder	1	28%	Moderate
Gunnison	0	26%	Moderate
Teller	0	25%	Moderate
Alamosa	1	22%	Moderate
Jefferson	1	21%	Moderate
Custer	0	20%	Moderate
Pitkin	0	18%	Moderate
Morgan	4	16%	Moderate
Delta	4	8%	Moderate
Yuma	4	7%	Moderate
Washington	4	5%	Moderate
Bent	6	-5%	Moderate
Prowers	6	-5%	Moderate
Otero	6	-7%	Moderate
Kiowa	6	-8%	Moderate
Baca	6	-13%	Moderate
Lake	0	17%	Slight
Ouray	2	17%	Slight
Mineral	0	16%	Slight
Clear Creek	0	14%	Slight
Gilpin	0	13%	Slight

County	Combined Risk	Population Change	Exposure Rating
Saguache	0	9%	Slight
Costilla	1	7%	Slight
Fremont	2	5%	Slight
Dolores	1	5%	Slight
San Juan	0	5%	Slight
Cheyenne	4	2%	Slight
Kit Carson	4	-1%	Slight
Sedgwick	4	-3%	Slight
Phillips	4	-3%	Slight
Las Animas	4	-9%	Slight
Rio Blanco	2	2%	Negligible
Conejos	0	1%	Negligible
Huerfano	2	-1%	Negligible
Moffat	2	-3%	Negligible
Rio Grande	0	-5%	Negligible
Jackson	1	-7%	Negligible

Source: NOAA, Colorado State Demography Office, 2017

FIGURE 3-17 EXTREME HEAT EXPOSURE PROJECTIONS, 2010 TO 2030



In review of local hazard mitigation plans, no information on future develop trends were profiled for extreme heat.

At this time, it is impossible to stop an extreme temperature event; however, limiting its effect on the population is feasible. Therefore, mitigation activities should be tailored towards protecting lives and preventing injury from an extreme temperature event. The following are some sample mitigation activities which can save lives in the event of an extreme temperature hazard:

- Conduct pre-season public information campaigns
- Establish cooling centers
- Identify locations of vulnerable populations
- Issue advisories and warnings
- Limit growth in areas with most extreme heat hazards
- Implement/support green roofing techniques and use impervious surface alternatives

## 9. CLIMATE CHANGE

According to the best data available at the time of this plan update, the future impacts of climate change are expected to influence future extreme heat events. Table 3-38 presents a breakdown of these projected changes in terms of hazard: location, extent/intensity, frequency, and duration. However, ongoing efforts to reduce Colorado’s greenhouse gas emissions and adapt to a changing climate, such as the Colorado Climate Plan, will help to reduce the impacts of climate change on extreme heat.

TABLE 3-38 CLIMATE CHANGE IMPACTS

Impact	Projected Change
<b>Location</b>	At present, extreme heat events occur in lower elevation areas across the state. These events are projected to increase and expand to more northern and higher elevation regions in the future.
<b>Extent/Intensity</b>	Extreme heat events are projected to increase in intensity. Extent is not projected to change.
<b>Frequency</b>	The frequency of extreme heat events is projected to rise.
<b>Duration</b>	The duration of extreme heat events is projected to increase.

Source: FEMA 2017

## 10. RISK TO STATE ASSETS

Typically, the only impact extreme heat has on general building stock and critical facilities is increased demand on air conditioning equipment which in turn may cause strain on electrical systems. Public utility infrastructure such as electrical generating and conveyance systems may become damaged and breakdown causing either localized or widespread power outages. Under these situations, it is important that critical infrastructure have backup electrical generating systems in order to maintain critical functions and services. Similarly, transportation infrastructure, especially bridges, roads, highways, and rail lines can be structurally damaged as a result of very high heat conditions or extended exposure to high heat conditions, as previously described. Concrete pavements have experienced “blowouts or heaves” both on local highways and the higher volume parkway and interstate systems. Blowouts occur when pavements expand and cannot function properly within their allotted spaces. Pavement sections may rise up several inches during such events. Train tracks that are not made of materials designed for high heat conditions may also warp or buckle. These conditions can cause vehicle accidents in their initial stages and can shut down traffic lanes or roads and railways entirely until such times as the conditions are mitigated.

Heat waves coupled with increased penetration of air conditioning in the Colorado market lead to water scarcity and grid stress, which can in turn result in price increases and system instabilities. The electric transmission system is impacted when power lines sag in high temperatures and can lead to power outages. The combination of extreme heat and the added

demand for electricity to run air conditioning causes transmission line temperatures to rise. The demand for electric power during heat waves is well documented. In 1980, consumers paid \$1.3 billion more for electric power during the summer than the previous year. That demand for electricity, 5.5 percent above normal, outstripped the supply, causing electric companies to have rolling black outs.

Increases in road maintenance needs and road closures from heat-related problems, interruption of rail and airport operations, and high costs to replace or withstand heat waves with new roads or bridges and heat resistant rail tracks are all potential impacts to infrastructure related to extreme heat. Aircraft lose lift at high temperatures and major airports have been closed due to periods of extreme heat that made aircraft operations unsafe. Highways and roads are damaged by excessive heat as asphalt roads soften and concrete roads have been known to "explode", lifting three to four foot pieces of concrete. During the 1980 heat wave, hundreds of miles of highways buckled across the state. Stress is placed on automobile cooling systems, diesel trucks, and railroad locomotives which lead to an increase in mechanical failures. Train rails develop sun kinks and distort. Refrigerated goods experience a significantly greater rate of spoilage due to extreme heat. However, since 2008, no state asset property losses were reported due to extreme heat. It is important to note that state asset loss data is only available for state assets included in the 2017 Office of Risk Management (ORM) database. These numbers exclude many Higher Education assets, and therefore may under-represent actual losses.

With the majority of extreme heat events on the eastern portion of the state, it follows that state assets located in this area are at most risk. State operated roadways, bridges, rail lines, and power lines and substations in the counties with the highest and most frequent extreme heat locations have been identified as at high risk of damage. These assets may require more frequent repair or replacement with more heat resistant options. Table 3-39 shows the number and value of state assets in counties most affected by extreme heat.

**TABLE 3-39 STATE ASSET EXPOSURE PROJECTIONS, 2010 TO 2030**

County	State Assets	Value	Exposure Rating
Denver	479	\$2,631,589,250	Severe
Adams	225	\$2,161,277,205	Severe
Pueblo	391	\$1,100,717,917	Severe
Weld	270	\$723,621,025	Severe
Mesa	316	\$571,483,873	Severe
Arapahoe	231	\$539,093,242	Severe
Montezuma	92	\$26,250,957	Severe
Broomfield	7	\$7,925,505	Severe
Larimer	931	\$2,520,380,927	High
Garfield	227	\$935,656,624	High

County	State Assets	Value	Exposure Rating
El Paso	252	\$664,445,003	High
La Plata	199	\$459,565,269	High
Logan	174	\$321,168,914	High
Summit	54	\$210,520,143	High
Lincoln	80	\$115,435,435	High
Crowley	28	\$99,475,999	High
Douglas	139	\$41,437,868	High
Routt	153	\$19,636,862	High
Archuleta	68	\$12,576,015	High
San Miguel	36	\$6,959,484	High
Elbert	16	\$6,135,197	High
Boulder	288	\$3,184,873,780	Moderate
Jefferson	481	\$1,220,747,270	Moderate
Alamosa	123	\$361,142,477	Moderate
Gunnison	146	\$297,472,630	Moderate
Chaffee	196	\$135,641,023	Moderate
Bent	173	\$116,882,345	Moderate
Otero	83	\$79,711,658	Moderate
Prowers	86	\$73,450,933	Moderate
Morgan	168	\$67,190,695	Moderate
Delta	116	\$39,890,610	Moderate
Eagle	148	\$22,080,215	Moderate
Montrose	65	\$19,168,190	Moderate
Park	120	\$17,071,984	Moderate
Yuma	84	\$14,101,083	Moderate
Grand	69	\$12,702,273	Moderate
Teller	53	\$9,932,426	Moderate
Washington	31	\$4,317,254	Moderate
Hinsdale	19	\$1,605,114	Moderate
Baca	14	\$1,559,394	Moderate
Kiowa	8	\$1,308,651	Moderate
Custer	6	\$1,130,092	Moderate
Pitkin	14	\$712,333	Moderate
Fremont	360	\$762,885,780	Slight
Las Animas	118	\$152,450,902	Slight
Clear Creek	75	\$117,846,308	Slight
Mineral	21	\$30,302,497	Slight
Gilpin	39	\$10,009,237	Slight

County	State Assets	Value	Exposure Rating
Ouray	46	\$8,684,296	Slight
Saguache	49	\$5,188,186	Slight
San Juan	22	\$4,603,609	Slight
Dolores	20	\$4,252,291	Slight
Costilla	28	\$4,179,435	Slight
Kit Carson	27	\$4,146,763	Slight
Lake	21	\$2,881,105	Slight
Sedgwick	30	\$1,827,494	Slight
Cheyenne	9	\$712,471	Slight
Phillips	5	\$196,988	Slight
Rio Grande	155	\$134,839,206	Negligible
Rio Blanco	66	\$63,910,055	Negligible
Huerfano	66	\$35,640,305	Negligible
Moffat	90	\$15,349,886	Negligible
Jackson	85	\$13,799,847	Negligible
Conejos	41	\$6,598,803	Negligible

Source: Colorado State Demography Office, 2017; Office of Risk Management, 2017 and 2013

## 11. RESOURCES

- Climate and Colorado’s Health: Examining the Connection Report
- Colorado and Climate Change Vulnerability Study
- Colorado Department of Local Affairs (DoLA)
- Colorado Department of Transportation (CDOT) Emergency Operations Plan (EOP)
- Colorado Department of Transportation (CDOT) Threat and Hazard Identification and Risk Assessment (THIRA)
- Colorado Energy Assurance Emergency Plan (CEAEP), 2016
- Federal Emergency Management Agency (FEMA). (2017). Assessing Future Conditions, Colorado
- Future Climate Extremes Boulder County Study
- Future Climate Extremes Larimer County Study
- National Climatic Data Center (NCDC)
- National Weather Service (NWS)
- Rocky Mountain Insurance Institute (RMIIA)
- The Tornado Project Online

# FLOOD

Colorado has a separate, more detailed Flood Hazard Mitigation Plan that is currently also in the process of being updated. Information from that updated plan will be incorporated as it becomes available. Portions of information included in this section are also taken directly from the 2013 Flood Mitigation Plan for Colorado.



## 1. DEFINITION

A flood is a general and temporary condition of partial or complete inundation of normally dry land areas from: (1) the overflow of stream banks, (2) the unusual and rapid accumulation of runoff of surface waters from any source, or (3) mudflows or the sudden collapse of shoreline land. Flooding results when the flow of water is greater than the normal carrying capacity of the stream channel. Rate of rise, magnitude (or peak discharge), duration, and frequency of floods are a function of specific physiographic characteristics. Generally, the rise in water surface elevation is quite rapid on small (and steep gradient) streams and slow in large (and flat sloped) streams. Table 3-40 describes the hazard profile summary for floods.

TABLE 3-40 HAZARD PROFILE SUMMARY

Consideration	Impact	Description
<b>Location</b>	Statewide	Flood prone areas have been identified in 213 of 274 cities and towns, the Southern Ute Indian Tribe, and in all of the 64 counties in Colorado.
<b>Previous Occurrences</b>	Seasonal	Dozens of notable flood events have occurred from 1864 to 2017. These event totals included significant deaths (372) and damages (\$2 billion est.). Since 1995 there have been 24 reported deaths. Most occurrences are between April and September.
<b>Probability</b>	Likely	In addition to annual minor flooding events, Colorado experiences major floods every five years on average.
<b>Extent</b>	Extensive	Major floods may induce property damage that threatens structural integrity, result in deaths and injuries, and impact critical services, facilities, and infrastructure. Between 20 and 30 large magnitude floods (in terms of peak discharge) occur somewhere in Colorado every year with varying impact depending on location.

## 2. LOCATION

The locations of Colorado’s rivers are closely related to the impact of flood hazards on growth and development within the state. Many rivers originate in Colorado, and flood prone areas have been identified in 213 cities and towns, the Southern Ute Indian Tribe, and in all of the 64

counties in the state. Between 20 and 30 large magnitude floods (in terms of peak discharge) occur somewhere in Colorado every year. Colorado has seven major river basins as identified below, which are broken down even further into river networks.

As shown in Figure 3-18, these river networks reach nearly all parts of the state. Because of this, the chance of flooding can be very high due to snow runoff and precipitation. Cascading effects such as the September 2013 flood, where multiple (connected) rivers received historical rainfall, contribute to flooding events.

## GROUNDWATER FLOODING

*Beginning around 2006, as a result of changes in requirements that limited pumping of wells, portions of northeast Colorado have experienced rising groundwater levels. The rising levels have resulted in basement flooding and damages to water treatment facilities in several communities, especially within Weld and Broomfield Counties. In Gilcrest, located in Weld County, groundwater levels have risen to less than five feet below the ground in places and caused damages to the town's water treatment plant, requiring more than \$1.3 million in replacement costs.*

**FIGURE 3-18 100-YEAR FLOODPLAINS AND DFIRM AVAILABILITY IN COLORADO**

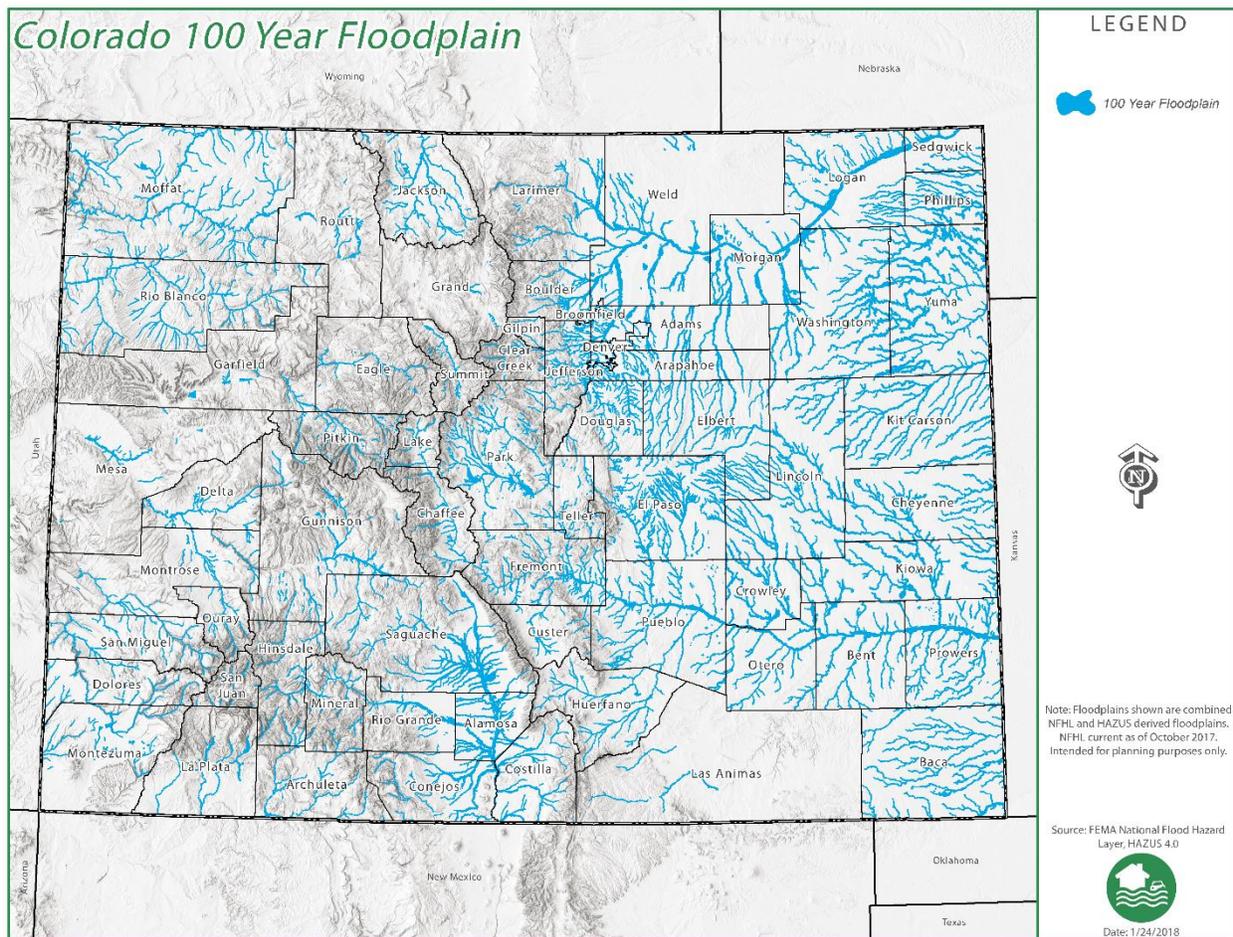


Figure 3-19 shows the FEMA National Flood Hazard Layer (NFHL) status by county for Colorado. The NFHL is a digital database that contains flood hazard mapping data from FEMA's National Flood Insurance Program (NFIP). In Colorado, 28 counties have an effective NFHL status, one county with a pending effective status, and five with a preliminary status.

**FIGURE 3-19 FEMA NFHL STATUS IN COLORADO**

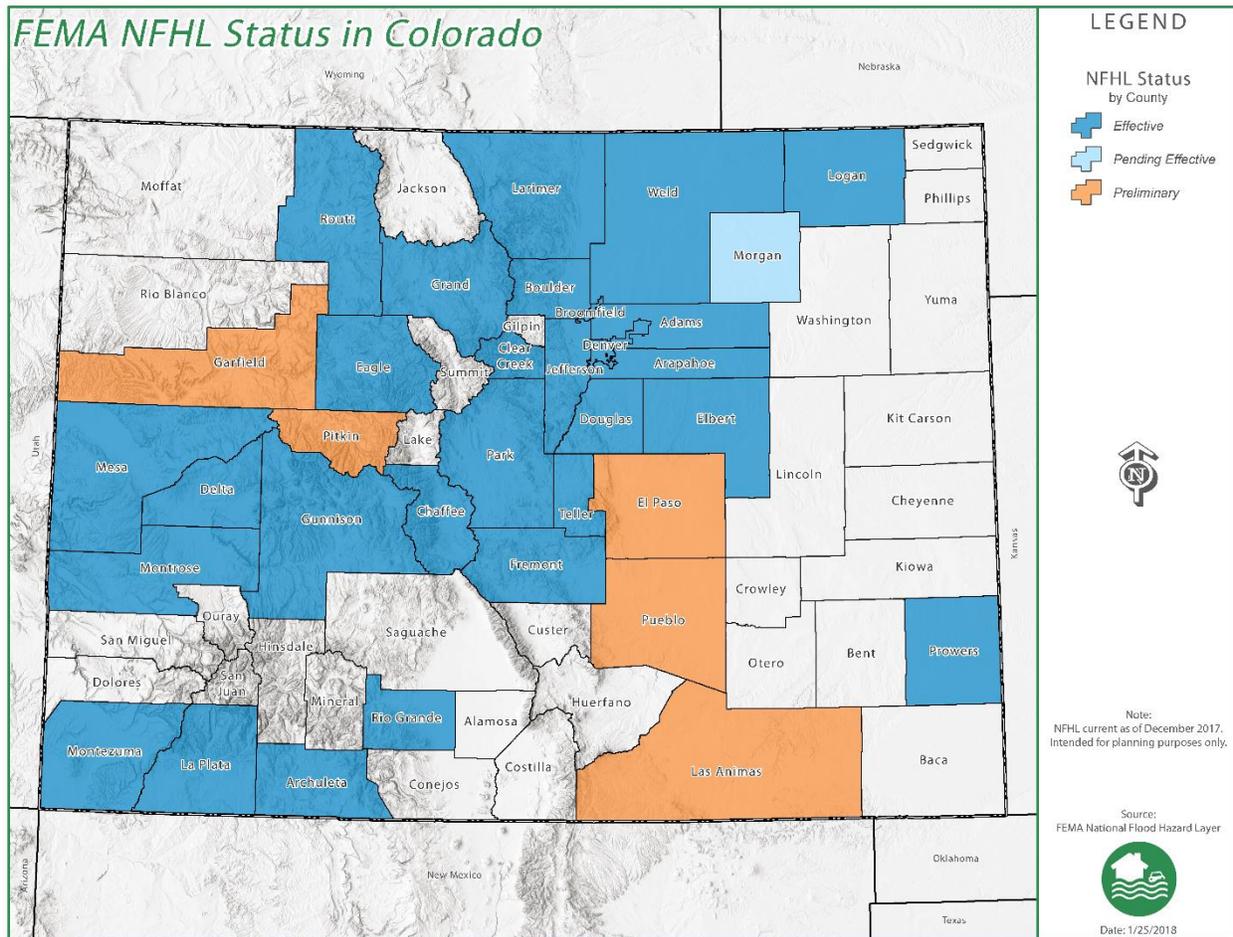


Figure 3-20 presents river flows and how they compare during a typical dry year as compared to a wet year. This also helps to identify the major drainages and sources of riverine flooding across the state. Figure 3-21 shows the major river drainage basins in Colorado, as defined in the Flood Mitigation Plan.

FIGURE 3-20 COLORADO RIVER FLOWS

DRAFT

STATEWIDE

Summary of Observed Wet & Dry Surface Water Hydrology

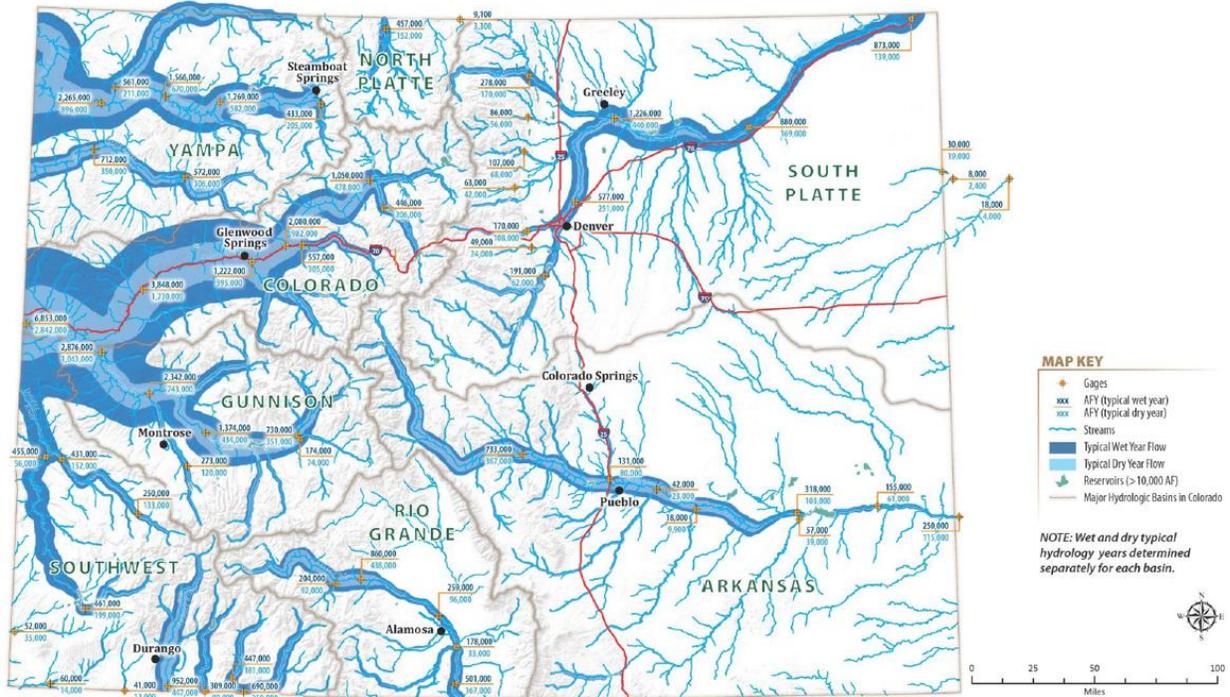
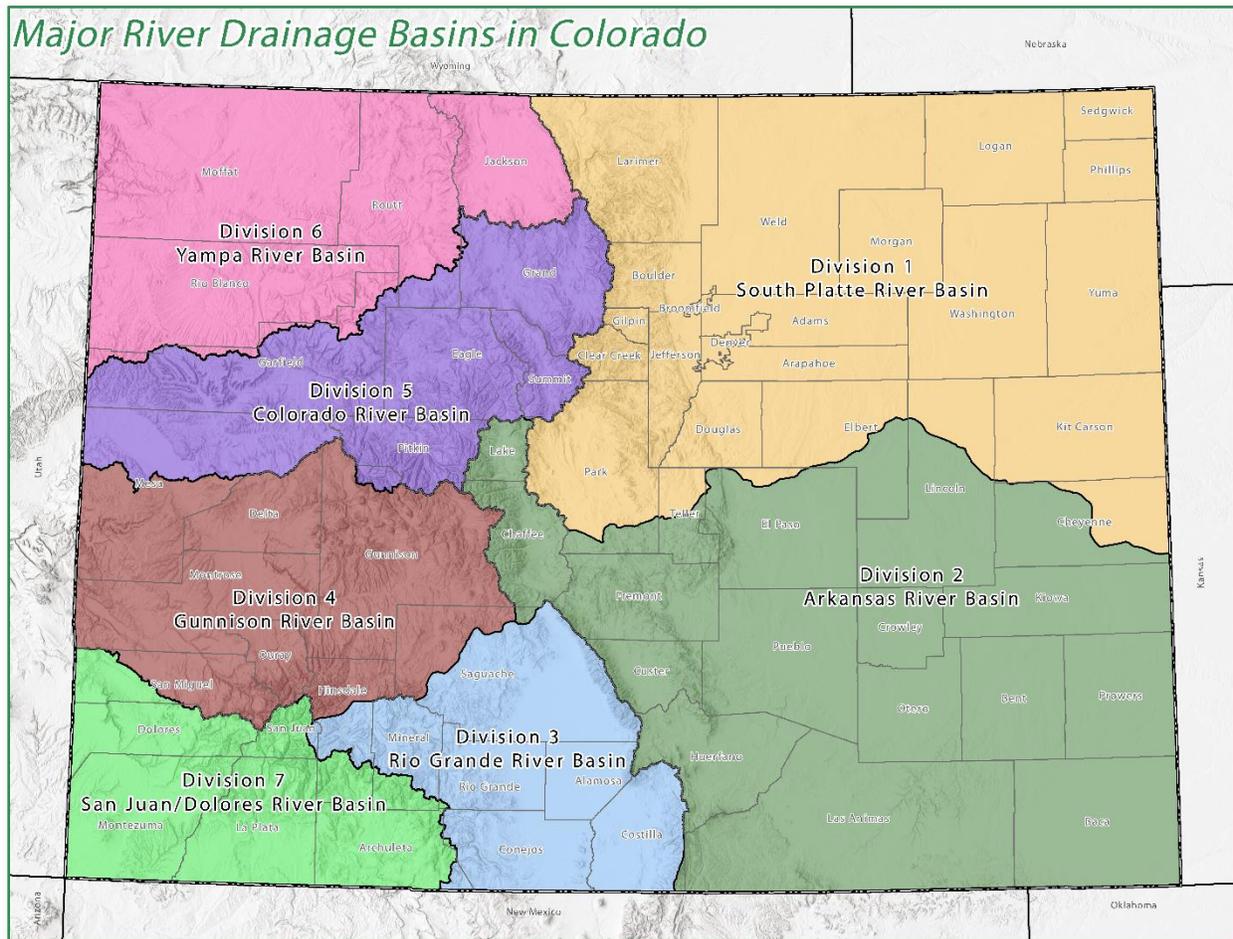


FIGURE 3-21 MAJOR RIVER DRAINAGE BASINS IN COLORADO



### 3. EXTENT (MAGNITUDE/STRENGTH)

Floods are often measured in terms of magnitude and the statistical probability that they will occur. The one percent annual chance flood event is the standard national measurement for flood mitigation actions and insurance. The one percent annual chance flood, also referred to as the 100-year flood, has a one in 100 chance of being equaled or exceeded in any one year, and it has an average recurrence interval of 100 years. This recurrence interval is an average; it does not necessarily mean that a flood of such a magnitude will happen exactly every 100 years. Only a few years may pass between one-one percent annual chance flood and another, while two other one percent annual chance floods may be separated by 150 years. The 0.2 percent annual chance flood, or 500-year flood event, is another measurement which has a one in 500 chance of occurring in a given year.

Colorado’s mountain and foothill environment increases the propensity for flash flooding. Statewide flood events come in all levels of intensity, but Colorado does have a history of tragic flood events. In 1965, damages in Denver were evaluated at over \$3.05 billion (in 2017 dollars)

due to a South Platte River flood. The greatest loss of life occurred during the Big Thompson flood of 1976 with 144 deaths.

One of the state's most costly and widespread floods affected the Colorado Front Range in September 2013. During the week beginning on September 9, 2013, a slow moving cold front stalled over Colorado, clashing with warm humid monsoonal air from the south. A report from Accuweather summarized the weather events that led to the flooding as follows:

“The key weather players during the September 2013 flooding event were a large swath of tropical moisture over the Rockies (referred to as the Monsoon by locals), a large area of high pressure over the Midwest and a storm in the upper atmosphere over the Great Basin. The moisture over the Rockies was literally being squeezed from both sides by the high to the east and the dry air rotating in from the Great Basin around the upper-level storm. This squeezing resulted in a much more vertical profile of moisture than would have occurred without either system present. The high over the Midwest also drove additional air thousands of feet uphill from the plains to the foothills and Rockies. This action released extra moisture and further enhanced the rainfall. The high over the Midwest acted like a giant roadblock and turned what would have been a several-hour event into a week-long ordeal. The result was a plume of heavy rain that re-fired on an almost daily basis from New Mexico to Colorado and southern Wyoming. While the Flood of 1976 was more intense over a small area and the Flood of 1965 was intense and lasted for days, the Flood of 2013 lasted nearly a week and covered hundreds of square miles in multiple states. Rainfall exceeded 12 inches at a number of locations.”

## 4. PROBABILITY

Flooding will continue to occur in Colorado and it is expected that extreme events may become more common. As mentioned previously, between 20 and 30 large magnitude floods (in terms of peak discharge) occur somewhere in Colorado every year. Major flood disasters can be expected on the order of once every decade. Since 1980, there have also been 19 state declared flooding disasters. Furthermore, between 1959 and 2017, Colorado experienced 12 federally declared flood disasters as indicated below:

- 1956 (DR-59): Front Range
- 1965 (DR-200): 33 Front Range communities
- 1969 (DR-261): 15 Front Range communities
- 1970 (DR-293): Southwestern Colorado
- 1973 (DR-396 and DR-385): 13 Front Range communities
- 1976 (DR-517): Two Front Range communities
- 1982 (DR-665): Larimer County (dam failure)
- 1984 (DR-719): 15 Western Slope counties
- 1997 (DR-1186): 13 Eastern Colorado counties

- 1999 (DR-1276): 12 southeastern Colorado counties
- 2013 (DR-4145): 11 Front Range and northeastern Colorado counties including Adams, Arapahoe, Boulder, Broomfield, Clear Creek, Crowley, Denver, El Paso, Fremont, Gilpin, Jefferson, Lake, Larimer, Lincoln, Logan, Morgan, Pueblo, Sedgwick, Weld, and Washington
- 2015 (DR-4229): 16 Colorado counties including Adams, Baca, Boulder, Broomfield, Denver, El Paso, Elbert, Fremont, Logan, Morgan, Park, Pueblo, Saguache, Sedgwick, Washington, and Yuma

Based on this flood history, Colorado experiences a major flood disaster roughly once every five years. The state faces an approximately 19 percent chance that a major flood disaster will occur in any given year.

## 5. PREVIOUS OCCURENCES

Colorado has a long history of tragic flood events. The earliest known floods are reported to have occurred in 1826 in the Arkansas River and Republican River basins. The most notable flood events in Colorado from 1864 to 2017 are presented in Table 3-41, and shown in Figure 3-22 for 1950 to 2017. As indicated in the table, the greatest loss of life occurred during the Big Thompson flood event of 1976. The most damaging flood in Colorado occurred in June 1965 on the South Platte River when over \$3.07 billion in damages (2017 dollars) was sustained in the Denver metro area. The 2013 flood also proved costly, with total damage estimates ranging from \$700 million (NOAA) to over \$2 billion (*An Assessment of Weather and Climate Monitoring Systems in Colorado – Current Systems, Gaps, and Future Needs*). It resulted in: 9 deaths, damages across 24 counties, 486 miles of CDOT roadways being impacted, 39 roadways being temporarily closed, and the closure of 120 bridges. Highway damages were estimated at \$535 million. Approximately 135 million cubic feet of debris was removed from the transportation network.

TABLE 3-41 NOTABLE FLOOD EVENTS IN COLORADO, 1864 - 2017

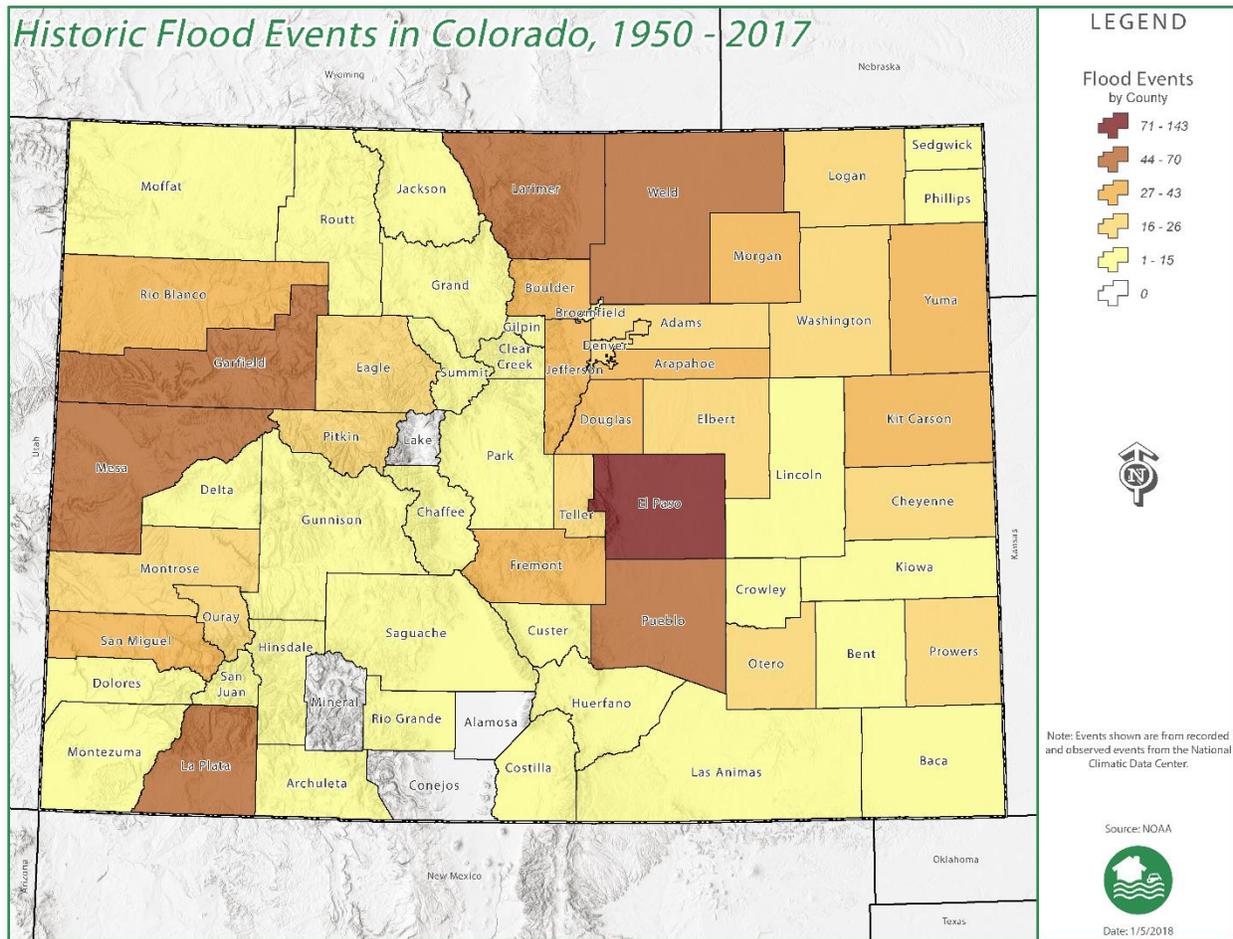
Year	Location	Deaths	Damages (2017\$)
1864	Cherry Creek (Denver)	0	\$8,268,439
1896	Bear Creek (Morrison)	27	\$9,449,645
1911	San Juan River (by Pagosa Springs and San Luis Valley)	2	\$8,268,439
1912	Cherry Creek (Denver)	2	\$184,268,088
1921	Arkansas River (Pueblo)	78	\$1,167,031,222
1935	Monument Creek (Colorado Springs)	18	\$80,321,986
1935	Kiowa Creek near Kiowa	9	\$23,624,113
1942	South Platte River Basin	N/A	\$12,757,022
1955	Purgatorie River (Trinidad)	2	\$55,516,667

Year	Location	Deaths	Damages (2017\$)
1956*	Denver, Jefferson, Arapahoe Counties		NA
1957	Western Colorado	0	\$27,167,731
1965*	South Platte River (Denver)	8	\$3,071,134,793
1965	Arkansas River Basin	16	\$315,381,919
1969*	South Platte River Basin	0	\$33,073,758
1970*	Southwest Colorado	0	\$20,080,497
1973*	South Platte River (Denver)	10	\$596,508,872
1976*	Big Thompson River (Larimer)	144	\$129,932,625
1982*	Fall River (Estes Park)	3	\$75,597,163
1983	North Central Counties	10	\$40,160,993
1984*	West & Northwest Counties	2	\$72,053,546
1993	Western Slope	0	\$3,189,256
1995	Western Slope & South Platte	21	\$80,321,986
1997*	Fort Collins & 13 East Counties	6	\$479,439,793
1999*	Colorado Springs & 12 East Counties	0	\$153,556,739
2000-06	Statewide Various Events	5	\$131,113,831
2006	Beaver, Brush Hollow and Eightmile Creeks (Fremont County)	0	\$2,245,080
2006	Horse Creek, West Creek (Douglas)	0	\$14,929,783
2006	Vallecito Creek (La Plata)	0	\$1,122,540
2007	Chalk Creek Canyon (Chaffee)	0	\$1,122,540
2007	Chalk Creek Canyon (mudflows) (Chaffee)	0	\$2,245,080
2009	Six Mile Creek (Fremont)	0	\$360,335
2010	Statewide flooding (various events)	0	\$884,562
2013*	Front Range and Northeast Counties	9	\$704,996,000
2015*	Central to Eastern Colorado	0	\$9,053,369
2017	South Central Colorado	0	TBD
<b>Totals</b>		<b>372</b>	<b>\$7,515,178,412</b>

Sources: Colorado Flood Hazard Mitigation Plan, SHELDUS, NOAA

\*Denotes federal disaster declaration event

FIGURE 3-22 HISTORIC FLOOD EVENTS, 1950 TO 2017



Insured flood losses are tracked by FEMA’s National Flood Insurance Program (NFIP). The following Table 3-42 presents this information by decade from 1975 through 2017.

TABLE 3-42 INSURED FLOOD LOSSES, 1975 TO 2017

Year	Total Insured Payouts
1975-1979	\$168,739
1980-1989	\$2,741,694
1990-1999	\$4,063,191
2000-2009	\$2,733,170
2010-2017	\$76,294,063*

\*Includes ~\$71.7 M from 2013 event

Table 3-43 provides information on other NFIP flood insurance related figures. Counties that have historically received over \$1 million in insurance payments include: Boulder, El Paso, Jefferson, Larimer, Otero, and Weld Counties. The highest average claim payments have occurred in Boulder, Chaffee, Larimer, and Weld Counties, each of which exceeds \$20,000. Per capita flood insurance payments stand out the most for Boulder and Otero Counties, with

calculated payments close to \$150 and \$100 respectively. Counties with no data do not currently participate in the NFIP.

TABLE 3-43 NFIP INSURANCE CLAIMS HISTORY

County	Active Policies	Population with Policies	Historical Claims	Insurance Paid	Average Payments per Claim	Payments per Capita
Adams	1216	0.24%	248	\$ 788,935.00	\$ 3,181.19	\$ 1.59
Alamosa	47	0.29%	18	\$ 10,441.00	\$ 580.06	\$ 0.65
Arapahoe	641	0.10%	96	\$ 504,518.00	\$ 5,255.40	\$ 0.79
Archuleta	137	1.06%	4	\$ 1,863.00	\$ 465.75	\$ 0.14
Baca						
Bent	6	0.11%	2	\$ 2,690.00	\$ 1,345.00	\$ 0.48
Boulder	5822	1.81%	1734	\$ 49,443,161.00	\$ 28,513.93	\$ 153.56
Broomfield	85	0.13%	14	\$ 21,601.00	\$ 1,542.93	\$ 0.33
Chaffee	132	0.69%	6	\$ 307,142.00	\$ 51,190.33	\$ 16.08
Cheyenne						
Clear Creek	130	1.38%	27	\$ 42,710.00	\$ 1,581.85	\$ 4.52
Conejos	7	0.09%	3	\$ -	\$ -	\$ -
Costilla	9	0.24%	1	\$ 10,317.00	\$ 10,317.00	\$ 2.78
Crowley	0	0.00%	1	\$ -	\$ -	\$ -
Custer						
Delta	60	0.20%	19	\$ 92,296.00	\$ 4,857.68	\$ 3.03
Denver	1278	0.18%	202	\$ 592,668.00	\$ 2,934.00	\$ 0.85
Dolores	5	0.25%	1	\$ 270.00	\$ 270.00	\$ 0.13
Douglas	412	0.13%	48	\$ 501,799.00	\$ 10,454.15	\$ 1.53
Eagle	451	0.84%	32	\$ 178,739.00	\$ 5,585.59	\$ 3.31
El Paso	2775	0.40%	753	\$ 5,580,662.00	\$ 7,411.24	\$ 8.09
Elbert	30	0.12%	2	\$ -	\$ -	\$ -
Fremont	300	0.63%	67	\$ 169,633.00	\$ 2,531.84	\$ 3.57
Garfield	194	0.33%	24	\$ 77,005.00	\$ 3,208.54	\$ 1.31
Gilpin	25	0.42%	7	\$ 9,794.00	\$ 1,399.14	\$ 1.65
Grand	152	1.01%	2	\$ 5,960.00	\$ 2,980.00	\$ 0.40
Gunnison	279	1.70%	43	\$ 152,531.00	\$ 3,547.23	\$ 9.30
Hinsdale	23	2.97%	1	\$ -	\$ -	\$ -
Huerfano	72	1.08%	5	\$ 1,885.00	\$ 377.00	\$ 0.28
Jackson						
Jefferson	1273	0.22%	371	\$ 2,228,399.00	\$ 6,006.47	\$ 3.90
Kiowa						
Kit Carson						

County	Active Policies	Population with Policies	Historical Claims	Insurance Paid	Average Payments per Claim	Payments per Capita
La Plata	756	1.36%	36	\$ 486,383.00	\$ 13,510.64	\$ 8.73
Lake	5	0.07%	1	\$ 2,582.00	\$ 2,582.00	\$ 0.34
Larimer	1551	0.46%	538	\$ 14,846,242.00	\$ 27,595.25	\$ 43.84
Las Animas	25	0.18%	3	\$ 10,992.00	\$ 3,664.00	\$ 0.78
Lincoln	10	0.18%	5	\$ 4,362.00	\$ 872.40	\$ 0.79
Logan	193	0.88%	75	\$ 853,931.00	\$ 11,385.75	\$ 38.73
Mesa	340	0.23%	56	\$ 281,065.00	\$ 5,019.02	\$ 1.86
Mineral	10	1.36%	1	\$ 268.00	\$ 268.00	\$ 0.36
Moffat	24	0.18%	0	\$ -		\$ -
Montezuma	114	0.42%	5	\$ 18,588.00	\$ 3,717.60	\$ 0.69
Montrose	109	0.26%	6	\$ 56,693.00	\$ 9,448.83	\$ 1.37
Morgan	116	0.41%	41	\$ 449,479.00	\$ 10,962.90	\$ 15.97
Otero	82	0.45%	136	\$ 1,742,883.00	\$ 12,815.32	\$ 95.29
Ouray	58	1.20%	6	\$ 33,046.00	\$ 5,507.67	\$ 6.82
Park	33	0.19%	2	\$ 343.00	\$ 171.50	\$ 0.02
Phillips	6	0.14%	2	\$ 7,402.00	\$ 3,701.00	\$ 1.73
Pitkin	273	1.54%	26	\$ 219,978.00	\$ 8,460.69	\$ 12.38
Prowers	66	0.56%	23	\$ 27,035.00	\$ 1,175.43	\$ 2.28
Pueblo	171	0.10%	89	\$ 287,740.00	\$ 3,233.03	\$ 1.74
Rio Blanco	21	0.32%	10	\$ 31,031.00	\$ 3,103.10	\$ 4.78
Rio Grande	142	1.24%	6	\$ 2,651.00	\$ 441.83	\$ 0.23
Routt	393	1.59%	33	\$ 414,728.00	\$ 12,567.52	\$ 16.80
Saguache	5	0.08%	0	\$ -		\$ -
San Juan	5	0.72%	1	\$ 1,144.00	\$ 1,144.00	\$ 1.64
San Miguel	525	6.56%	17	\$ 132,604.00	\$ 7,800.24	\$ 16.58
Sedgwick	2	0.08%	0	\$ -		\$ -
Summit	504	1.66%	26	\$ 43,798.00	\$ 1,684.54	\$ 1.44
Teller	72	0.30%	10	\$ 12,024.00	\$ 1,202.40	\$ 0.50
Washington	1	0.02%	0	\$ -		\$ -
Weld	517	0.18%	161	\$ 5,457,853.00	\$ 33,899.71	\$ 18.54
Yuma	15	0.15%	3	\$ 3,298.00	\$ 1,099.33	\$ 0.33

Source: FEMA, December 2017

The NFIP also tracks structures that experience repetitive flooding losses, with the intention to focus attention on these properties so that they can be bought out or relocated. A Repetitive Loss (RL) property is any insurable building for which two or more claims of more than \$1,000 were paid by the NFIP within any rolling 10 year period, since 1978. There are four RL structures in the state located in the City of Boulder, Manitou Springs (2), and Rangley.

FEMA further defines a Severe Repetitive Loss (SRL) property as one that has: a) four or more flood insurance claims that each exceeded \$5,000, with at least two of those payments occurring in a 10 year period, and with the total claims paid exceeding \$20,000, or b) two or more flood insurance claim payments that together exceed the value of the property. There is one SRL structure in Colorado located in Greeley.

## 6. IMPACT ANALYSIS

Beyond their human costs, natural disasters such as floods have significant economic and environmental impacts. Economic development research has long recognized the importance of quality transportation infrastructure. Much of the United States' economic growth history is driven by reductions in transportation costs, first through its canal systems, then its railways, then its interstate highways. The 2013 floods had a tremendous impact on many of the state's roads and bridges. Some communities were effectively isolated for weeks if not months. The destruction of transportation infrastructure affected state businesses in many ways. Some saw significant increases in transportation costs and employee scheduling difficulties. Many agricultural producers had a harder time getting their products to markets. Some manufacturing companies had to reroute their shipping. Other employers found that their workers' commute times increased, impacting the productivity and availability of their workforce.

People lost their jobs because of the flooding. Businesses were damaged and destroyed, with some closing for good because of the event. Because Colorado's economy was still feeling the lingering effects of the Great Recession, some displaced workers found it challenging to find new opportunities that fully utilized their capabilities. Many people turned to the state's workforce system for help, needing assistance with job searches and resume writing. Business and property owners were hard hit by flooding. In the canyons, floodwaters washed away motels, cabins, bars, and restaurants. In other places retail and commercial establishments suffered extensive damage. Farther east, farmers lost their crops, and oil wells were damaged or shut down. At the time of this Plan update, five years later, recovery efforts relating to the 2013 flood event continue.

Additional impacts of flood are characterized in Table 3-44.

### FUTURE FLOOD ADAPTATION MEASURES

*In a study by Willner et al. (2018), it was determined that the United States requires extensive adaptation measures to keep flood risk at its present level over the next 25 years. This is mainly because surface temperatures will continue to rise for another 20 to 30 years, even with the strongest carbon emission reductions. The study found that the adaptation need is similarly large in highly developed countries as it is in developing countries. For the United States, 42 of the 50 states (including Colorado) and the District of Columbia will experience an increased flood risk if no additional protection measures are taken.*

TABLE 3-44 FLOOD EMAP IMPACT SUMMARY

Consideration	Description
<b>General Public</b>	Impacts of people will change with characteristic of event (e.g., flash flood in a canyon, river flood on the plains, etc.). Localized impacts may be severe with moderate to light impacts for outward or other affected areas. The Big Thompson flood event which resulted from localized heavy rainfall and a subsequent flash flood took the lives of 144 people. Residents/property owners without flood insurance may be impacted greater than those with coverage. Residents may be displaced due to evacuation, damage, or inaccessibility to homes. Persons within flood areas have the potential for direct contact with hazardous materials.
<b>First Responders</b>	Need for evacuation support such as door-to-door notification and traffic management may increase responder risk as event escalates. Localized impact expected to limit damage to personnel in flood areas at the time of incident. Impacts to transportation corridors and communications lines may affect responder ability to effectively respond. There may be a higher risk to responders in flash flood events which are prevalent in the state.
<b>Property</b>	Private property losses with increased risk to those without flood insurance.
<b>Facilities and Infrastructure</b>	Localized impact to facilities and infrastructure in incident area. Some severe damage possible. Critical facilities may be impacted by flooding: communications, energy, hospitals, schools, nursing homes, utilities, wastewater and water treatment plants, and roadways. Evacuation routes can become flooded.
<b>Economic</b>	Local economy and finances adversely affected, possibly for an extended period of time depending on damage and length of investigation of flood event. Localized disruption of roads, facilities, and/or utilities caused by flooding may postpone delivery of some services.
<b>Environment</b>	Localized impact expected to be severe for incident areas and moderate to light for other areas affected by flood. Wetland impacts due to flooding can result in water quality and wildlife habitat impacts. Orphan drums (containers that may contain hazardous materials) and releases from oil wells and facilities. Commercial hazmat/hazardous waste. Household hazardous waste. Releases from transportation. Releases into streams and rivers, drinking water supply, ground water, and air.
<b>Continuity of Government and Services</b>	Damage to facilities/personnel in incident area may require temporary relocation of some operations.
<b>Confidence in Government</b>	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.
<b>Critical Assets</b>	Critical facilities may be impacted by flooding such as those related to communications, hospitals, schools, nursing homes, utilities, wastewater treatment plants, and roadways.

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

The following section discusses the methodology used to perform the flood loss estimation associated with the 2018 update to the Colorado Hazard Mitigation Plan. Hazus-MH 4.0 was utilized to model the one percent annual chance floodplain (100-year) and perform associated building and population risk assessments. The Hazus flood model results included analysis for each of the 64 counties using two processing methods depending on floodplain data availability. These countywide assessments include analysis across all Tribal lands within the state as well. Colorado has 35 counties where FEMA has developed countywide (or near-countywide) digital floodplain maps; for these counties a so-called Level 1+ analysis was performed. The remaining 29 counties that did not have countywide digital FEMA floodplain maps were analyzed utilizing traditional Standard (Level 1) analysis.

The Level 1+ counties had a custom depth grid developed for each county using the Colorado FEMA effective (as of 10/26/17) floodplain data as well as the 10-meter (1/3 arc second) Digital Elevation Models (DEMs) from the National Elevation Dataset (NED) as the terrain data source. The resulting depth grid was then loaded into Hazus and a hydraulic analysis was performed before running the overall flood damage analysis.

The standard Level 1 counties used the Hazus software to develop a stream network and hydrology for a 10-square mile drainage area. The 30-meter (one arc second) DEMs were used in this analysis as the terrain source. Hazus then ran hydraulics for and delineated the 100-year floodplain boundary. At this point Hazus developed a depth grid for the one percent annual chance floodplain. While not as accurate as an official FEMA floodplain, this one percent boundary is available for use in GIS and could be valuable to communities that have not been mapped by the National Flood Insurance Program. Hazus generated damage estimates are directly related to the depth of flooding and are based on FEMA's depth-damage functions built into Hazus. This data is available to communities upon request.

Hazus provides a variety of results from the flood analysis, including the estimated number of buildings both moderately and completely damaged, the debris generated, and social impacts such as displaced households and temporary shelter needs. The economic losses associated with the flood event are also provided, including building contents and inventory; business impacts such as relocation and wage losses are also reported.

All estimated losses from the Hazus analysis are derived from default national inventory databases and may contain inaccuracies, thus all loss and damage estimates should be used for planning applications only. The damaged building counts generated are susceptible to rounding errors because they are based off 2010 census block data. There is also potential for errors associated with hydrologic and hydraulic modeling within Hazus. In rural Colorado, census blocks are large and often sparsely populated or developed; this may create inaccurate loss estimates. Hazus assumes population and building inventory to be evenly distributed over a

census block; flooding may occur in a small section of the census block where there are no actual buildings or people, but the model assumes that there is damage to that block. There could also be discrepancies in the extent and/or depth of the floodplains generated in certain counties. This is due in part to narrow mountain floodplains and ground surface terrain data resolution. One other important note is that losses were only calculated for counties where a created depth grid was present, however this does not mean other flood losses are not present elsewhere in the county. A Hazus Level II analyses based on local building inventory, higher resolution terrain data, and additional digital floodplain data could be used in the future to refine and improve the accuracy of the results. In addition, the Colorado Water Conservation Board (CWCB) has an inventory of local flood mapping efforts and flood studies that could supplement future analysis.

A summary of the Hazus results are included in the following tables. It should be again noted that these loss estimations are based off 2010 Census data and may under-represent expected losses in those Colorado counties that have experienced rapid growth since 2010. Table 3-45 presents the estimated expected building damages and total economic losses from the modeled flood event. As expected, those counties with larger populations and housing stocks oftentimes have the largest forecast building damages. Arapahoe, Boulder, El Paso, Jefferson, and Logan Counties are all estimated to have over 500 buildings moderately damaged. El Paso and Morgan Counties are modeled to have close to 200 and 300 buildings, respectively, completely destroyed. Related to expected total economic losses, a similar pattern is seen with Adams, Arapahoe, Boulder, Denver, El Paso, Jefferson, Larimer, Morgan, and Weld Counties each projecting at least \$200 million in loss. Figure 3-23 presents these loss estimates as well.

**TABLE 3-45 HAZUS ESTIMATED BUILDING DAMAGES AND TOTAL ECONOMIC LOSSES**

<b>County</b>	<b>Buildings Moderately Damaged</b>	<b>Buildings Completely Destroyed</b>	<b>Total Economic Loss</b>
<b>Adams</b>	330	67	\$243,570,000
<b>Alamosa*</b>	1	0	\$3,510,000
<b>Arapahoe</b>	606	99	\$433,230,000
<b>Archuleta</b>	16	11	\$22,740,000
<b>Baca*</b>	0	0	\$1,420,000
<b>Bent*</b>	0	0	\$2,010,000
<b>Boulder</b>	564	2	\$507,910,000
<b>Broomfield</b>	99	10	\$40,120,000
<b>Chaffee</b>	116	18	\$39,680,000
<b>Cheyenne*</b>	13	0	\$3,550,000
<b>Clear Creek</b>	79	35	\$43,640,000
<b>Conejos*</b>	11	0	\$7,640,000
<b>Costilla*</b>	7	6	\$5,440,000
<b>Crowley*</b>	14	0	\$6,040,000

<b>County</b>	<b>Buildings Moderately Damaged</b>	<b>Buildings Completely Destroyed</b>	<b>Total Economic Loss</b>
<b>Custer*</b>	135	60	\$26,780,000
<b>Delta</b>	1	0	\$8,310,000
<b>Denver</b>	426	23	\$315,960,000
<b>Dolores*</b>	9	0	\$3,670,000
<b>Douglas</b>	238	51	\$182,600,000
<b>Eagle</b>	123	44	\$103,380,000
<b>El Paso</b>	625	202	\$442,930,000
<b>Elbert</b>	43	1	\$20,190,000
<b>Fremont</b>	158	73	\$80,720,000
<b>Garfield</b>	289	20	\$56,500,000
<b>Gilpin*</b>	29	13	\$15,850,000
<b>Grand</b>	0	0	\$11,600,000
<b>Gunnison</b>	48	19	\$55,730,000
<b>Hinsdale*</b>	26	0	\$14,270,000
<b>Huerfano*</b>	19	2	\$17,250,000
<b>Jackson*</b>	3	0	\$2,570,000
<b>Jefferson</b>	1126	166	\$553,300,000
<b>Kiowa*</b>	3	0	\$1,380,000
<b>Kit Carson*</b>	0	0	\$1,640,000
<b>La Plata</b>	222	73	\$127,260,000
<b>Lake*</b>	2	0	\$1,650,000
<b>Larimer</b>	315	37	\$200,600,000
<b>Las Animas</b>	11	4	\$42,820,000
<b>Lincoln*</b>	6	0	\$7,250,000
<b>Logan</b>	542	13	\$116,340,000
<b>Mesa</b>	151	30	\$64,250,000
<b>Mineral*</b>	11	2	\$10,570,000
<b>Moffat*</b>	78	0	\$26,000,000
<b>Montezuma</b>	59	5	\$20,630,000
<b>Montrose</b>	1	0	\$7,350,000
<b>Morgan</b>	431	293	\$216,850,000
<b>Otero*</b>	119	2	\$29,200,000
<b>Ouray*</b>	36	6	\$30,300,000
<b>Park</b>	255	128	\$143,100,000
<b>Phillips*</b>	18	0	\$8,280,000
<b>Pitkin</b>	33	13	\$61,480,000
<b>Prowers</b>	12	2	\$20,970,000

County	Buildings Moderately Damaged	Buildings Completely Destroyed	Total Economic Loss
Pueblo	210	51	\$111,860,000
Rio Blanco*	26	1	\$26,940,000
Rio Grande	71	11	\$36,024,000
Routt	82	21	\$75,310,000
Saguache*	19	0	\$7,270,000
San Juan*	6	0	\$5,640,000
San Miguel*	49	5	\$36,440,000
Sedgwick*	4	0	\$1,850,000
Summit	11	0	\$20,000,000
Teller	75	17	\$47,100,000
Washington*	9	0	\$6,390,000
Weld	462	32	\$197,220,000
Yuma*	124	0	\$59,480,000

\* Denotes Standard (Level 1) Hazus analysis

Table 3-46 includes a summary of some other expected impacts as a result of the modeled flood events, per county. El Paso, Jefferson, and Morgan Counties should plan for the greatest amount of post-flood debris to be generated, each estimated to be over 20,000 tons. The most modeled displaced households would be in Boulder and Jefferson Counties. When reviewed as a percentage of a county's population however, Crowley and Logan Counties both stand out from the rest. Shelter needs are expected to be the largest in Boulder and Jefferson Counties, but Crowley and Logan Counties again stand out when shelter needs are considered as a percentage of the county population.

TABLE 3-46 HAZUS ESTIMATED DEBRIS, DISPLACEMENT, AND SHELTER NEEDS

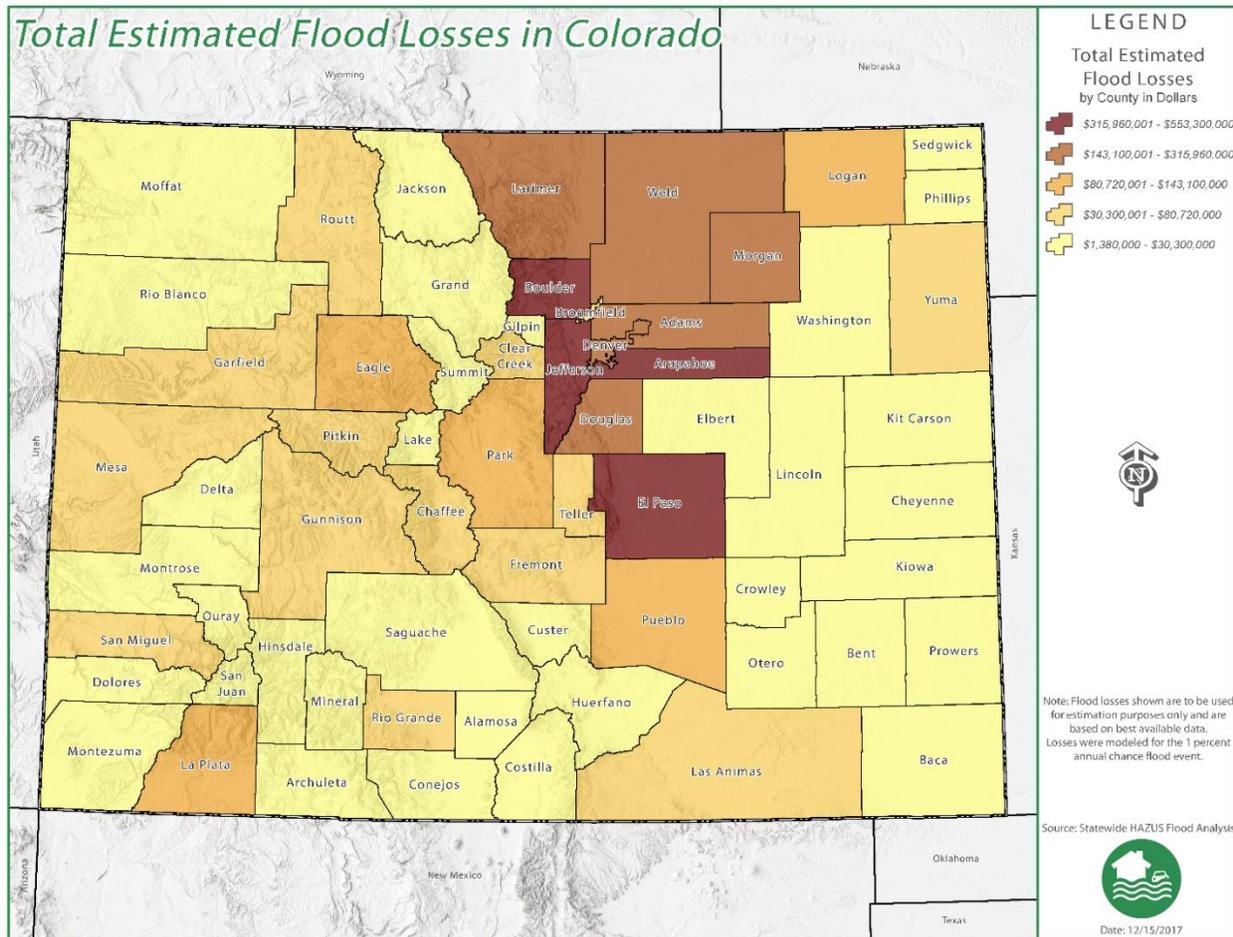
County	Debris Generated (in tons)	Displaced Households	Displaced %	People in Need of Shelter	Shelter %
Adams	6,241	2,466	2%	4,911	1%
Alamosa*	55	185	3%	173	1%
Arapahoe	10,638	2,897	1%	6,308	1%
Archuleta	1,113	131	3%	140	1%
Baca*	236	9	0%	0	0%
Bent*	207	30	2%	1	0%
Boulder	9,750	6,005	5%	14,280	5%
Broomfield	99	489	2%	1,077	2%
Chaffee	1,824	251	3%	345	2%
Cheyenne*	433	55	6%	29	2%
Clear Creek	5,407	382	10%	241	3%
Conejos*	908	145	5%	109	1%

County	Debris Generated (in tons)	Displaced Households	Displaced %	People in Need of Shelter	Shelter %
Costilla*	1,194	70	4%	43	1%
Crowley*	619	365	37%	622	11%
Custer*	5,140	87	4%	145	3%
Delta	900	106	1%	42	0%
Denver	11,221	2,652	1%	6,144	1%
Dolores*	352	11	1%	2	0%
Douglas	1,096	991	1%	1,770	1%
Eagle	3,884	795	4%	1,559	3%
El Paso	29,978	3,715	2%	6,610	1%
Elbert	991	178	2%	223	1%
Fremont	6,917	1,279	8%	2,132	5%
Garfield	3,185	507	3%	691	1%
Gilpin*	840	36	2%	31	1%
Grand	630	56	1%	35	0%
Gunnison	5,189	393	6%	523	3%
Hinsdale*	602	34	3%	18	2%
Huerfano*	1,105	106	4%	42	1%
Jackson*	263	22	2%	0	0%
Jefferson	24,307	5,080	2%	10,336	2%
Kiowa*	154	25	3%	3	0%
Kit Carson*	180	12	0%	0	0%
La Plata	8,043	796	4%	1,488	3%
Lake*	274	30	1%	29	0%
Larimer	7,989	1,578	1%	2,997	1%
Las Animas	3,104	178	3%	212	1%
Lincoln*	571	128	6%	73	1%
Logan	8,682	2,038	25%	4,261	19%
Mesa	1,642	821	1%	1,725	1%
Mineral*	1,025	25	3%	10	1%
Moffat*	1,987	447	9%	653	5%
Montezuma	2,225	294	3%	342	1%
Montrose	731	57	0%	33	0%
Morgan	39,076	1,123	11%	1,624	6%
Otero*	2,063	227	3%	375	2%
Ouray*	1,845	99	5%	109	2%
Park	9,752	375	5%	628	4%
Phillips*	629	108	5%	92	2%
Pitkin	3,859	274	3%	421	2%

County	Debris Generated (in tons)	Displaced Households	Displaced %	People in Need of Shelter	Shelter %
<b>Prowers</b>	992	165	3%	207	2%
<b>Pueblo</b>	6,348	770	1%	1,440	1%
<b>Rio Blanco*</b>	2,361	188	6%	146	2%
<b>Rio Grande</b>	2,920	255	5%	277	2%
<b>Routt</b>	2,106	476	5%	738	3%
<b>Saguache*</b>	1,295	136	5%	76	1%
<b>San Juan*</b>	221	69	7%	40	6%
<b>San Miguel*</b>	675	163	5%	241	3%
<b>Sedgwick*</b>	195	53	5%	13	1%
<b>Summit</b>	839	208	2%	178	1%
<b>Teller</b>	2,707	248	2%	316	1%
<b>Washington*</b>	794	106	5%	29	1%
<b>Weld</b>	7,346	2,405	3%	4,628	2%
<b>Yuma*</b>	2,611	581	15%	540	5%

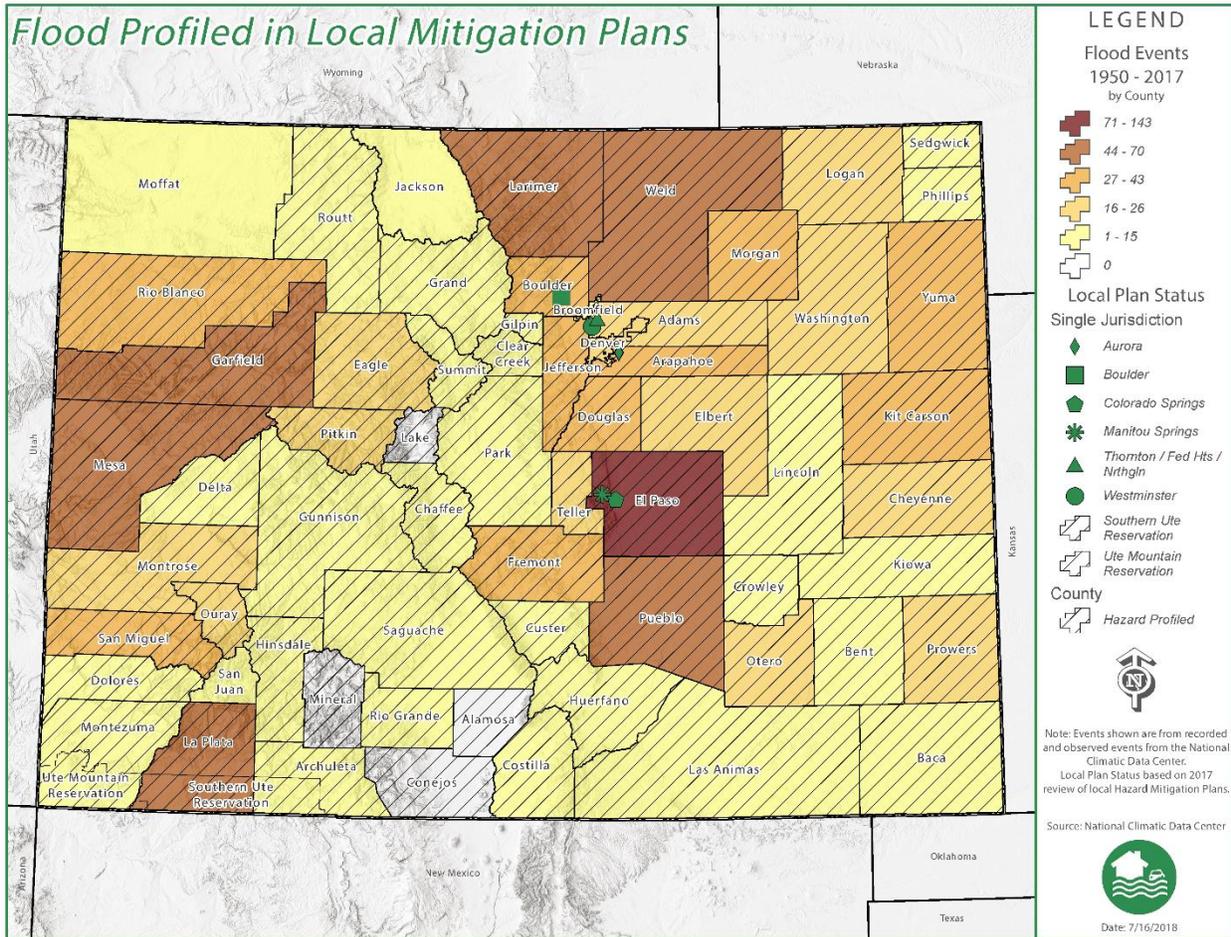
\* Denotes Standard (Level 1) Hazus analysis

FIGURE 3-23 TOTAL ESTIMATED FLOOD LOSSES IN COLORADO



Based upon an updated (2017) review of local mitigation plans, Figure 3-24 illustrates which local jurisdictions profiled flood as a hazard, compared with historical flood events. Nearly all counties and several major single jurisdictions profile floods in their local hazard mitigation plan. The only three counties in the state that do not are Jackson, Moffat, and San Juan Counties. None of these three counties currently have local hazard mitigation plans. Moffat County has experienced nine flood events from 1950 to 2017, San Juan County six, and Jackson County has only experienced one.

FIGURE 3-24 FLOOD PROFILED IN LOCAL MITIGATION PLANS



Based on review of local hazard mitigation plans, 66 jurisdictions profile flood as one of their top four hazards. Within these jurisdictions, 211,588 structures or parcels are in flood hazard areas, and 1,687 critical facilities are in flood hazard areas. The total estimated losses are over \$19 billion. Table 3-47 describes this information in further detail. Jurisdictions that estimated total losses from floods used Hazus and GIS software to derive the loss estimate.

TABLE 3-47 LOCAL HAZARD MITIGATION PLANS

Jurisdiction	# of Structures/ Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate	Loss Estimate Methodology
Adams County	4,461	6	Hazus	\$315,824,000	Hazus
Alamosa County	1,259	4	Hazus	\$57,441,000	Hazus

Jurisdiction	# of Structures/ Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate	Loss Estimate Methodology
Arapahoe County	294	66	Hazus	\$41,000,000	Hazus
Archuleta County	326	2	DFIRM	\$13,404,490	
City of Aurora	7,392	0	Hazus	\$10,512,223,000	Hazus
Baca County		0	Hazus	\$2,367,000	Hazus
Bent County		130	Hazus	\$5,503,000	Hazus
Boulder County	3,040	51		\$1,555,460,000	GIS with 25% damage
City of Boulder	2,021	41	Due to the numerous drainages in the city, it was necessary to develop a methodology that allowed loss estimates to be summarized by creek to show how the risk varies across the planning area.	\$489,967,000	20% damage
City and County of Broomfield	59	0			
Chaffee County	532	13	Hazus	\$400,246,000	Hazus
Cheyenne County		10	Hazus	\$6,151,000	Hazus
Clear Creek County	143	9	GIS Mapping	\$14,369,000	Hazus
City of Colorado Springs	6,107	8	Hazus	\$937,952,000	Hazus
University of Colorado		40		\$87,370,100	Risk Management Report
Conejos County		0		\$4,440,000	Hazus
Costilla County		13		\$120,835,308	GIS Mapping
Crowley County			Hazus	\$15,848,000	Hazus
Custer County	79	3	Hazus	\$22,588,324	Hazus
Delta County	124	23	Hazus	\$21,468	Hazus

Jurisdiction	# of Structures/ Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate	Loss Estimate Methodology
<b>City and County of Denver</b>	1,468	134	Hazus	\$79,404,645	Hazus
<b>Dolores County</b>	39	3	Hazus	\$4,825,000	Hazus
<b>Douglas County</b>	452	101		\$18,680,574	GIS with 25% damage
<b>Eagle County</b>	886				
<b>El Paso County</b>	5,556	114	Hazus	\$1,692,013,000	Hazus
<b>Elbert County</b>	545	0	Hazus	\$23,690,000	Hazus
<b>Fremont County</b>	1,258	37	Hazus	\$157,985,000	Hazus
<b>Gilpin County</b>	55	8	Hazus	\$18,636,000	Hazus
<b>Grand County</b>	199	2	Hazus	\$16,812,176	Hazus
<b>Gunnison County</b>	591	3	Hazus	\$48,460,652	Hazus
<b>Hinsdale County</b>		28	Hazus	\$2,000,000	
<b>Huerfano County</b>	372	89	Hazus	\$20,405,619	Hazus
<b>Jefferson County</b>	4,843	224	Hazus	\$705,804,417	GIS Mapping
<b>Kiowa County</b>			Hazus	\$2,365,000	Hazus
<b>Kit Carson County</b>		0	Hazus	\$3,060,000	Hazus
<b>La Plata County</b>	23180	5	Hazus	\$88,050,000	Hazus
<b>Lake County</b>	752	0	Hazus	\$1,687,000	GIS Mapping
<b>Larimer County</b>	126,553	38	Hazus	\$145,111,080	Hazus
<b>Las Animas County</b>	271	5	Hazus	\$36,916,000	Hazus
<b>Lincoln County</b>		43	Hazus	\$8,920,000	Hazus
<b>Logan County</b>		8	Hazus	\$52,966,000	Hazus
<b>City of Manitou Springs</b>	480	10	Hazus	\$192,051,000	Hazus
<b>Mineral County</b>				\$6,050,000	Hazus
<b>Montezuma County</b>	3366	28	Hazus	\$62,266,000	Hazus
<b>Montrose County</b>				\$3,580,460	
<b>Morgan County</b>		10	Hazus	\$97,477,000	Hazus
<b>Otero County</b>			Hazus	\$40,756,000	Hazus
<b>Ouray County</b>	78	2	Hazus	\$7,180,748	Hazus

Jurisdiction	# of Structures/ Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate	Loss Estimate Methodology
Park County	5611	38	Hazus	\$26,876,000	Hazus
Phillips County		13	Hazus	\$27,783,000	Hazus
Pitkin County				\$71,590,000	Hazus
Prowers County		50	Hazus	\$112,838,000	Hazus
Pueblo County	1,298			\$1,205,174,000	
Rio Grande County	797	2	Hazus	\$47,419,000	Hazus
Saguache County	335	1	Hazus	\$12,494,000	Hazus
San Miguel County	2098	9	FEMA Map with Buffer		
Sedgwick County		5	Hazus	\$5,079,000	Hazus
Southern Ute Indian Tribe	138	99		\$12,994,040	Hazus
Summit County	499	1	Hazus	\$172,477,598	Hazus
Teller County	182	25	Hazus	\$3,973,500	Hazus
Thornton/Federal Heights/ Northglenn	1682	67	Hazus	\$9,200,000	Hazus
Ute Mountain Ute Tribe	71			\$176,000	Hazus
Washington County		1	Hazus	\$6,798,000	Hazus
Weld County	2,096	55		\$54,067,400	Hazus
City of Westminster		0			
Yuma County		10	Hazus	\$29,543,000	Hazus
<b>Total</b>	<b>211,588</b>	<b>1,687</b>		<b>\$19.938 B</b>	

## 8. FUTURE DEVELOPMENT

Changes in growth and development naturally affect loss estimates and vulnerability. When the population in a flood hazard area increases, so too does the vulnerability of the people and property unless mitigation measures are taken. When the population of a hazard area

decreases, the burden of managing communal property may exceed the resources of the declining population.

FEMA’s NFIP is aimed at reducing existing structures and eliminating future development in the floodplain. Communities participating in the NFIP agree to support these efforts at the local level. As of December 15, 2017, there are 255 Colorado communities participating in the NFIP.

Changes in development patterns can generally be related to changes in population. Population growth and development contribute to increased exposure of people and property to flooding and its related impacts. Understanding changes in hazard exposure over time is an important element of comprehensive hazard mitigation planning. Among other things, increased population growth and development elevate exposure levels of property and people to the impacts of flooding.

Colorado continues to experience some of the largest population growth in the country and future projections seem to indicate a similar trend should be expected. Table 3-48 presents the projected percent change in housing on a county scale from 2010 to 2030. Those counties that have a large expected percent change in housing as well as a history of significant flood events can be viewed as being potentially the most at risk for future exposure. Historical events only include those reported from NOAA by county, as some of their recent reporting is now based off of NWS Zones. Many of the historical floods have occurred in those counties expected to see the highest housing growth. For all counties, future flood losses can be mitigated by ensuring that all future development avoids flood hazard areas. Unfortunately, not all floodplains have yet been mapped across the state and some existing mapping is in need of updates.

**TABLE 3-48 HOUSING PROJECTIONS (2010 TO 2030) AND HISTORICAL EVENTS**

County	Historical Floods	Housing Percent Change	Growth Rating
La Plata	59	50%	Highest
Larimer	51	47%	Highest
Weld	48	93%	Highest
Garfield	47	51%	Highest
Douglas	43	67%	Highest
Arapahoe	37	52%	Highest
San Miguel	31	64%	Highest
Montrose	24	61%	Highest
Eagle	22	56%	Highest
Adams	22	60%	Highest
Elbert	20	120%	Highest
Routt	10	46%	Highest
Summit	8	49%	Highest
Park	8	65%	Highest
Archuleta	6	61%	Highest
Broomfield	2	78%	Highest

County	Historical Floods	Housing Percent Change	Growth Rating
El Paso	143	40%	High
Mesa	70	38%	High
Pueblo	54	26%	High
Jefferson	40	30%	High
Morgan	37	26%	High
Fremont	35	28%	High
Boulder	33	37%	High
Denver	23	37%	High
Pitkin	20	34%	High
Lincoln	15	26%	High
Montezuma	14	37%	High
Gunnison	11	28%	High
Delta	11	35%	High
Custer	11	41%	High
Chaffee	10	38%	High
Grand	2	44%	High
Yuma	38	17%	Moderate
Kit Carson	32	20%	Moderate
Teller	24	23%	Moderate
Ouray	20	13%	Moderate
Logan	18	21%	Moderate
Las Animas	13	23%	Moderate
Huerfano	10	13%	Moderate
Kiowa	8	12%	Moderate
Clear Creek	7	20%	Moderate
Hinsdale	5	19%	Moderate
Crowley	5	26%	Moderate
Gilpin	2	12%	Moderate
Saguache	2	17%	Moderate
Conejos	0	14%	Moderate
Lake	0	21%	Moderate
Alamosa	0	25%	Moderate
Rio Blanco	36	10%	Low
Washington	26	8%	Low
Prowers	24	3%	Low
Otero	23	6%	Low
Cheyenne	23	11%	Low
Bent	14	7%	Low
Phillips	12	1%	Low
Baca	9	-6%	Low
Moffat	9	7%	Low

County	Historical Floods	Housing Percent Change	Growth Rating
San Juan	6	10%	Low
Dolores	4	4%	Low
Rio Grande	2	7%	Low
Costilla	2	10%	Low
Sedgwick	1	1%	Low
Jackson	1	9%	Low
Mineral	0	10%	Low

Source: NOAA, Colorado State Demography Office, 2017

The following section provides county-scale flood exposure projections by comparing current flood risk with projected population data. Table 3-51 provides county-scale flood exposure projections by analyzing flood risk and population change between 2010 and 2030. Below, Table 3-49 and Table 3-50 outline the methodology used to determine the exposure projections for each county. Many counties along the Front Range have the highest flood exposure projection. These are all high-density counties, where damaging flood events are more frequent. Arapahoe, Jefferson, Adams, Douglas, and Denver Counties are all part of the metro Denver area. Figure 3-25 presents this same information on a statewide map.

TABLE 3-49 FLOOD EXPOSURE PROJECTIONS

Future Flood Exposure Projections					
		County Growth Projections (%), 2010 to 2030			
Flood Risk		-13% to 2%	3% to 17%	18% to 34%	35% to 89%
High ↑ Moderate	3	Moderate	High	Severe	Extreme
	2	Slight	Moderate	High	Severe
	1	Negligible	Slight	Moderate	High

The Combined Risk calculations in Table 3-49 are based on the methodology outlined in Table 3-50. Values (between zero and three) have been assigned to the total economic losses that were modeled in Hazus for the one percent annual chance flood event. The Jenks Natural Breaks algorithm was used to classify this estimated loss data set value.

TABLE 3-50 COMBINED RISK METHODOLOGY

Hazus Estimated Total Economic Losses	Value
\$315.9 - \$553.3 M	3
\$80.7 M - \$315.9 M	2
\$1.3 M - \$80.7 M	1

Exposure to floods is expected to intensify across the State of Colorado between 2010 and 2030 as population increases. The darker, more red colors in Table 3-49 illustrate relative rates of increase in exposure between counties. This same information is also shown on the following Table 3-51 by county. As Colorado’s population increases, infrastructure and businesses will follow these population centers. This further adds to the potential future exposure that counties face from flood. Figure 3-25 presents this information on a statewide map. Arapahoe and El Paso Counties are at the highest risk due to its high estimated economic losses from a 100-year flood and projected population growth. Many of the counties with severe projected exposure to floods are counties along the Front Range. These counties have high populations, and their populations are projected to continue to grow, putting many people and infrastructure at risk for future flooding.

TABLE 3-51 FLOOD EXPOSURE PROJECTIONS, 2010 TO 2030

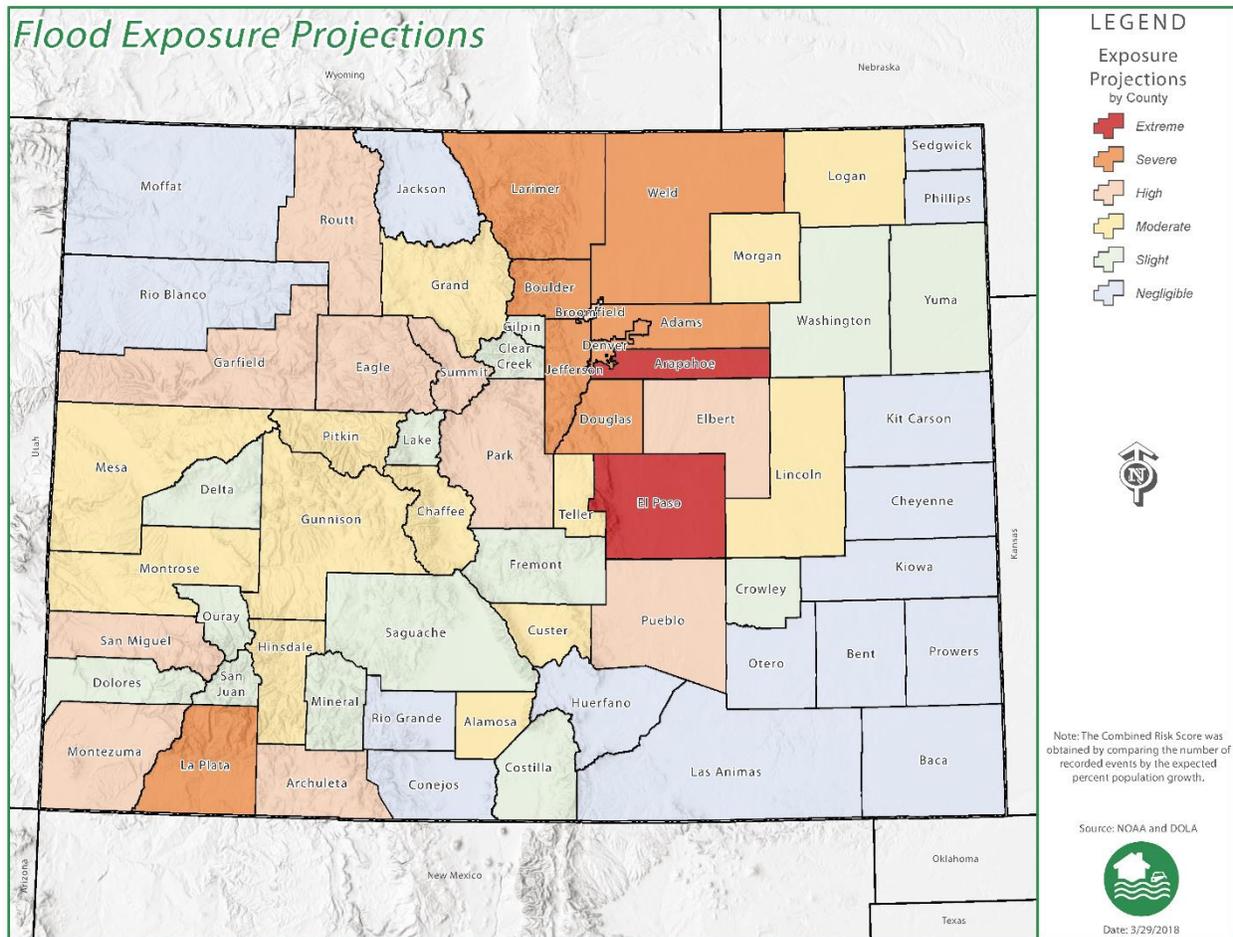
County	Risk	Population Change	Exposure Rating
Arapahoe	3	36%	Extreme
El Paso	3	36%	Extreme
Weld	2	81%	Severe
Adams	2	48%	Severe
Douglas	2	44%	Severe
Denver	2	42%	Severe
La Plata	2	42%	Severe
Larimer	2	42%	Severe
Boulder	3	28%	Severe
Jefferson	3	21%	Severe
Elbert	1	89%	High
Broomfield	1	71%	High
San Miguel	1	59%	High
Summit	1	41%	High
Routt	1	40%	High
Archuleta	1	40%	High
Garfield	1	38%	High
Montezuma	1	37%	High
Park	2	34%	High

County	Risk	Population Change	Exposure Rating
Eagle	2	34%	High
Pueblo	2	20%	High
Grand	1	32%	Moderate
Montrose	1	30%	Moderate
Hinsdale	1	29%	Moderate
Chaffee	1	29%	Moderate
Gunnison	1	26%	Moderate
Teller	1	25%	Moderate
Mesa	1	24%	Moderate
Alamosa	1	22%	Moderate
Lincoln	1	21%	Moderate
Custer	1	20%	Moderate
Pitkin	1	18%	Moderate
Morgan	2	16%	Moderate
Logan	2	14%	Moderate
Lake	1	17%	Slight
Ouray	1	17%	Slight
Mineral	1	16%	Slight
Clear Creek	1	14%	Slight
Gilpin	1	13%	Slight
Saguache	1	9%	Slight
Delta	1	8%	Slight
Costilla	1	7%	Slight
Yuma	1	7%	Slight
Fremont	1	5%	Slight
Washington	1	5%	Slight
Dolores	1	5%	Slight
Crowley	1	5%	Slight
San Juan	1	5%	Slight
Cheyenne	1	2%	Negligible
Rio Blanco	1	2%	Negligible
Conejos	1	1%	Negligible
Kit Carson	1	-1%	Negligible
Huerfano	1	-1%	Negligible
Sedgwick	1	-3%	Negligible
Phillips	1	-3%	Negligible
Moffat	1	-3%	Negligible
Rio Grande	1	-5%	Negligible
Bent	1	-5%	Negligible
Prowers	1	-5%	Negligible
Otero	1	-7%	Negligible

County	Risk	Population Change	Exposure Rating
Jackson	1	-7%	Negligible
Kiowa	1	-8%	Negligible
Las Animas	1	-9%	Negligible
Baca	1	-13%	Negligible

Source: NOAA, Colorado State Demography Office, 2017

FIGURE 3-25 FLOOD EXPOSURE PROJECTIONS, 2010 TO 2030



Future development is a subject that must be evaluated within local hazard mitigation plans. Below lists these trends as specifically mentioned in local hazard mitigation plans:

- Adams County – High probability of increased development in floodplain.
- La Plata County - La Plata County, and its incorporated cities and towns, have floodplain policies regulating development in flood-prone areas. Some flood protection measures are provided in the City and Town Ordinances and La Plata County Flood Hazard Regulations for areas within the 100-year floodplains.

- Archuleta County - While overall development has slowed down, some of the development has occurred in hazard areas such as the wildland urban interface and floodplains.
- City of Boulder - Development that occurs is typically re-development of a previously developed area. The 2006 redevelopment of the Crossroads Mall into the 29th Street shopping district is an example. This development considers flood hazard risk from Boulder Creek and includes a Home Depot elevated to provide protection from the 100-year flood.
- Clear Creek County - Clear Creek County is a historic mining district that has only seen modest land development since that period. There is extensive large-lot development however in the eastern-most areas of the county adjoining Jefferson County. Most all of the commercial development is located within the towns and cities along Interstate 70 bordering Clear Creek.

## 9. CLIMATE CHANGE

According to the best data available at the time of this plan update, the future impacts of climate change are expected to influence future flood events. Table 3-52 presents a breakdown of these projected changes in terms of hazard: location, extent/intensity, frequency, and duration. However, ongoing efforts to reduce Colorado’s greenhouse gas emissions and adapt to a changing climate, such as the Colorado Climate Plan and the Climate Change in Colorado Report, will help to reduce the impacts of climate change on floods.

**TABLE 3-52 CLIMATE CHANGE IMPACTS**

Impact	Projected Change
<b>Location</b>	The location of floods is not projected to change.
<b>Extent/Intensity</b>	Flood extent is not projected to change. Flood intensity may increase due to transition from hail to rain on the Front Range of the Rocky Mountains resulting in higher flash-flood risk specifically in eastern Colorado. In the mountainous regions of Colorado, snowmelt-driven spring and summertime floods are expected to diminish.
<b>Frequency</b>	There are no clear trends in heavy precipitation events for Colorado, and like annual precipitation, there is considerable variability at annual and decadal time scales.
<b>Duration</b>	The duration of flood events is not likely to change. However, seasonal runoff shifting one to four weeks earlier may contribute to earlier flooding during the spring.

Source: FEMA 2017; Garfin et al. 2013; Lukas et al. 2014; and Childress et al. 2015

## 10. RISK TO STATE ASSETS

Figure 3-26 shows counties with state assets at risk to flooding. These assets were identified by intersecting the state asset GIS database with the 100-year floodplains shown in Figure 3-18. Boulder, Denver, and Crowley Counties contain the highest values of state assets in the 100-year floodplain. Boulder County has the highest, with 34 assets valued at \$149,212,000. Denver County has the next highest, with 20 assets valued at \$125,129,000. Crowley County has the third highest, with 15 state assets valued at \$96,864,496. Larimer County contains the most state assets in the 100-year floodplain, with 63 and a value of \$21,396,900. Overall, generally counties along the Front Range and northern Eastern Plains have the highest values of state assets in the 100-year floodplain. Statewide, 661 state assets are located in the 100-year floodplain, and \$465,353,021 in state asset value. Table 3-53 shows state assets located in the 100-year floodplain by county.

Since 2008, there have been 146 property losses reported on state assets due to flooding, resulting in over \$16 million in losses. Approximately \$12 million of these losses, or 74 percent, were due to the September 2013 floods. It is important to note that state asset loss data is only available for state assets included in the 2017 Office of Risk Management (ORM) database. These numbers exclude many Higher Education assets, and therefore may under-represent actual losses.

FIGURE 3-26 STATE ASSETS AT RISK FOR FLOOD

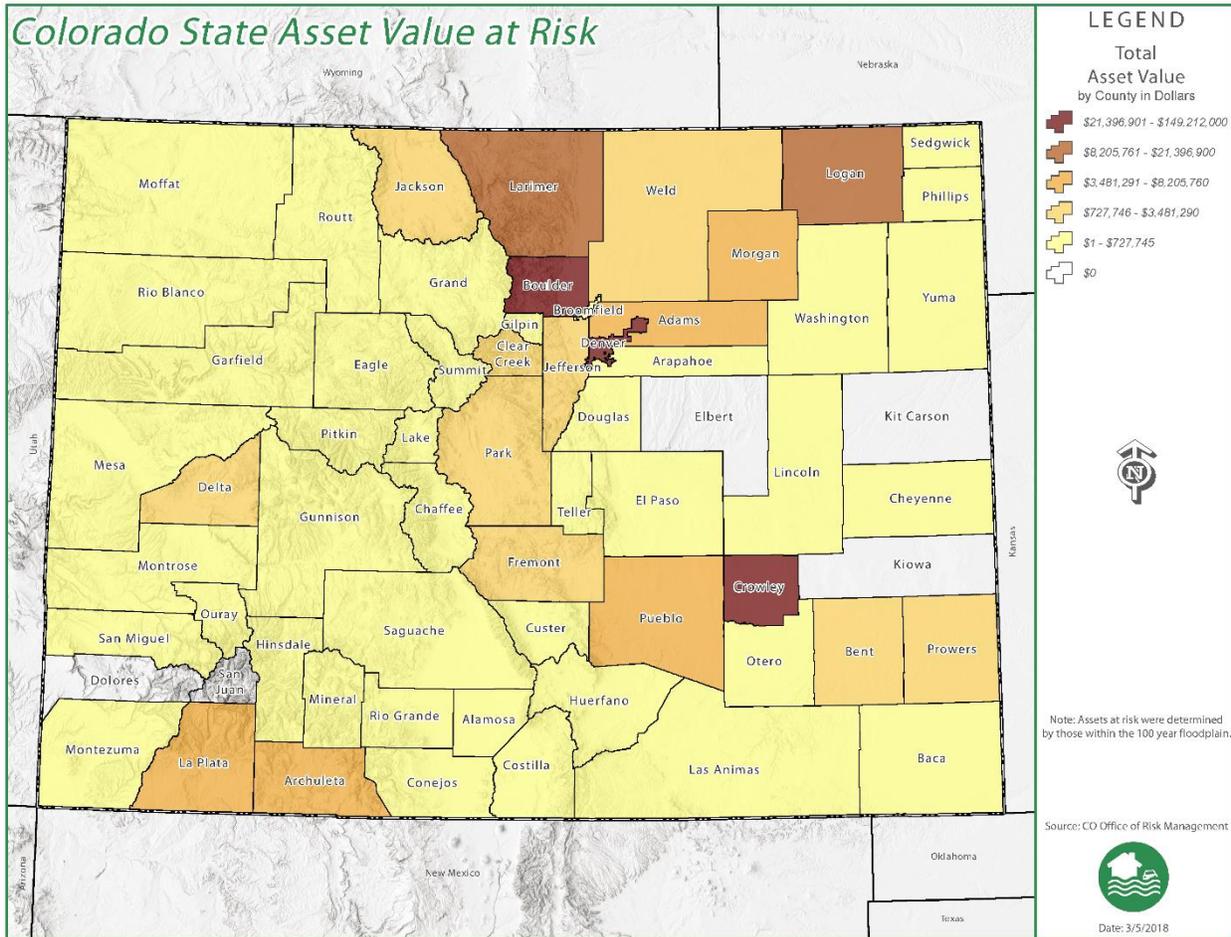


TABLE 3-53 VALUE AND COUNT OF STATE ASSETS IN THE 100-YEAR FLOODPLAIN BY COUNTY

County	State Asset Value	State Asset Count
<b>Boulder</b>	\$149,212,000	34
<b>Denver</b>	\$125,129,000	20
<b>Crowley</b>	\$96,864,496	15
<b>Larimer</b>	\$21,396,900	63
<b>Logan</b>	\$14,997,400	43
<b>La Plata</b>	\$8,205,760	14
<b>Pueblo</b>	\$5,858,980	28
<b>Archuleta</b>	\$4,812,380	28
<b>Adams</b>	\$4,368,850	17
<b>Morgan</b>	\$4,238,660	31
<b>Park</b>	\$3,481,290	37
<b>Jefferson</b>	\$3,189,300	25
<b>Weld</b>	\$3,036,390	39

<b>County</b>	<b>State Asset Value</b>	<b>State Asset Count</b>
Fremont	\$2,833,760	30
Clear Creek	\$2,769,800	13
Delta	\$2,532,890	13
Bent	\$2,385,810	25
Jackson	\$1,741,550	6
Prowers	\$1,701,550	12
Rio Blanco	\$727,745	6
Mesa	\$697,831	10
Summit	\$696,062	2
Yuma	\$657,374	11
Arapahoe	\$615,085	4
Conejos	\$517,090	9
Chaffee	\$449,357	16
Gunnison	\$383,097	15
Teller	\$258,770	5
Gilpin	\$167,514	1
El Paso	\$166,738	5
Routt	\$155,988	5
Montezuma	\$140,516	11
Phillips	\$108,058	1
Moffat	\$94,084	2
Broomfield	\$74,387	1
Rio Grande	\$66,596	9
Garfield	\$56,327	4
Las Animas	\$53,394	3
Lincoln	\$53,012	2
Douglas	\$52,644	4
Lake	\$44,884	6
Custer	\$35,761	2
Saguache	\$35,577	3
Otero	\$33,441	5
Cheyenne	\$30,750	1
Montrose	\$30,407	3
Alamosa	\$30,236	2
Sedgwick	\$27,510	4
Baca	\$25,625	1
Huerfano	\$24,271	3
Pitkin	\$20,271	2
Costilla	\$20,271	2
Mineral	\$20,271	2
Ouray	\$15,170	1
Hinsdale	\$10,136	1

County	State Asset Value	State Asset Count
<b>Eagle</b>	\$1	1
<b>San Miguel</b>	\$1	1
<b>Washington</b>	\$1	1
<b>Grand</b>	\$1	1
<b>San Juan</b>	\$0	0
<b>Kit Carson</b>	\$0	0
<b>Kiowa</b>	\$0	0
<b>Elbert</b>	\$0	0
<b>Dolores</b>	\$0	0
<b>Total</b>	<b>\$465,353,021</b>	<b>661</b>

## 11. RESOURCES

- Childress, A., Gordon, E., Jedd, T., Klein, R., Lukas, J., and McKeown, R. (2015). Colorado Climate Change Vulnerability Study.
- Colorado Climate Center (CCC)
- Colorado Climate Plan
- Colorado Division of Homeland Security & Emergency Management (DHSEM) Threat and Hazard Identification and Risk Assessment (THIRA)
- Colorado Department of Transportation (CDOT) Emergency Operations Plan (EOP)
- Colorado Department of Transportation (CDOT) Threat and Hazard Identification and Risk Assessment (THIRA)
- Colorado Division of Water Resources (DWR)
- Colorado Energy Assurance Emergency Plan (CEAEP), 2016
- Colorado Flood Mitigation Plan (2013)
- Colorado Water Plan
- Federal Emergency Management Agency (FEMA). (2017). Assessing Future Conditions, Colorado.
- Federal Emergency Management Agency (FEMA), Region VIII
- Garfin, G., A. Jardine, R. Merideth, M. Black, and S. LeRoy, eds. (2013). Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment. A report by the Southwest Climate Alliance. Washington, DC: Island Press.
- Lukas, J., Barsugli, J., Doesken, N., Rangwala, I., and Wolter, K. (2014). Climate Change in Colorado: A Synthesis to Support Water Resources Management and Adaptation.
- National Climatic Data Center (NCDC)
- Spatial Hazard Events and Losses Database for the United States (SHELDUS)

- Willner, S. N., Levermann, A., Zhao, F., & Frieler, K. (2018). Adaptation required to preserve future high-end river flood risk at present levels. *Science Advances*, 4(1). doi:10.1126/sciadv.aao1914

# HAIL



## 1. DEFINITION

Hail occurs when atmospheric water particles in thunderstorms form into rounded or irregular lumps of ice that fall to the earth. Strong updrafts in storm clouds can carry water droplets to altitudes with temperatures below freezing. As the frozen droplets rise and fall within the cloud, they grow larger until their weight is too great for the wind to keep them aloft. The Colorado Resilience Framework notes that “such conditions are typical of spring and summer storms on the Eastern Plains of Colorado and are exacerbated by strong updraft potential along the front of the Rocky Mountains.”

Large hailstones can smash glass and dent metal, resulting in costly damage to roofs and windows, automobiles, landscaping, and crops, as well as occasional injuries. Large hail is often associated with the types of severe thunderstorms that can also produce tornadoes. Table 3-54 describes the hazard profile summary for hail.

TABLE 3-54 HAZARD PROFILE SUMMARY

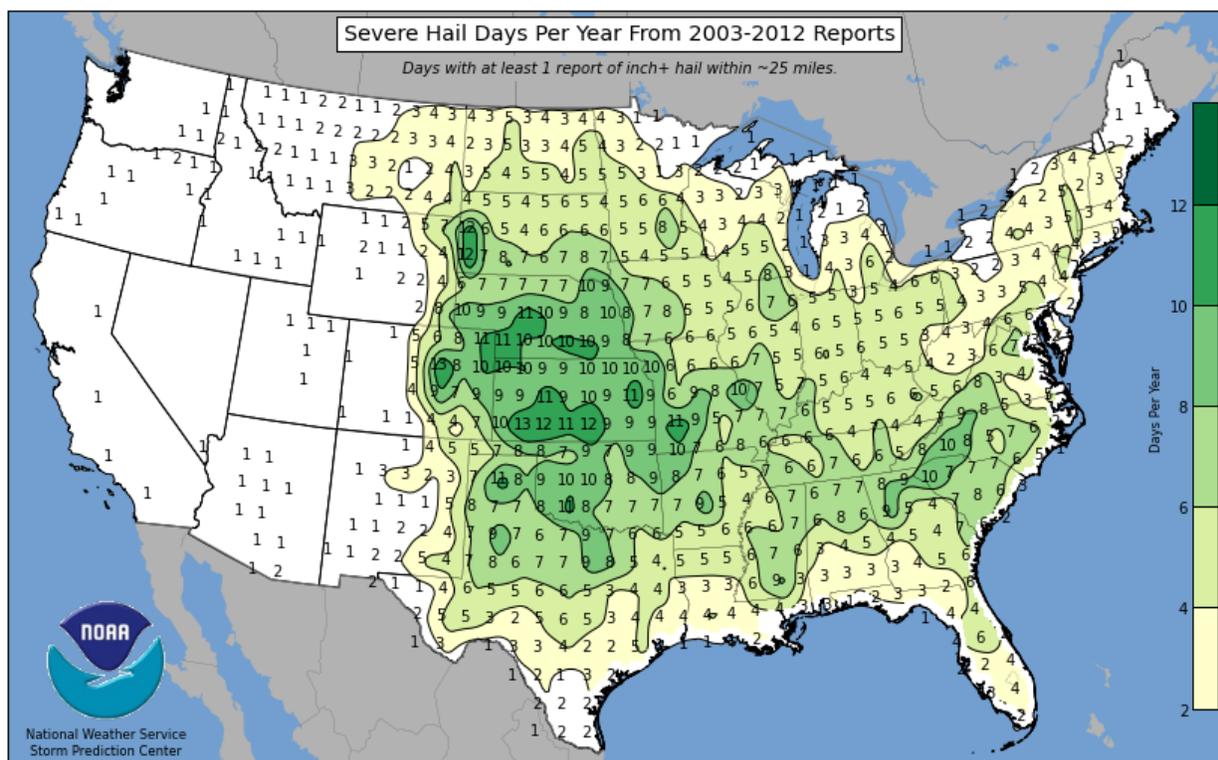
Consideration	Impact	Description
<b>Location</b>	Regional	Concentrated along the Front Range and Eastern Plains, particularly east-central to northeast Colorado, although most counties have recorded hail events.
<b>Previous Occurrence</b>	Seasonal	Storms occur many times a year, mostly late spring through early fall. Over last 20 years, an annual average of 433 events have been reported statewide, 63% of which were considered severe.
<b>Probability</b>	Expected	Hailstorms resulting in property or agricultural damage occur multiple times every year. Intense summer storms may occur more often in the future, increasing the frequency of hail events.
<b>Extent</b>	Moderate	Hailstones are 1.2 inches on average and have exceeded four inches on 45 occasions. Large events may result in high aggregate insured losses, but typically cause no threat to structural integrity, minor injuries, and little or no impact to critical services or facilities.

## 2. LOCATION

Colorado is one of the most hail-prone states, as hail occurs more frequently on the eastern side of the Rockies than anywhere else in North America. Colorado’s Front Range and Eastern Plains are within the United States’ “Hail Alley,” a region spanning several states that receives the highest frequency of large hail. Figure 3-27 shows that the further east in Colorado, the

more hail days typically occur. The state is generally on the western edge of the most hail-prone portion of the country. Destructive hail occurs most frequently on the western Great Plains, with the area near the border of Wyoming, Nebraska, and Colorado among those that experience large hailstones most frequently.

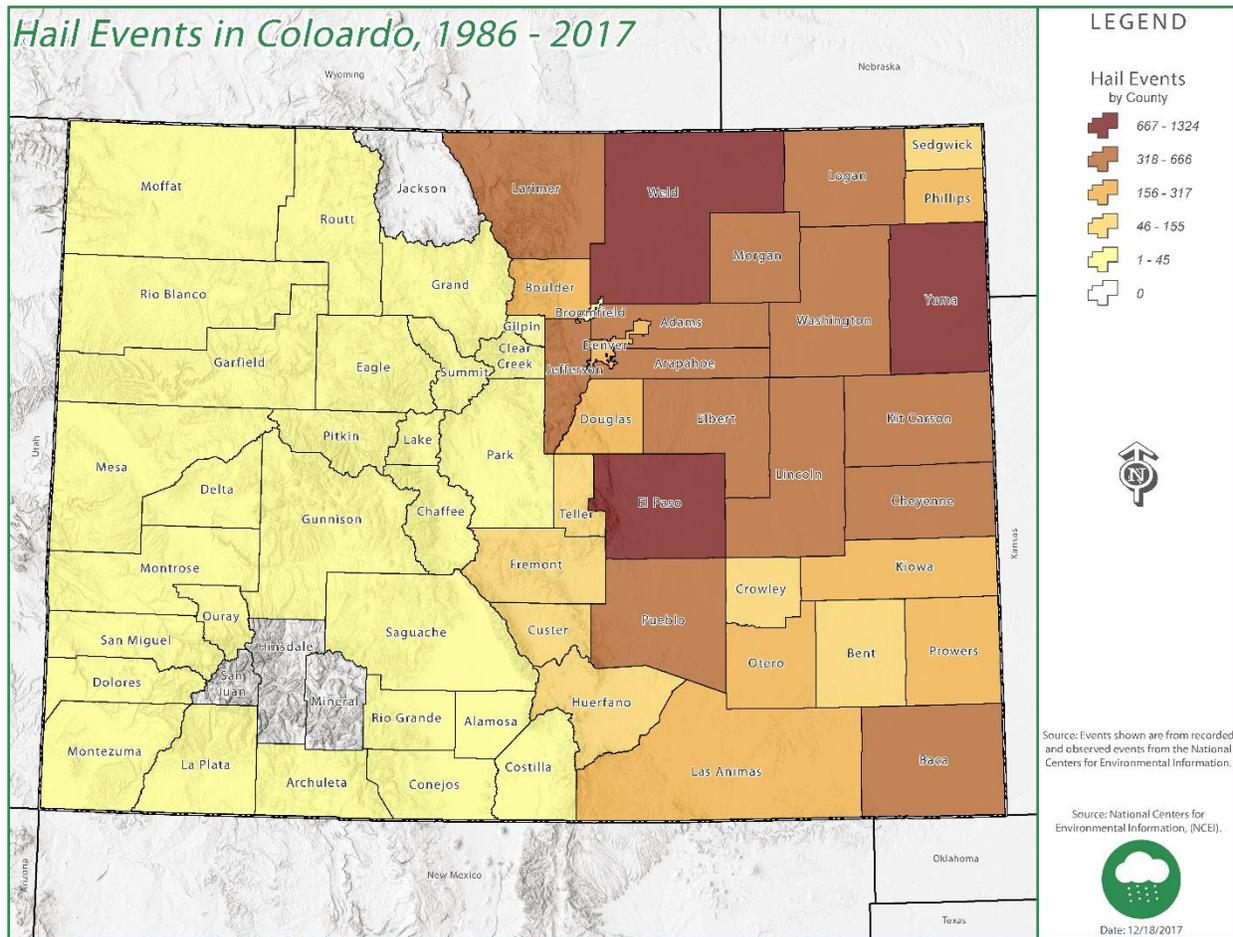
**FIGURE 3-27 NATIONAL SEVERE HAIL DAYS**



Source: NOAA

In Colorado, areas range from one to 13 severe hail days per year. The primary threat of hail is east of the Continental Divide along the Front Range and across the Eastern Plains. Five counties - El Paso, Kit Carson, Washington, Weld, and Yuma - have experienced over 500 reports of hail between 1955 and 2017. El Paso County has the highest number of hail reports in the state with 1,324 during this timeframe. Denver County has experienced just 228 reports, but it has the most reports for its size; there have been 1.5 hail reports per square mile, more than double the rate of El Paso County. Figure 3-28 highlights hail events across the state in recent years. Hail also occurs frequently in the high Colorado mountains during the summer. These stones, however, tend to be small and soft and rarely do damage.

FIGURE 3-28 HAIL EVENTS IN COLORADO



### 3. EXTENT (MAGNITUDE/STRENGTH)

Hail is more variable (from place to place and year to year) than almost any other climatic event. Strong winds accompanying hail greatly increase the damage potential. Table 3-55 describes how hail is measured.

TABLE 3-55 HAIL MEASUREMENTS

Severity	Description	Hail Diameter Size
<b>Non-Severe Hail</b> Does not typically cause damage and does not warrant severe thunderstorm warning from NWS.	Pea	1/4"
	Plain M&M	1/2"
	Penny	3/4"
	Nickel	7/8"
<b>Severe Hail</b> Research has shown that damage occurs after hail reaches around 1" in diameter and larger. Hail of this size will trigger a severe thunderstorm warning from NWS.	Quarter	1" (severe)
	Half Dollar	1 1/4"
	Walnut/Ping Pong Ball	1 1/2"
	Golf Ball	1 3/4"
	Hen Egg/Lime	2"
	Tennis Ball	2 1/2"
	Baseball	2 3/4"
	Teacup/Large Apple	3"
	Grapefruit	4"
	Softball	4 1/2"
Computer CD-DVD	4 3/4" - 5"	

Source: NOAA

Hailstones of one to two inches in diameter (which may fall at a rate of 80 miles per hour) occur many times in eastern Colorado each summer, but fortunately occur over small areas.

The National Oceanic and Atmosphere Administration (NOAA) Storm Prediction Center Severe Weather Database, which maintains records on reported hail events since 1955, shows that hailstones in Colorado are, on average, 1.2 inches in diameter. Hailstones larger than four inches have been observed on 43 occasions, mostly in northeastern Colorado. Stones of that size have been known to penetrate some roofs.

## 4. PROBABILITY

Hailstorms resulting in property or agricultural damage occur multiple times every year. Most years involve at least one catastrophic hailstorm that causes \$25 million or more in insured damage. Intense summer storms may become more frequent in the future, increasing the frequency of hail events.

## 5. PREVIOUS OCCURRENCES

NOAA's Severe Weather Database lists 11,476 reports of hail in Colorado from 1955 to 2017. Of these reports, 65 percent were severe, defined as having hail measuring at least one inch in

diameter. Many of these reports are within the same county on the same day and may have been produced by a single storm system. In addition, hail reporting has changed over the years. The number of hail events reported annually has increased from 14 in 1955 to an average of more than 400 over the last 20 years. Colorado can generally expect to experience about 60 days of hail each year, with an average of three counties affected on each occasion. Table 3-56 and Table 3-57 provide historic hail data for the last 10 years and by decade since 1955. Damage estimates reflect the cost at the time and are not adjusted for inflation.

**TABLE 3-56 HAIL EVENTS, DEATHS, AND INJURIES, 2007-2017**

Year	Reported Events	Injuries	Property Damage
2007	525	0	\$36,000
2008	392	0	\$1,039,000
2009	676	7	\$602,346,900
2010	594	0	\$72,778,500
2011	394	2	\$164,851,000
2012	233	0	\$321,103,000
2013	249	0	\$1,400
2014	442	0	\$213,313,000
2015	420	0	\$0
2016	521	0	\$352,868,500
2017	302	0	\$2,300,000,000
<b>Total</b>	<b>4,748</b>	<b>9</b>	<b>\$4,028,337,300</b>

Source: NOAA

**TABLE 3-57 HAIL EVENTS, DEATHS, INJURIES, AND DAMAGE BY DECADE**

Years	Count	Deaths	Injuries	Property Damage	Crop Damage	Total Damage
1955-59	74	0	0	n/a	n/a	n/a
1960-69	192	0	0	n/a	n/a	n/a
1970-79	317	1	0	n/a	n/a	n/a
1980-89	903	0	9	n/a	n/a	n/a
1990-99	2,358	0	69	\$266,903,000	n/a	\$266,903,000
2000-09	4,477	0	12	\$863,934,900	\$40,370,000	\$904,304,900
2010-17	3,155	0	2	\$3,424,940,700	\$21,640,000	\$3,446,580,700
<b>Total</b>	<b>11,476</b>	<b>1</b>	<b>92</b>	<b>\$3,655,778,600</b>	<b>\$62,010,000</b>	<b>\$4,617,788,600</b>

Source: NOAA

Colorado's damaging hail season is from mid-April to mid-August. About 35 percent of reported hail events took place in June, and hailstorms are most likely to be destructive in mid-June.

However, in some areas - including Custer, Fremont, and Teller Counties - hail reports have historically peaked later in the summer.

The database began tracking injuries and property damage in the mid-1980s, and precise damage estimates in 1996. Property damage estimates are known for 311 reports since 1987, eight percent of which caused more than \$5 million in damages.

The Rocky Mountain Insurance Information Association (RMIIA) also tracks data on non-flood disasters that result in at least \$25 million in insured damage. In the last 10 years, there have been nine hail events in Colorado that have met this threshold, causing a combined \$5.2 billion in damages when adjusted for inflation. Six of the hailstorms were centered in the Denver metro area (due largely to the area having the biggest concentration of property in the state). The costliest of these storms recently occurred on May 8, 2017, causing \$2.3 billion in damages in the Denver metro area. Table 3-59 lists the top damaging hail events in Colorado according to RMIIA data.

There are three counties with over 700 reported hail events between 1955 and 2017. El Paso County has the highest number of hail events with 1,324, followed by Weld County with 796, and Yuma County with 746. Although these counties account for a quarter of total reported events combined, they only account for 1.4 percent of total reported damage since 1996.

Some events of note are further described below.

**City of Fort Collins – 1979:** Deaths from hail are rare, with only a few fatalities ever reported in the United States. One of these occurred during a 1979 hailstorm in Fort Collins. Several sources, including *The (Fort Collins) Coloradoan* newspaper, report that an infant died after being struck on the head by a large hailstone.

**Denver Metro – July 11, 1990:** Colorado's second most costly hail event struck the Denver area on July 11, 1990, causing \$625 million in damages, or nearly \$1.2 billion in today's dollars. A severe thunderstorm developed near Estes Park and moved southeast, producing hail up to 2.75 inches in diameter across seven counties, as well as flooding and two small tornadoes. The hail caused damage to thousands of homes and tens of thousands of automobiles. It remains the state's most harmful hail event, with 60 reported injuries.

**Northwest Denver Suburbs – July 20, 2009:** On the night of July 20, 2009, a strong storm hit the northwest suburbs of Denver, dumping as much as an inch of rain in less than an hour and hail that was one inch in diameter. The storm damaged numerous cars, windows, and roofs. A greenhouse containing plants worth more than \$250,000 was destroyed. Straight-line winds of 80 miles per hour uprooted mature trees and damaged roofs. The storm also left 50,000 residents without power. The RMIIA identified \$767.6 million in damages from the storm.

The July 20 storm was not the only event to cause significant damage in 2009. Severe weather, including hail and tornadoes, from June 6 to 15 resulted in \$353.3 million in insured losses. Another storm in the Pueblo Area on July 29 caused more than \$200 million in damages.

Overall, 2009 was the state’s costliest severe weather season at the time, with a total of \$1.4 billion in insured losses.

**Greater Denver Metro Area – May 8, 2017:** On the afternoon of May 8, 2017, a severe thunderstorm struck the Denver area, producing large hailstones, strong winds, heavy rain, and flash flooding. Hail was reported at locations across 11 counties, with official reports of hailstones up to 2.75 inches. The hail caused extensive damage to homes, businesses, and cars across a large part of Denver and its western suburbs, as well as Greeley. Because the storm struck during evening commute hours, many cars were exposed rather than in garages. The hail broke skylights at the Colorado Mills Mall in Lakewood, letting in rain that flooded the stores, common areas, and electrical and mechanical systems. An auto dealership in Lakewood reported that more than 250 vehicles on its lot were damaged. Broken windows were also reported at a medical center in Wheat Ridge and apartment complex near Regis University. Additionally, an estimated \$2.1 million in damages to state vehicles, including Colorado State Patrol vehicles and Central Services fleet vehicles resulted from this storm. With estimated damages of \$2.3 billion, the storm surpassed the 1990 and 2009 hail events and ranks among the costliest disasters ever in Colorado.

## 6. IMPACT ANALYSIS

Vehicles, roofs of buildings and homes, and landscaping are the property most commonly damaged by hail. A significant amount of damage inflicted by hail is to crops. Even small hail can cause significant damage to crops in a short period of time. If a person is caught exposed during a large hail event significant bodily injury may occur. The 2017 Colorado Department of Transportation (CDOT) Threat and Hazard Identification and Risk Assessment (THIRA) details the impact of hail on the public, responders, the delivery of services, infrastructure, the environment, the economy, confidence in governance, and the department’s own operations. It notes: “Insurance claims from large hailstorms tend to be small in amount (i.e., property by property damages) but high in the total number of claims which results in high aggregate insured losses. Crop damage and loss to farmers may be significant and result in agricultural disaster declarations.” The Plan states that resources may be necessary to clear roads of severe hail. The 2016 Colorado Energy Assurance Emergency Plan reports that hailstorms have a negligible effect on the energy sector, including “cosmetic or minor to moderate damage to grid components.” Table 3-58 includes an overall summary of hail impacts.

**TABLE 3-58 HAIL EMAP IMPACT SUMMARY**

Consideration	Description
<b>General Public</b>	Injuries and deaths have occurred from hail. Motorists, outdoor workers, outdoor recreationists are at risk from direct impact or deteriorated road conditions due to precipitation on the road surface.

Consideration	Description
<b>First Responders</b>	Some exposure exists to personnel performing routine duties when an event occurs; otherwise storm-related duties are typically post-event. Some impact related to unsafe road surface conditions from hail on roadways.
<b>Property</b>	Generally, many instances of small amounts of damage reflect high event-wide property losses, including structures and vehicles.
<b>Facilities and Infrastructure</b>	Buildings and equipment are exposed to hailstorms; however there is typically limited loss of facility use or infrastructure function or accessibility and limited uninsured damages. Value of state assets located in highest hail-prone counties totals over \$8.7 billion.
<b>Economic</b>	Insurance claims from large hailstorms tend to be small in amount (i.e., property by property damages) but high in the total number of claims which results in high aggregate insured losses. Crop damage and loss to farmers may be significant and result in agricultural disaster declarations.
<b>Environment</b>	Limited short-term impacts such as leaf and small limb removal from leaves and plants.
<b>Continuity of Government and Services</b>	None or limited loss of facilities or infrastructure function or accessibility or ability to provide services.
<b>Confidence in Government</b>	Characteristics of hailstorms such as duration and speed of onset result in limited response and recovery functions for government beyond first responders.
<b>Critical Assets</b>	Buildings and equipment are exposed to hailstorms but damage to such should not typically amount to disruption or debilitating damage to critical assets.

The RMIIA ranks the top 12 hail incidents, by insurance claims as shown in Table 3-59.

TABLE 3-59 TOP DAMAGING HAIL EVENTS IN COLORADO

Date	Location	Cost when occurred (Millions)	2017 Dollars (Millions)
June 13-14, 1984	Denver Metro	\$276.70	\$651.67
July 11, 1990	Denver Metro	\$625.00	\$1,170.14
October 1, 1994	Denver Metro	\$225.00	\$371.51
May 22, 1996	Denver Metro	\$122.00	\$190.27
August 11, 1997	Denver Metro	\$128.00	\$195.15
June 8-9, 2004	Denver Metro	\$146.50	\$189.78
May 22, 2008	Windsor	\$193.50	\$219.92
June 6-15, 2009	Denver Metro	\$353.30	\$403.04

Date	Location	Cost when occurred (Millions)	2017 Dollars (Millions)
July 20, 2009	Denver Metro	\$767.60	\$875.67
July 29, 2009	Pueblo	\$232.80	\$265.58
July 13, 2011	CO Front Range	\$164.80	\$179.31
June 6-7, 2012	CO Front Range	\$321.10	\$342.22
September 29, 2014	Denver Metro	\$213.30	\$220.51
July 28, 2016	Colorado Springs	\$352.80	\$359.71
May 8, 2017	Denver Metro	\$2,300.00	\$2,300.00

\*2017 estimated cost calculations based on the Consumer Price Index.

Source: RMIIA

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

In Colorado, counties with the highest population densities are generally located along the Front Range. In particular, the higher density counties include the Denver region along with El Paso County (City of Colorado Springs), Larimer County (City of Fort Collins), Weld County (City of Greeley), and Pueblo County (City of Pueblo). The total number of high-density counties including the Denver metro area is 11. All other 53 counties in the state are considered lower density.

Table 3-60 provides a comparison of hail events and property damage between higher and lower population density counties in Colorado. Higher-density counties, while only representing 40.7 percent of all reported hail events between 1996 and 2017, account for approximately 99 percent of reported statewide damage. This percentage equates to the 11 high-density counties accounting for \$4.5 billion of the \$4.6 billion in total reported statewide damage since 1996.

TABLE 3-60 HAIL DAMAGE BY COUNTY POPULATION DENSITY, 1996-2017

County by Density	Number of Events	Property Damage	Crop Damage	Total Damage
<b>Total</b>				
<b>Higher Density Counties</b>	<b>3,648</b>	<b>\$4,534,281,000</b>	<b>\$24,050,000</b>	<b>\$4,558,331,000</b>
Metro Denver*	1,313	\$4,033,131,000	\$25,000	\$4,033,156,000
El Paso	1,043	\$387,832,000	\$0	\$387,832,000
Larimer	345	\$0	\$1,025,000	\$1,025,000
Weld	583	\$9,316,000	\$3,000,000	\$12,316,000
Pueblo	364	\$104,002,000	\$20,000,000	\$124,002,000
<b>Lower Density Counties</b>	<b>5,310</b>	<b>\$21,497,600</b>	<b>\$37,960,000</b>	<b>\$59,457,600</b>
Total	8,958	\$4,555,778,600	\$62,010,000	\$4,617,788,600
<b>Percent</b>				
<b>Higher Density Counties</b>	<b>40.7%</b>	<b>99.5%</b>	<b>38.8%</b>	<b>98.7%</b>
Metro Denver	14.7%	85.7%	0.0%	84.3%
El Paso	11.6%	10.6%	0.0%	10.4%
Larimer	3.9%	0.0%	1.7%	0.0%
Weld	6.5%	0.3%	4.8%	0.3%
Pueblo	4.1%	2.8%	32.3%	3.3%
<b>Lower Density Counties</b>	<b>59.3%</b>	<b>0.5%</b>	<b>61.2%</b>	<b>1.3%</b>

Source: NOAA; Colorado State Demography Office

\*Includes the counties of Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, and Jefferson

Since 1986, hail has resulted in a total of 92 injuries in Colorado. The majority were due to a single storm on July 11, 1990, that injured 60 people in the Denver area, including 47 when golf ball-sized hail fell on Elitch Gardens Theme Park. Table 3-61 shows a breakout of deaths, injuries, and property damage by county. Note the damage estimates in this table reflect the 2017 estimate of damages from the May 2017 hail event in the Denver metro area of \$1.4 billion, rather than the updated estimate of \$2.3 billion. The updated damage estimate is not currently reflected in the NOAA Storm Events Database. Therefore, damages in Denver metro area counties are under estimated.

TABLE 3-61 HAIL EVENTS, DEATHS, INJURIES AND DAMAGE IN COLORADO BY COUNTY, 1996-2017

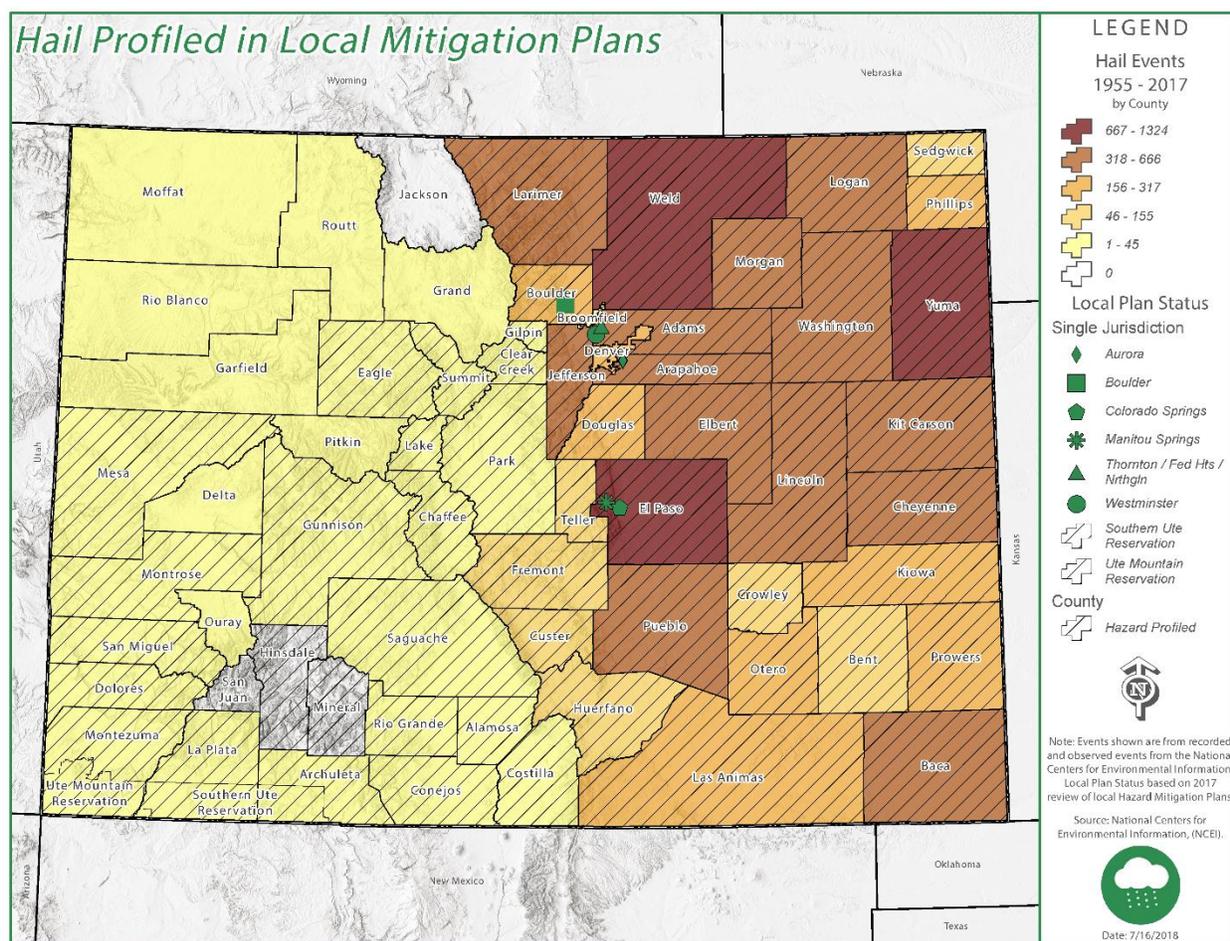
County	Number of Events	Deaths	Injuries	Property Damage	Crop Damage	Total Damage
Adams	232	0	7	\$438,800,000	\$0	\$438,800,000
Alamosa	7	0	0	\$0	\$0	\$0
Arapahoe	304	0	0	\$783,830,000	\$25,000	\$783,855,000
Archuleta	5	0	0	\$12,000	\$0	\$12,000
Baca	311	0	0	\$400,000	\$0	\$400,000
Bent	104	0	0	\$6,200,000	\$0	\$6,200,000
Boulder	130	0	0	\$1,000,000	\$0	\$1,000,000
Broomfield	18	0	0	\$0	\$0	\$0
Chaffee	8	0	0	\$0	\$0	\$0
Cheyenne	332	0	0	\$873,000	\$0	\$873,000
Clear Creek	7	0	0	\$0	\$0	\$0
Conejos	7	0	0	\$0	\$0	\$0
Costilla	4	0	0	\$450,000	\$0	\$450,000
Crowley	70	0	0	\$0	\$0	\$0
Custer	76	0	0	\$0	\$0	\$0
Delta	5	0	0	\$0	\$0	\$0
Denver	135	0	0	\$156,500,000	\$0	\$156,500,000
Dolores	2	0	0	\$5,000	\$0	\$5,000
Douglas	249	0	3	\$3,000,000	\$0	\$3,000,000
Eagle	2	0	0	\$0	\$0	\$0
Elbert	327	0	0	\$5,000	\$0	\$5,000
El Paso	1,043	0	2	\$387,832,000	\$0	\$387,832,000
Fremont	63	0	0	\$0	\$0	\$0
Garfield	16	0	0	\$0	\$0	\$0
Gilpin	12	0	0	\$0	\$0	\$0
Grand	1	0	0	\$0	\$0	\$0
Gunnison	1	0	0	\$0	\$0	\$0
Hinsdale	0	0	0	\$0	\$0	\$0
Huerfano	72	0	0	\$30,000	\$0	\$30,000
Jackson	0	0	0	\$0	\$0	\$0
Jefferson	245	0	0	\$1,750,001,000	\$0	\$1,750,001,000
Kiowa	222	0	0	\$20,000	\$0	\$20,000
Kit Carson	582	0	0	\$1,010,400	\$0	\$1,010,400

County	Number of Events	Deaths	Injuries	Property Damage	Crop Damage	Total Damage
Lake	1	0	0	\$0	\$0	\$0
La Plata	15	0	0	\$11,000	\$0	\$11,000
Larimer	345	0	0	\$0	\$1,025,000	\$1,025,000
Las Animas	215	0	0	\$10,000	\$0	\$10,000
Lincoln	310	0	0	\$0	\$0	\$0
Logan	303	0	0	\$21,000	\$200,000	\$221,000
Mesa	39	0	0	\$750,000	\$0	\$750,000
Mineral	0	0	0	\$0	\$0	\$0
Moffat	16	0	0	\$10,000	\$20,000	\$30,000
Montezuma	18	0	0	\$1,032,000	\$0	\$1,032,000
Montrose	5	0	0	\$0	\$0	\$0
Morgan	277	0	2	\$2,200,000	\$0	\$2,200,000
Otero	143	0	0	\$70,000	\$0	\$70,000
Ouray	3	0	0	\$0	\$0	\$0
Park	20	0	0	\$0	\$0	\$0
Phillips	141	0	0	\$20,000	\$8,500,000	\$8,520,000
Pitkin	4	0	0	\$0	\$0	\$0
Prowers	238	0	0	\$5,330,000	\$0	\$5,330,000
Pueblo	364	0	7	\$104,002,000	\$20,000,000	\$124,002,000
Rio Blanco	6	0	0	\$1,010,000	\$0	\$1,010,000
Rio Grande	10	0	0	\$0	\$0	\$0
Routt	15	0	0	\$105,000	\$0	\$105,000
Saguache	30	0	0	\$0	\$0	\$0
San Juan	0	0	0	\$0	\$0	\$0
San Miguel	4	0	0	\$0	\$0	\$0
Sedgwick	126	0	0	\$0	\$0	\$0
Summit	0	0	0	\$0	\$0	\$0
Teller	66	0	0	\$0	\$0	\$0
Washington	425	0	0	\$30,000	\$0	\$30,000
Weld	583	0	0	\$9,316,000	\$3,000,000	\$12,316,000
Yuma	644	0	0	\$1,893,200	\$29,240,000	\$31,133,200
<b>Total</b>	<b>8,958</b>	<b>0</b>	<b>21</b>	<b>\$3,655,778,600</b>	<b>\$62,010,000</b>	<b>\$3,717,788,600</b>

Source: NOAA

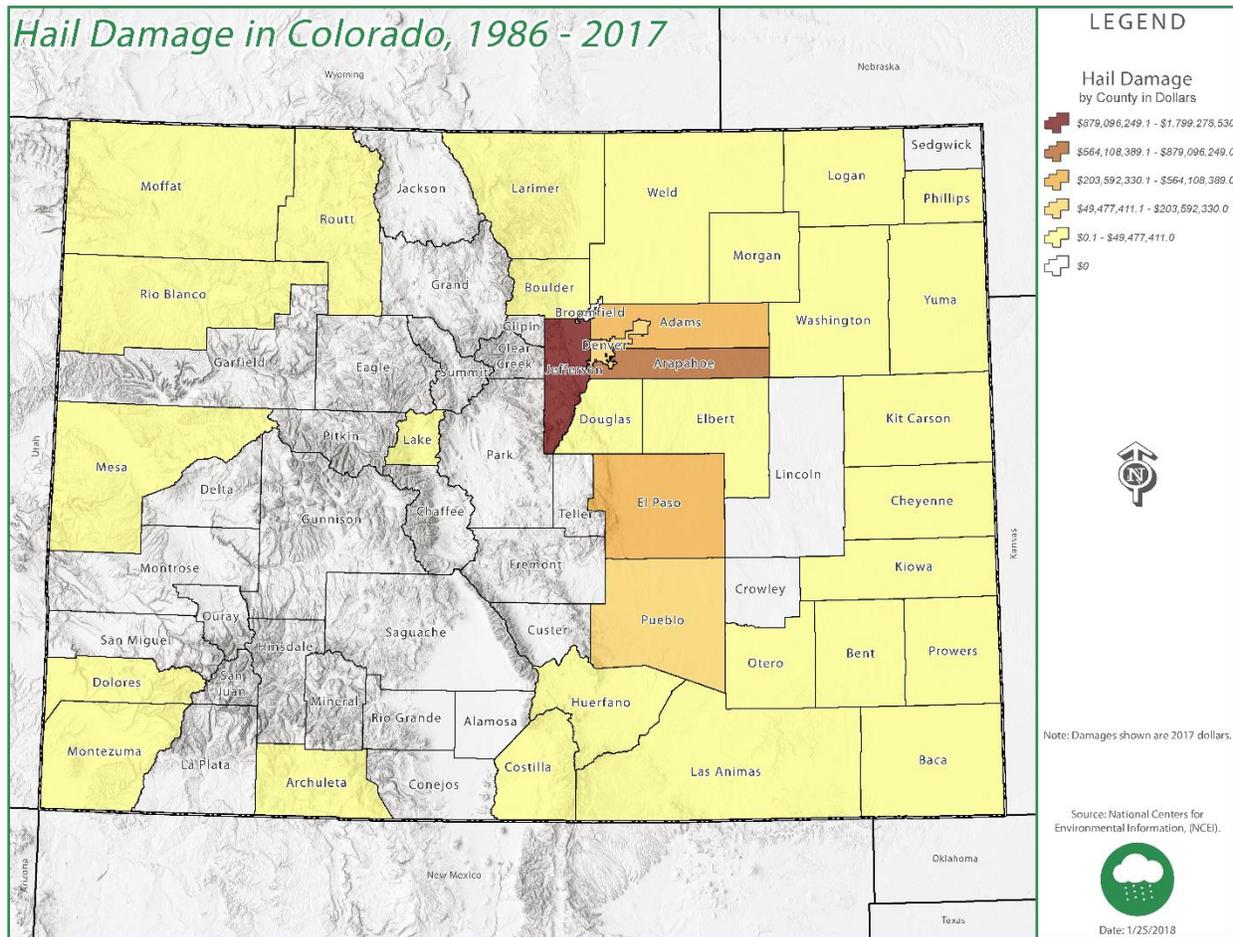
Based upon an updated (2017) review of local mitigation plans, Figure 3-29 illustrates which local jurisdictions profiled hail as a hazard, compared with historical hail events. Most counties along the Front Range and in northeast Colorado, as well as major single jurisdictions along the Front Range, have profiled hail.

**FIGURE 3-29 HAIL HAZARD IN LOCAL MITIGATION PLANS**



Based upon historical data, Figure 3-30 highlights damage totals (by county) for the past 21 years. Jefferson County, located on the west side of the Denver metro area, experienced the highest amount of property damage in the state since 1996. This County has \$1.8 billion in reported damages, representing 52 percent of the statewide totals; however, this is due largely to the fact that all \$1.4 billion associated with the May 8, 2017 hailstorm that affected the greater Denver metro area was entirely assigned to Jefferson County in the NOAA database. It is unknown how much of the reported damage, if any, from the storm was associated with the other 10 affected counties. Additionally, this map does not provide the most recent damage estimate of \$2.3 billion from the May 8, 2017 event. Arapahoe, Adams, and El Paso Counties, which comprise the next three highest totals, have each incurred losses between \$388 million and \$784 million. These each equate to between 10 percent and 23 percent of the statewide historical damages.

FIGURE 3-30 DAMAGE FROM HAIL EVENTS IN COLORADO BY COUNTY



Based on review of local hazard mitigation plans, eight jurisdictions profile hail as one of their top four hazards. Within those eight jurisdictions, a total of 352,792 structures or parcels are in hail hazard areas, and 2,561 critical facilities are in hail hazard areas. Table 3-62 describes this information in more detail, as well as the total estimated losses.

TABLE 3-62 LOCAL HAZARD MITIGATION PLANS

Jurisdiction	# of Structures/ Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate (\$)	Loss Estimate Methodology
City of Aurora	96,098	313		\$5,560,163	Avg Annual Losses
Conejos County	5,653	37			
Fremont County	16,707	238		\$522,230,652	10% damage

Jurisdiction	# of Structures/ Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate (\$\$)	Loss Estimate Methodology
Jefferson County	205,858	1499		\$6,518,232	avg annual losses (storms in general affecting power loss)
Las Animas County	14,232	338		\$2,143	avg annual loss
Rio Grande County	9,482	45			
Saguache County	4,762	55			
City of Westminster		36			
<b>Total</b>	<b>352,792</b>	<b>2561</b>		<b>\$534,311,190</b>	

## 8. FUTURE DEVELOPMENT

Development and population growth contribute to increased exposure of people and property to hazards. Understanding changes in hazard exposure over time is an important element of comprehensive hazard mitigation planning. In the context of hail, increased population and development elevates exposure of property and people to the impacts of hail.

Colorado continues to experience some of the largest population growth in the country, and future projections seem to indicate a similar trend should be expected. Table 3-63 presents the projected percent change in housing on a county scale from 2010 - 2030. Among the 10 counties with the most historical hail reports, all but one are projected to see at least moderate housing growth; four of them - Weld, Larimer, Arapahoe, and Elbert Counties - are in the highest growth category, with increases in housing ranging from 47 percent to 120 percent from 2010 to 2030.

TABLE 3-63 HOUSING PROJECTIONS (2010 TO 2030) AND HISTORICAL HAIL EVENTS

County	Historical Hail Reports	Housing Percent Change	Growth Rating
Weld	796	93%	Highest
Larimer	477	47%	Highest
Arapahoe	443	52%	Highest
Elbert	400	120%	Highest
Adams	359	60%	Highest
Douglas	317	67%	Highest
Park	30	65%	Highest
Broomfield	19	78%	Highest
La Plata	19	50%	Highest

County	Historical Hail Reports	Housing Percent Change	Growth Rating
Garfield	17	51%	Highest
Routt	17	46%	Highest
Montrose	9	61%	Highest
San Miguel	5	64%	Highest
Archuleta	5	61%	Highest
Eagle	2	56%	Highest
Summit	1	49%	Highest
El Paso	1,324	40%	High
Pueblo	451	26%	High
Lincoln	406	26%	High
Jefferson	379	30%	High
Denver	228	37%	High
Boulder	210	37%	High
Crowley	88	26%	High
Custer	85	41%	High
Fremont	80	28%	High
Mesa	45	38%	High
Montezuma	19	37%	High
Chaffee	10	38%	High
Pitkin	6	34%	High
Delta	5	35%	High
Grand	2	44%	High
Gunnison	2	28%	High
Yuma	745	17%	Moderate
Kit Carson	666	20%	Moderate
Logan	381	21%	Moderate
Morgan	372	26%	Moderate
Kiowa	278	12%	Moderate
Las Animas	251	23%	Moderate
Teller	88	23%	Moderate
Huerfano	83	13%	Moderate
Saguache	36	17%	Moderate
Gilpin	15	12%	Moderate
Alamosa	12	25%	Moderate
Clear Creek	12	20%	Moderate
Conejos	8	14%	Moderate
Ouray	3	13%	Moderate
Lake	2	21%	Moderate
Hinsdale	0	19%	Moderate
Washington	524	8%	Low
Cheyenne	389	11%	Low

County	Historical Hail Reports	Housing Percent Change	Growth Rating
Baca	356	-6%	Low
Prowers	295	3%	Low
Otero	188	6%	Low
Phillips	179	1%	Low
Sedgwick	155	1%	Low
Bent	131	7%	Low
Rio Grande	19	7%	Low
Moffat	17	7%	Low
Rio Blanco	7	10%	Low
Costilla	6	10%	Low
Dolores	2	4%	Low
Mineral	0	10%	Low
San Juan	0	10%	Low
Jackson	0	9%	Low

Source: Colorado State Demography Office, 2017

Table 3-66 provides county-scale hail exposure projections by analyzing hail risk and population change between 2010 and 2030. Below, Table 3-64 and Table 3-65 outline the methodology used to determine the exposure projections for each county. Weld, Adams, Douglas, Larimer, El Paso, and Jefferson Counties have the highest hail exposure projection. These are all high-density counties located along the Front Range, where damaging hail events are frequent. Jefferson, Adams, and Douglas are part of the metro Denver area. Figure 3-31 presents this same information on a statewide map.

TABLE 3-64 HAIL EXPOSURE PROJECTIONS

Future Hail Exposure Projections					
		County Population Percent Change Projections, 2010 to 2030			
Combined Risk (Hail)		-13% to 2%	3% to 17%	18% to 34%	35% to 89%
High ↑ Moderate	5-6	Moderate	High	Severe	Extreme
	3-4	Slight	Moderate	High	Severe
	0-2	Negligible	Slight	Moderate	High

The Combined Risk calculations are based on the methodology outlined in Table 3-65. Values (between zero and three) have been assigned to total deaths and injuries and total number of

hail events per county. The Jenks Natural Breaks algorithm was used to classify these historical data sets. These values were summed to determine the Combined Risk value for each county.

**TABLE 3-65 COMBINED RISK METHODOLOGY**

Deaths and Injuries (1986 – 2017)	Value	# of Hail Events (1955-2017)	Value
8 – 60	3	525 – 1,324	3
4 – 7	2	296 – 524	2
1 – 3	1	89 – 295	1
0	0	0 – 88	0

Exposure to hail is expected to intensify across the State of Colorado over the next decade. The darker colors in Table 3-64 and Table 3-66 illustrate relative rates of increase in exposure between counties.

**TABLE 3-66 HAIL EXPOSURE PROJECTIONS, 2010 TO 2030**

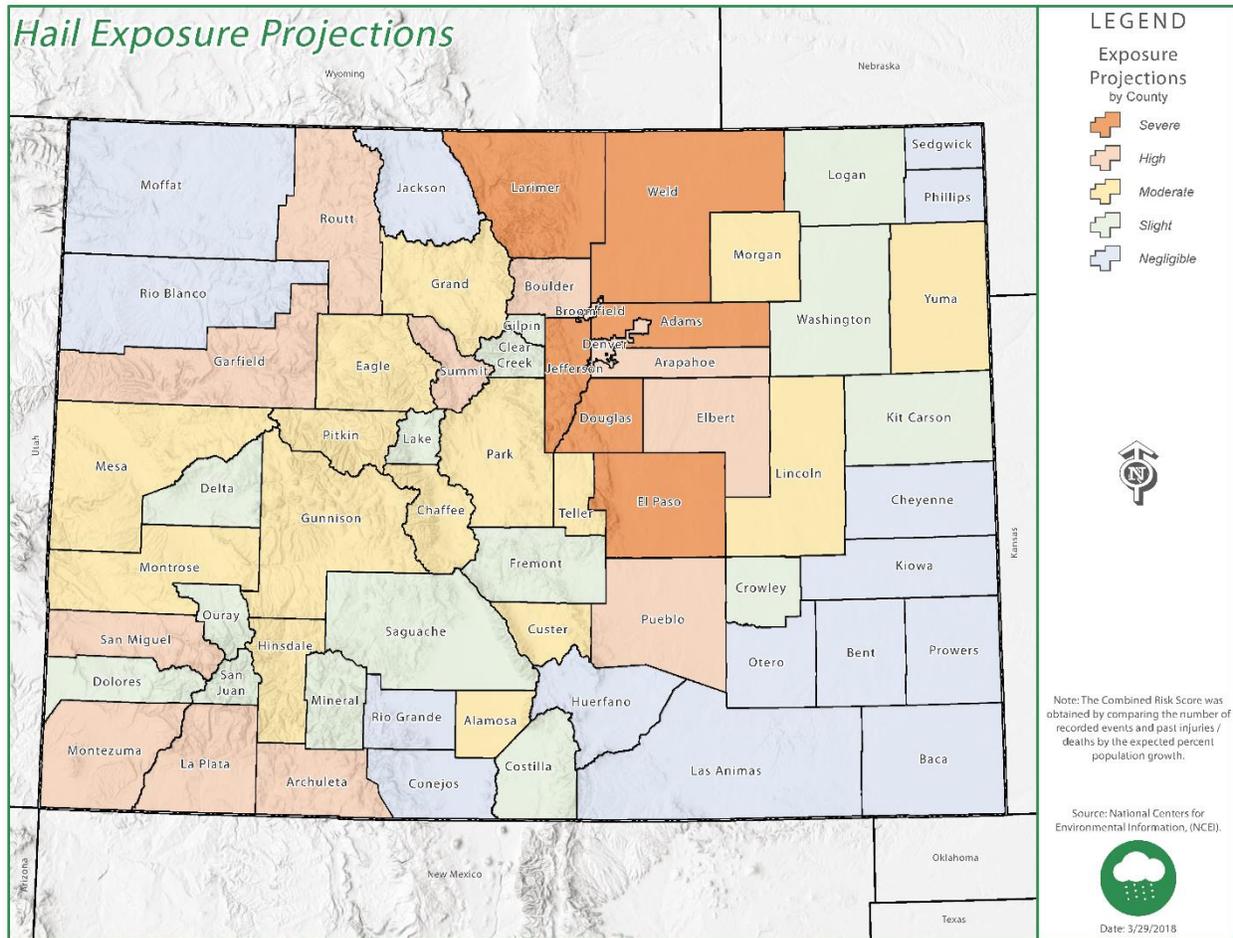
County	Combined Risk	Population Change	Exposure Rating
Weld	3	81%	Severe
Adams	4	48%	Severe
Douglas	3	44%	Severe
Larimer	3	42%	Severe
El Paso	4	36%	Severe
Jefferson	5	21%	Severe
Elbert	2	89%	High
Broomfield	0	71%	High
San Miguel	0	59%	High
Denver	2	42%	High
La Plata	0	42%	High
Summit	0	41%	High
Routt	0	40%	High
Archuleta	0	40%	High
Garfield	0	38%	High
Montezuma	0	37%	High
Arapahoe	2	36%	High
Boulder	3	28%	High
Pueblo	4	20%	High
Park	0	34%	Moderate

County	Combined Risk	Population Change	Exposure Rating
Eagle	0	34%	Moderate
Grand	0	32%	Moderate
Montrose	0	30%	Moderate
Hinsdale	0	29%	Moderate
Chaffee	0	29%	Moderate
Gunnison	0	26%	Moderate
Teller	0	25%	Moderate
Mesa	0	24%	Moderate
Alamosa	0	22%	Moderate
Lincoln	2	21%	Moderate
Custer	1	20%	Moderate
Pitkin	0	18%	Moderate
Morgan	3	16%	Moderate
Yuma	3	7%	Moderate
Lake	0	17%	Slight
Ouray	0	17%	Slight
Mineral	0	16%	Slight
Logan	2	14%	Slight
Clear Creek	0	14%	Slight
Gilpin	0	13%	Slight
Saguache	1	9%	Slight
Delta	0	8%	Slight
Costilla	0	7%	Slight
Fremont	0	5%	Slight
Washington	2	5%	Slight
Dolores	0	5%	Slight
Crowley	0	5%	Slight
San Juan	0	5%	Slight
Kit Carson	3	-1%	Slight
Cheyenne	2	2%	Negligible
Rio Blanco	0	2%	Negligible
Conejos	0	1%	Negligible
Huerfano	0	-1%	Negligible
Sedgwick	1	-3%	Negligible
Phillips	1	-3%	Negligible
Moffat	0	-3%	Negligible

County	Combined Risk	Population Change	Exposure Rating
Rio Grande	0	-5%	Negligible
Bent	1	-5%	Negligible
Prowers	1	-5%	Negligible
Otero	1	-7%	Negligible
Jackson	0	-7%	Negligible
Kiowa	1	-8%	Negligible
Las Animas	1	-9%	Negligible
Baca	2	-13%	Negligible

Source: Colorado State Demography Office, 2017; NOAA

FIGURE 3-31 HAIL EXPOSURE PROJECTIONS, 2010 TO 2030



In review of local hazard mitigation plans, no information on future development trends were profiled for hail.

## 9. CLIMATE CHANGE

According to the best data available at the time of this plan update, the future impacts of climate change are expected to influence future hail events. Table 3-67 presents a breakdown of these projected changes in terms of hazard: location, extent/intensity, frequency, and duration. Ongoing efforts to reduce Colorado’s greenhouse gas emissions and adapt to a changing climate, such as the Colorado Climate Plan and the Climate Change in Colorado Report, will help to reduce the impacts of climate change on hail.

TABLE 3-67 CLIMATE CHANGE IMPACTS

Impact	Projected Change
<b>Location</b>	Hail events occur across most areas of the state. Surface hail in Colorado Front Range over the 2041–2070 time period is projected to be nearly eliminated.
<b>Extent/Intensity</b>	Along the Front Range where hail events are supposed to be nearly eliminated by 2070, both extent and intensity of hail events will also decrease.
<b>Frequency</b>	Along the Front Range where hail events are supposed to be nearly eliminated by 2070, the frequency of hail would decrease.
<b>Duration</b>	Along the Front Range where hail events are supposed to be nearly eliminated by 2070, the duration of hail events would decrease.

Source: FEMA 2017 and Garfin et al. 2013

## 10. RISK TO STATE ASSETS

Colorado’s Front Range and Eastern Plains receive the highest frequency of severe hail (one inch and greater) in the state. Since 1955, 93 percent of all reported hail events occurred in these eastern regions. The eastern side of the state is also where the majority of state asset value is located. About 30 percent of all state asset values are in counties where over 300 hail events occurred between 1955 and 2017.

Since 2008, there have been 100 property losses reported on state assets due to hail, 22 of which occurred in 2017. These 22 losses represent just four hail events, with the May 8, 2017, hailstorm alone accounting for 16 losses. From 2008 to 2016, a total of \$6.6 million was paid to cover losses to state assets due to hail, the majority of which represent roof damage to buildings and state vehicle damage. Estimated losses due to the 2017 events total \$5.0 million; if paid in full, that amount would represent 43 percent of the total over the last 10 years. The May 8, 2017, hailstorm accounts for 84 percent of the 2017 estimates, or \$4.2 million. Among the losses from that one storm was an estimated \$1.9 million in damage to state vehicles. It is important to note that state asset loss data is only available for state assets included in the 2017 Office of Risk Management (ORM) database. These numbers exclude many higher education assets, and therefore may under-represent actual losses.

Although hail-producing storm events that impact state assets occur a couple times a year, they vary greatly in location and degree of damage. With such randomness in occurrence and resulting damages, general vulnerability to state assets is low and the costs of a comprehensive application of structural mitigation is likely to exceed the benefits. Table 3-68 shows state asset exposure projections from 2010 - 2030.

**TABLE 3-68 STATE ASSET EXPOSURE PROJECTIONS, 2010 TO 2030**

<b>County</b>	<b>State Assets</b>	<b>Asset Valuation</b>	<b>Future Exposure Rating</b>
Larimer	931	\$2,520,380,927	Severe
Adams	225	\$2,161,277,205	Severe
Jefferson	481	\$1,220,747,270	Severe
Weld	270	\$723,621,025	Severe
El Paso	252	\$664,445,003	Severe
Douglas	139	\$41,437,868	Severe
Boulder	288	\$3,184,873,780	High
Denver	479	\$2,631,589,250	High
Pueblo	391	\$1,100,717,917	High
Garfield	227	\$935,656,624	High
Arapahoe	231	\$539,093,242	High
La Plata	199	\$459,565,269	High
Summit	54	\$210,520,143	High
Montezuma	92	\$26,250,957	High
Routt	153	\$19,636,862	High
Archuleta	68	\$12,576,015	High
Broomfield	7	\$7,925,505	High
San Miguel	36	\$6,959,484	High
Elbert	16	\$6,135,197	High
Mesa	316	\$571,483,873	Moderate
Alamosa	123	\$361,142,477	Moderate
Gunnison	146	\$297,472,630	Moderate
Chaffee	196	\$135,641,023	Moderate
Lincoln	80	\$115,435,435	Moderate
Morgan	168	\$67,190,695	Moderate
Eagle	148	\$22,080,215	Moderate
Montrose	65	\$19,168,190	Moderate
Park	120	\$17,071,984	Moderate
Yuma	84	\$14,101,083	Moderate

County	State Assets	Asset Valuation	Future Exposure Rating
Grand	69	\$12,702,273	Moderate
Teller	53	\$9,932,426	Moderate
Hinsdale	19	\$1,605,114	Moderate
Custer	6	\$1,130,092	Moderate
Pitkin	14	\$712,333	Moderate
Fremont	360	\$762,885,780	Slight
Logan	174	\$321,168,914	Slight
Clear Creek	75	\$117,846,308	Slight
Crowley	28	\$99,475,999	Slight
Delta	116	\$39,890,610	Slight
Mineral	21	\$30,302,497	Slight
Gilpin	39	\$10,009,237	Slight
Ouray	46	\$8,684,296	Slight
Saguache	49	\$5,188,186	Slight
San Juan	22	\$4,603,609	Slight
Washington	31	\$4,317,254	Slight
Dolores	20	\$4,252,291	Slight
Costilla	28	\$4,179,435	Slight
Kit Carson	27	\$4,146,763	Slight
Lake	21	\$2,881,105	Slight
Las Animas	118	\$152,450,902	Negligible
Rio Grande	155	\$134,839,206	Negligible
Bent	173	\$116,882,345	Negligible
Otero	83	\$79,711,658	Negligible
Prowers	86	\$73,450,933	Negligible
Rio Blanco	66	\$63,910,055	Negligible
Huerfano	66	\$35,640,305	Negligible
Moffat	90	\$15,349,886	Negligible
Jackson	85	\$13,799,847	Negligible
Conejos	41	\$6,598,803	Negligible
Sedgwick	30	\$1,827,494	Negligible
Baca	14	\$1,559,394	Negligible
Kiowa	8	\$1,308,651	Negligible
Cheyenne	9	\$712,471	Negligible
Phillips	5	\$196,988	Negligible

Source: Colorado State Demography Office, 2017; Office of Risk Management, 2017 and 2013

## 11. RESOURCES

- Colorado Department of Local Affairs (DoLA)
- Colorado Department of Transportation (CDOT) Threat and Hazard Identification and Risk Assessment (THIRA)
- Colorado Energy Assurance Emergency Plan (CEAEP), 2016
- Colorado Resiliency Framework
- Community Collaborative Rain, Hail, & Snow Network (CoCoRaHS)
- Federal Emergency Management Agency (FEMA). (2017). Assessing Future Conditions, Colorado.
- Garfin, G., A. Jardine, R. Merideth, M. Black, and S. LeRoy, eds. (2013). Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment. A report by the Southwest Climate Alliance. Washington, DC: Island Press.
- National Climatic Data Center (NCDC)
- National Severe Storms Laboratory, NOAA
- National Weather Service (NWS)
- Rocky Mountain Insurance Information Association (RMIIA)

# SEVERE WIND



## 1. DEFINITION

Windstorms are defined as a storm with high winds or violent gusts, separate from tornado activity. These events are often associated with summer thunderstorms, but may occur at other times of year as well, as noted in the 2017 Colorado Department of Transportation (CDOT) Threat and Hazard Identification and Risk Assessment (THIRA):

“Another dangerous aspect of straight line winds is that they occur more frequently beyond the April to September time frame than is seen with the other thunderstorm hazards. It is not rare to see severe winds ravage parts of the state in October and November. Stark temperature contrasts seen in colliding air masses along swift-moving cold fronts occur regularly during those months (CDOT THIRA).”

Colorado also experiences unique wintertime wind conditions due to the interaction of air masses and the Continental Divide. The Colorado Resiliency Framework explains that Chinook winds occur seasonally due to convective air movements where the Rocky Mountains meet the Great Plains. Warm, dry winds descend from the eastern slopes of the mountains, causing a rapid rise in temperature, snowmelt, and sometimes flooding. Bora winds are similarly dry and sweep down from mountain slopes, but they are cold. Both types can move at considerable force.

Microbursts are downdrafts, or columns of sinking air, found within strong thunderstorms. As the plummeting air reaches the ground, it spreads out in all directions. Microbursts are highly localized and can cause extensive damage within a small area.

The Colorado Resiliency Framework notes that strong winds can affect other hazards. Wildfire conditions are exacerbated by high winds. In an area experiencing long-term drought, windstorms can become dust storms, leading to massive erosion.

Table 3-69 describes the hazard profile summary for severe wind.

**TABLE 3-69 HAZARD PROFILE SUMMARY**

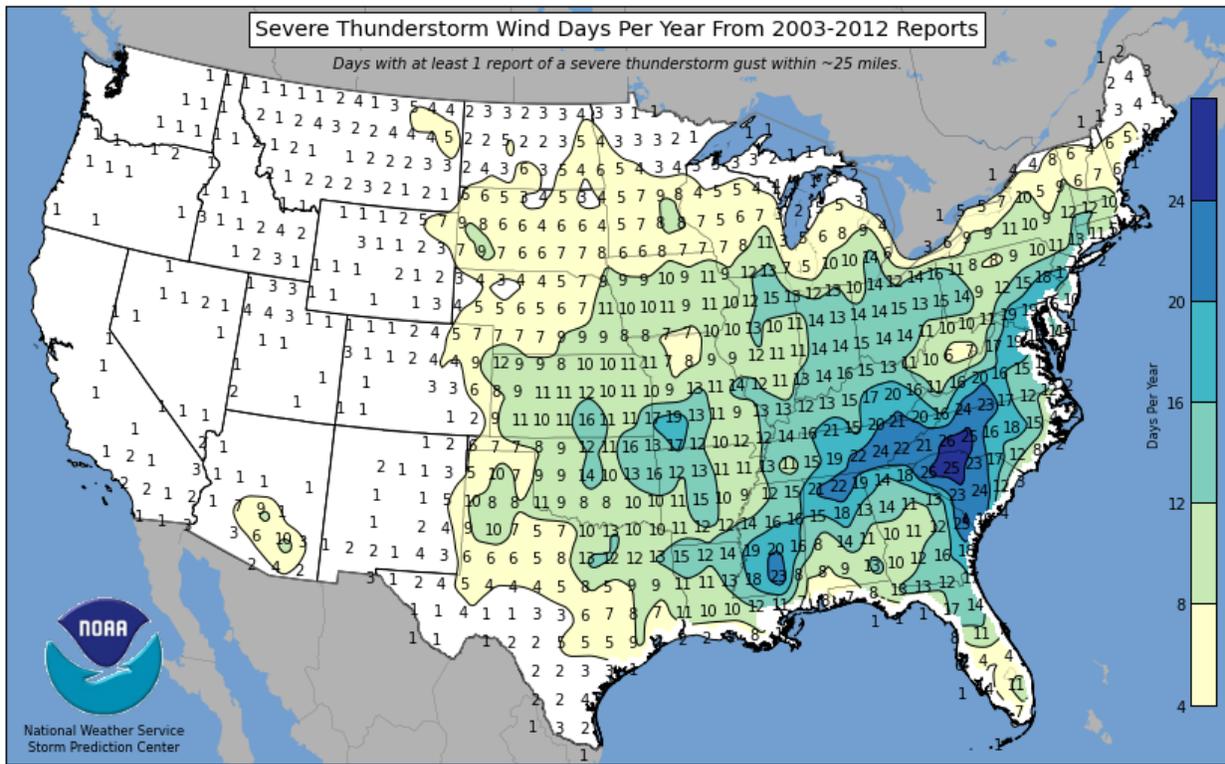
Consideration	Impact	Description
<b>Location</b>	Regional	Concentrated along the Front Range, east-central to northeast, and Grand Valley. Most counties have recorded windstorm events.
<b>Previous Occurrence</b>	Perennial	Storms occur many times a year, often with widespread limited damage. Front Range and eastern Colorado experience seasonal high winds in spring and summer.

Consideration	Impact	Description
<b>Probability</b>	Expected	Windstorms are a perennial occurrence, with some regions experiencing multiple events per year. In the future, intense summer storms are projected to occur more often, increasing the frequency of severe wind events.
<b>Extent</b>	Moderate	The average severe wind event has recorded winds of 66 mph, though gusts in excess of 100 mph are possible. A typical wind event will cause limited property damage, minor or no injuries, and limited impact to critical services or facilities. Strong wind gusts or prolonged strong wind events may have great effects on people and property, including occasional deaths.

## 2. LOCATION

Severe winds can affect every community in Colorado. The National Weather Service’s Severe Weather Database Files, which began tracking severe wind in 1955, shows that reports are particularly common in northeastern Colorado, including the Front Range and the northern Eastern Plains. The CDOT THIRA notes that “severe winds occur more frequently along the Front Range than any other area of the state.” Eastern Colorado near the Nebraska and Kansas border may see up to nine days per year with severe thunderstorm gusts (Figure 3-32).

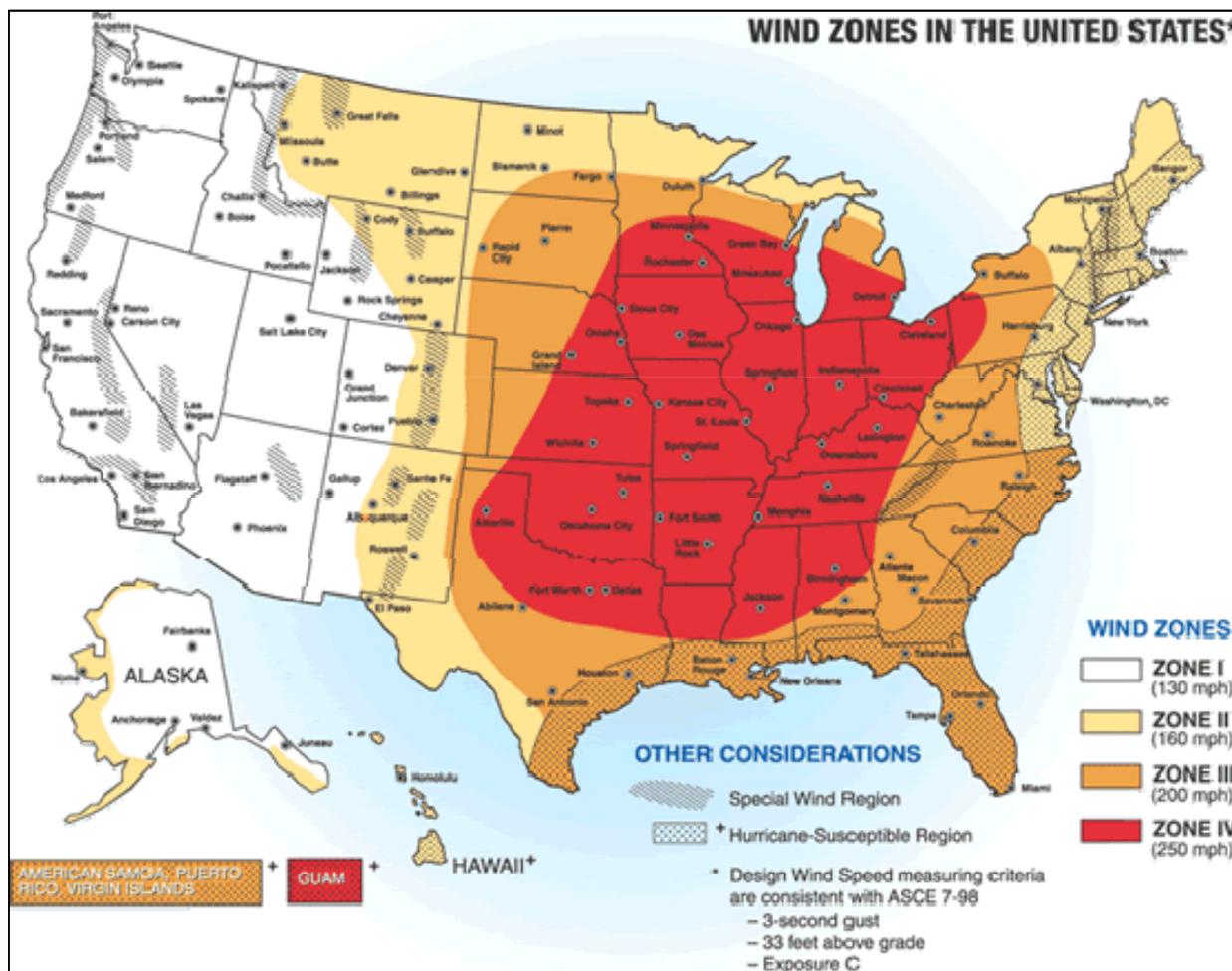
**FIGURE 3-32 SEVERE THUNDERSTORM WIND DAYS PER YEAR FROM 2003 TO 2012**



Source: NOAA

FEMA’s map of Wind Zones in the United States (Figure 3-33) is primarily based on tornado and hurricane history, but the map identifies a large Special Wind Region along Colorado’s Front Range due to the unique conditions related to the downslope Chinook and Bora winds. These include foothill counties and those generally along the Interstate 25 corridor. Winds of 60 to near 100 mph will occur in and near the foothills in areas such as Fort Collins, Boulder, Denver, Colorado Springs, Cañon City, Westcliffe, Walsenburg, and Trinidad. The areas around Boulder and Westcliffe are especially prone to these extreme wind episodes.

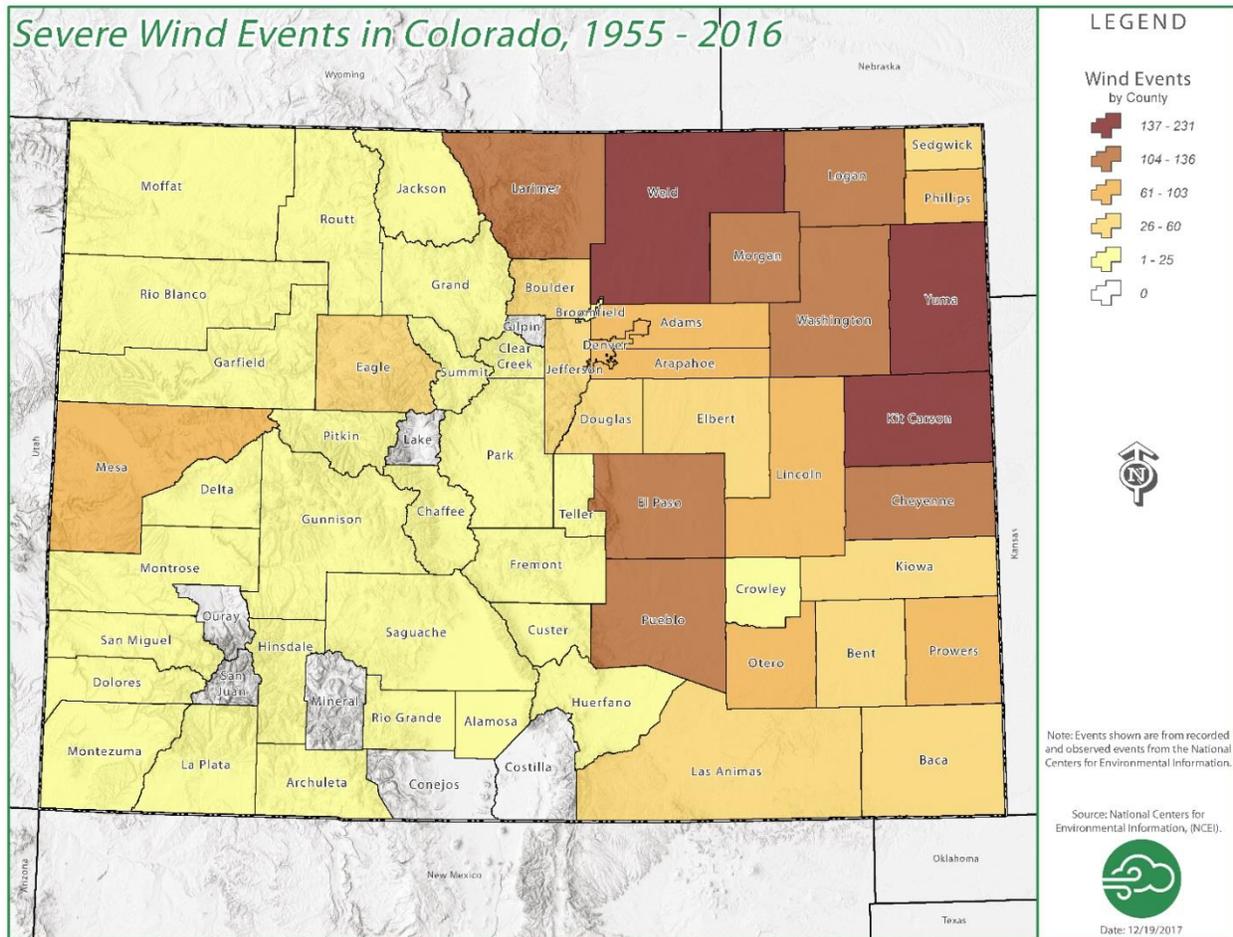
FIGURE 3-33 WIND ZONES IN THE UNITED STATES



Source: FEMA

Three counties, Kit Carson, Weld, and Yuma, each had more than 150 reports of severe wind between 1955 and 2016. Weld County has the highest number of wind reports in the state, with 231 during this time frame. The Western Slope generally sees far fewer windstorms than eastern Colorado, but one exception is the Grand Valley. Mesa County, which encompasses the portion of the Grand Valley within Colorado, has experienced 99 severe wind events since 1955, comparable to some Front Range counties. Figure 3-34 highlights wind events across the state.

FIGURE 3-34 SEVERE WIND EVENTS IN COLORADO, 1955 TO 2016



### 3. EXTENT (MAGNITUDE/STRENGTH)

The severity of wind over land is generally measured in terms of its velocity. The Beaufort Wind Scale correlates wind velocity with effects on land and water (Table 3-70).

TABLE 3-70 BEAUFORT WIND SCALE

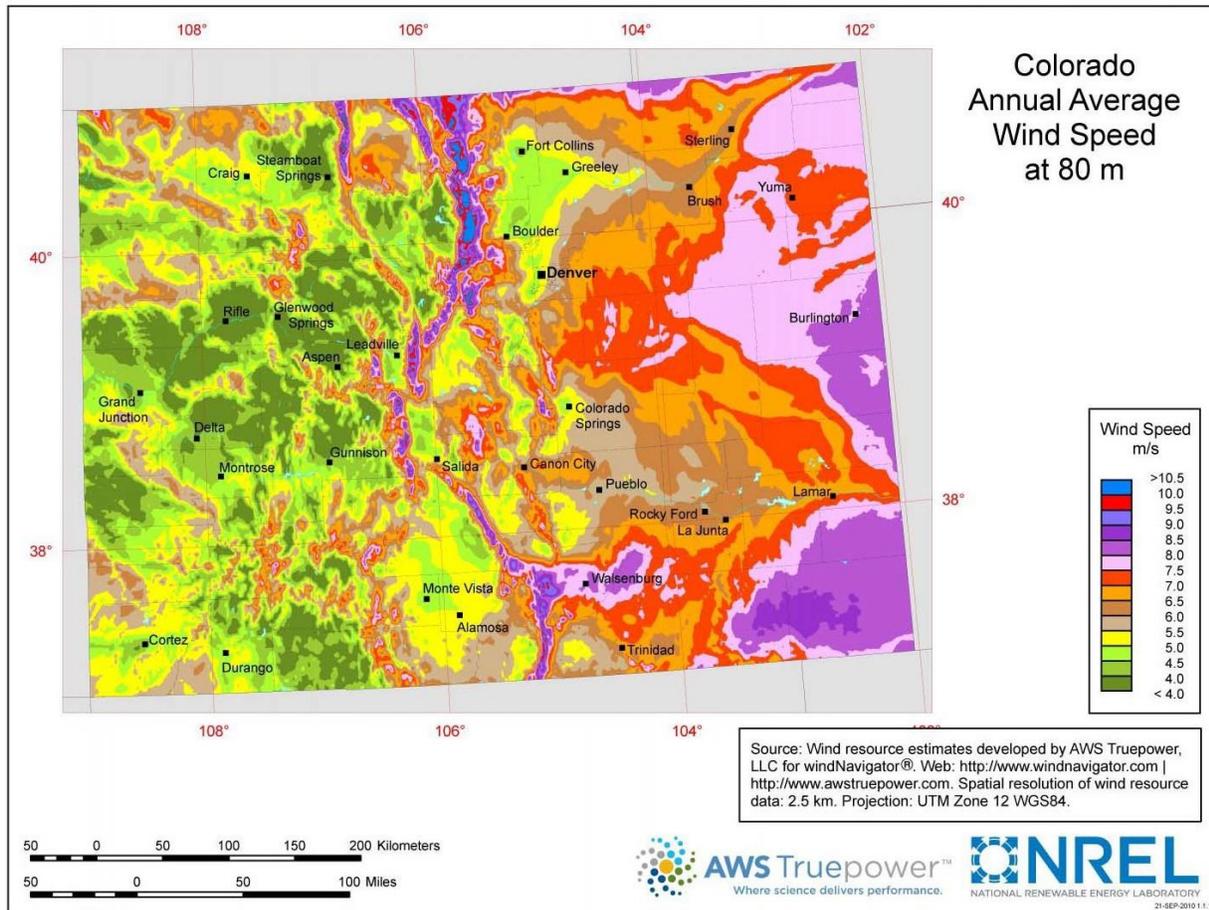
Force	Wind (Knots)	WMO Classification	Appearance of Wind Effects	
			On the Water	On Land
0	Less than 1	Calm	Sea surface smooth and mirror-like	Calm, smoke rises vertically
1	1-3	Light Air	Scaly ripples, no foam crests	Smoke drift indicates wind direction, still wind vanes
2	4-6	Light Breeze	Small wavelets, crests glassy, no breaking	Wind felt on face, leaves rustle, vanes begin to move

Force	Wind (Knots)	WMO Classification	Appearance of Wind Effects	
			On the Water	On Land
3	7-10	Gentle Breeze	Large wavelets, crests begin to break, scattered whitecaps	Leaves and small twigs constantly moving, light flags extended
4	11-16	Moderate Breeze	Small waves 1-4 ft. becoming longer, numerous whitecaps	Dust, leaves, and loose paper lifted, small tree branches move
5	17-21	Fresh Breeze	Moderate waves 4-8 ft taking longer form, many whitecaps, some spray	Small trees in leaf begin to sway
6	22-27	Strong Breeze	Larger waves 8-13 ft, whitecaps common, more spray	Larger tree branches moving, whistling in wires
7	28-33	Near Gale	Sea heaps up, waves 13-19 ft, white foam streaks off breakers	Whole trees moving, resistance felt walking against wind
8	34-40	Gale	Moderately high (18-25 ft) waves of greater length, edges of crests begin to break into spindrift, foam blown in streaks	Twigs breaking off trees, generally impedes progress
9	41-47	Strong Gale	High waves (23-32 ft), sea begins to roll, dense streaks of foam, spray may reduce visibility	Slight structural damage occurs, slate blows off roofs
10	48-55	Storm	Very high waves (29-41 ft) with overhanging crests, sea white with densely blown foam, heavy rolling, lowered visibility	Seldom experienced on land, trees broken or uprooted, "considerable structural damage"
11	56-63	Violent Storm	Exceptionally high (37-52 ft) waves, foam patches cover sea, visibility more reduced	
12	64+	Hurricane	Air filled with foam, waves over 45 ft, sea completely white with driving spray, visibility greatly reduced	

Source: NOAA

Wind speed in Colorado is correlated with elevation. Figure 3-35 shows annual average wind speed in Colorado (at 80 meters height above ground level). The highest winds in the state are concentrated along the north central mountains west of Fort Collins and average up to 10 meters per second, or about 22 mph. Wind speed patterns on the Eastern Plains are affected by the Palmer Divide in relation to elevation changes associated with the Platte and Arkansas River basins.

FIGURE 3-35 COLORADO ANNUAL AVERAGE WIND SPEED



Source: National Renewable Energy Laboratory (NREL), 2010

Mid and upper level winds over Colorado are much stronger in the winter than in the warm season, because of the huge difference in temperature from north to south across North America. West winds, under certain conditions, can bring warm, dry Chinook winds plowing down the slopes of the eastern mountains. These winds can exceed 100 mph in extreme cases, bringing the potential for widespread damage.

During a microburst, windspeeds on the ground can exceed 100 mph, causing damage to trees and buildings similar to a weak tornado.

The National Weather Service database records severe wind events with gusts of at least 50 knots, or 57.5 mph, although measured or estimated windspeeds are not available for 32 percent of recorded events prior to 2000. Among events with known wind speeds, the average was 66.2 mph. Winds of 100 mph or greater have been reported on 23 occasions. The highest wind speed in Colorado was an estimated 125 knots, or 143.8 mph, on May 20, 1987, near the City of Pueblo.

## 4. PROBABILITY

Windstorms resulting in property or agricultural damage occur multiple times every year. Over the last two decades, Colorado has experienced an average of about two wind events per year that result in injuries, death, or damages of at least \$100,000. In the future, intense summer storms are projected to occur more often, increasing the frequency of severe wind events.

Chinook winds are a common wintertime phenomenon in Colorado. These winds develop in well-defined areas and can be quite strong. In addition, Colorado will continue to experience Bora winds that will send winds in excess of 100 mph from the west and northwest and on to the Eastern Plains.

## 5. PREVIOUS OCCURENCES

The National Weather Service's Severe Weather Database lists 2,875 reports of damaging wind in Colorado from 1955 to 2016. Many of these reports are within the same county on the same day and may have been produced by a single storm system. In addition, wind reporting has changed over the years. The number of wind events reported annually has increased from three in 1955 to an average of 89 over the last 20 years. Colorado can generally expect to experience about 34 days with severe wind each year, with an average of two counties affected on each occasion.

The database began tracking injuries and property damage in the mid-1980s, and precise damage estimates in 1996. Property damage estimates are known for 357 reports since 1987, three percent of which caused more than \$500,000 in damages at the time. Table 3-71 and Table 3-72 provide historic data on severe wind events for the last 10 years and by decade since 1955.

TABLE 3-71 WIND EVENTS, DEATHS, AND INJURIES, 2006 TO 2016

Year	Reported Events	Injuries	Deaths	Property Damage (2017 Dollars)
2006	113	3	0	\$4,072,264
2007	78	0	0	\$179,423
2008	72	1	0	\$248,905
2009	122	6	2	\$561,270
2010	103	0	0	\$2,719,637
2011	150	2	0	\$5,149,689
2012	51	0	0	\$39,433
2013	92	0	0	\$103,236
2014	115	0	1	\$250,386
2015	51	0	0	\$107,482
2016	109	5	1	\$291,601

Year	Reported Events	Injuries	Deaths	Property Damage (2017 Dollars)
<b>TOTAL</b>	<b>1,056</b>	<b>17</b>	<b>4</b>	<b>\$13,723,327</b>

TABLE 3-72 WIND EVENTS, DEATHS, INJURIES, AND DAMAGE BY DECADE

Years	Count	Deaths	Injuries	Property Damage (2017 Dollars)	Crop Damage (2017 Dollars)	Total Damage (2017 Dollars)
<b>1955-59</b>	35	0	0	n/a	n/a	n/a
<b>1960-69</b>	100	0	0	n/a	n/a	n/a
<b>1970-79</b>	188	0	0	n/a	n/a	n/a
<b>1980-89</b>	317	103	1	n/a	n/a	n/a
<b>1990-99</b>	616	62	6	\$2,165,726	n/a	\$2,165,726
<b>2000-09</b>	948	35	4	\$9,640,278	\$62,744	\$9,703,021
<b>2010-16</b>	671	7	2	\$8,661,464	\$19,595,924	\$28,257,388
<b>Total</b>	<b>2,875</b>	<b>207</b>	<b>13</b>	<b>\$20,467,468</b>	<b>\$19,658,668</b>	<b>\$40,126,135</b>

The CDOT THIRA notes that damaging straight-line winds can occur outside the normal April-to-September timeframe associated with most other thunderstorm-related hazards: “It is not rare to see severe winds ravage parts of the state in October and November. Stark temperature contrasts seen in colliding air masses along swift-moving cold fronts occur regularly during those months.”

Some events of note are further described below.

**Las Animas County – July 14, 1989:** About 100 National Guard troops were injured, including about 20 who were hospitalized, after a thunderstorm with 60 mph winds struck an encampment at Pinyon Canyon near Trinidad. The winds brought down 12 to 15 large tents, including a field hospital, and sent debris flying.

**Front Range and northern Eastern Plains - May 20, 2001:** According to National Weather Service records: “Intense winds developed as a vigorous cold front, accompanied by a line of thunderstorms, spilled over the Cheyenne Ridge and moved rapidly across the urban corridor and northeast plains.” Wind gusts of more than 80 mph were recorded at the Greeley Airport and near Pueblo, downing trees and power lines across the region. Temperatures dropped from the mid-70s to mid-30s within one hour. Blowing dust and debris reduced visibility to zero in some locations and caused a multi-vehicle accident on U.S. Highway 85 between Greeley and Fort Lupton, resulting in six minor injuries. On Interstate 70 and Interstate 76, vehicles were blown off the roadways. At least 12 flights headed for Denver International Airport had to be diverted, and departing flights were grounded for an hour. Prior to the January 2017 windstorm discussed below, this was the costliest wind event in 20 years. About \$2.5 million in damage was reported at the time, or \$3.5 million in today’s dollars.

**Colorado Springs – January 9, 2017:** Gusts exceeding 100 mph killed two people on the city’s southwest side, both of whom were struck by debris and later died of their injuries. While Colorado Springs saw some of the most intense gusts from the winter storm system, severe winds were recorded at locations across the eastern mountains and Interstate 25 corridor well into the next day. Colorado Springs Utilities reported that the storm damaged 52 percent of the city’s overhead electric system, causing \$1.6 million in losses and knocking out power to almost 40,000 customers. Two students at a Colorado Springs school were injured by a falling tree. The winds also damaged roofs, overturned semi-trailers, uprooted trees, and blew down street signs. Overall damage estimates are as high as \$20 million.

Table 3-73 lists hazardous wind events in Colorado from the last five years that had recorded windspeeds of more than 85 mph, injuries, or deaths. Many of these events also involved hail and/or tornadoes, but descriptions focus on the conditions and damage related to straight-line wind and microbursts. In addition to the events listed in the table, many additional damaging wind events occur in the state every year.

**TABLE 3-73 COLORADO SEVERE WIND EVENTS, 2013 TO 2017**

Date	Affected Counties	Description
<b>April 8, 2013</b>	Kit Carson, Phillips, Washington, and Yuma	High winds associated with a fast-moving cold front spread across the urban corridor and northeast plains of Colorado. Several wind gusts to around 60 mph were observed as the cold front made its way across the region. The severe weather included damaging straight-line winds. The storms were most intense in and around Washington County where three weak tornadoes developed. A severe thunderstorm produced damaging straight-line winds which flipped a mobile home, blew the roof off a barn and downed numerous power lines. Half the town of Akron was left without power after six power poles were knocked down between Brush and Last Chance. In Denver, the cold front produced a peak wind gust to 52 mph when it moved through Denver International Airport. The strong winds toppled trees and caused several flight delays and cancellations. In Longmont, the wind knocked over a tree which landed on a house.
<b>June 4, 2013</b>	Baca	Strong to severe storms occurred across the southeast plains. Wind gusts up to 90 mph occurred across Baca County.
<b>June 18, 2014</b>	Logan, Phillips, Sedgewick, and Washington	Severe thunderstorms broke out across the northeast plains of Colorado. Intense straight-line winds downed trees and power lines across Washington, Sedgewick, and Phillips Counties. In addition, a barn, grain bins, and a transmission tower were extensively damaged.
<b>July 9, 2014</b>	Cheyenne, Kit Carson	Strong storms moved southeast from the Akron area during the evening and ultimately formed a line of storms extending from Burlington southwest to near Kit Carson. Strong winds to 63 mph were observed by the Automated Surface Observing System (ASOS) site at the Kit Carson County airport. The strong outflow winds resulted in blowing dirt which briefly reduced visibility to near zero in a few areas. Six utility poles were blown down on Highway 385 south of Burlington, and tree damage was also reported at a nearby farmstead.

Date	Affected Counties	Description
<b>July 12, 2014</b>	La Plata, Prowers	Severe thunderstorms produced severe winds across portions of the southeast plains in Prowers County. Vehicles and trailers were damaged from strong thunderstorm microburst at a residence in the community of Rockwood in La Plata County.
<b>July 15, 2014</b>	Otero, Pueblo	A powerful microburst occurred just west and south of Fowler in extreme eastern Pueblo County and far western Otero County.
<b>July 30, 2014</b>	Baca	A storm produced damaging winds just outside Vilas. An 84-year old man died. Damage occurred with a very compact microburst. A manufactured home was completely destroyed, along with three power poles.
<b>September 29, 2014</b>	Adams, Archuleta, Cheyenne, Kit Carson, Lincoln, Morgan, and Yuma	A storm system that moved through the area produced large hail and damaging winds. The intense thunderstorm winds downed trees near Fort Morgan.
<b>June 5, 2015</b>	Kit Carson	Late in the afternoon through evening, a series of strong to severe storms moved across east-central Colorado. Estimated wind gusts of 85 mph laid over pine trees and bent a radio tower west of Kanorado in Colorado.
<b>July 26, 2015</b>	Kit Carson, Yuma	During the afternoon, a line of strong to severe thunderstorms moved east across east-central Colorado. Winds from the storms blew down two large elm tree branches. The highest measured gust was 60 mph at the Burlington airport.
<b>July 30, 2015</b>	Kit Carson, Yuma	During the late afternoon, a severe thunderstorm moved south across western Yuma County into central Kit Carson County. Near Joes, estimated 80 mph winds snapped three to four inch diameter tree branches. The high winds caused rain to be driven in between the windows and walls into homes. In Joes, the storm blew down several trees approximately 12 inches in diameter. Later the storm produced an estimated 65 mph winds at Stratton.
<b>May 24, 2016</b>	Adams, Washington, and Yuma	A long-lived supercell thunderstorm produced widespread wind and hail damage, and several tornadoes as it tracked east/northeast across eastern Colorado. The supercell formed over south Denver and tracked east/northeast across northeast Adams, southern Morgan and northern Washington Counties; the storm continued to produce severe weather as it moved into Yuma County. The length of the path through northeast Colorado was approximately 121 miles from southeast Denver to the Yuma County line. As it moved across northeast Adams County, several power poles were sheared off at the base by straight-line winds, southwest of Leader. The damage path became more extensive as the storm tracked across northern Washington County. Wind driven hail up to 1.75 inches was reported with extensive damage from around Akron east to the Yuma County line. Several power poles were snapped near Otis. In all, up to 10 structures were damaged or destroyed from near Platner to the Yuma County line. While some of the damage was tornadic, most of the damage was caused by straight-line winds.

Date	Affected Counties	Description
<b>May 26, 2016</b>	Cheyenne, Kiowa, Kit Carson, and Otero	Scattered strong to severe thunderstorms moved into east-central Colorado during the latter half of the afternoon. During the late afternoon, a few of the storms produced a widespread swath of wind damage with wind speeds estimated up to 90 mph. A wall of dust was reported along the leading edge of these intense winds. Kit Carson County law enforcement closed westbound traffic from Cheyenne Wells west on Highway 40 for two hours due to debris in the roadway. Highway 287 south of Kit Carson was also closed due to semis being blown over from the intense winds. Two tornadoes were reported ahead of the widespread damaging winds. Severe storms also produced damaging severe winds in Kiowa County.
<b>June 12, 2016</b>	Crowley, El Paso, and Otero	Severe storms produced hail up to the size of golf balls and severe wind gusts. A man was killed in northeast Otero County when severe winds flipped his mobile home.
<b>July 15, 2016</b>	Cheyenne, Kiowa, and Prowers	A very severe storm produced a wide swath of damaging winds and a tornado across eastern Kiowa and extreme northeastern Prowers County. Power poles, 18 in all, were snapped between Sheridan Lake and Towner. Windows were broken in many structures, including the Plainview School. Stadium lights were also destroyed. Eight miles south of the school, a hog farm sustained roof damage. In northeast Prowers County on County Road 35, a house and barn were severely damaged. Many power poles were also snapped. During the afternoon, a severe thunderstorm moved south along the Kansas/Colorado border in Cheyenne County. The storm produced two tornadoes and hail up to baseball size, and broke tree branches south of Arapahoe.
<b>July 22, 2016</b>	Yuma	A line of strong to severe thunderstorms moved east across Yuma County. As the thunderstorms moved through the Town of Yuma the straight-line winds from the storms blew down power lines.
<b>September 4, 2016</b>	Kiowa, Prowers	Strong thunderstorms produced damaging wind gusts across portions of Kiowa and Prowers Counties. Damage to utility poles, irrigation pivots, and a semi-trailer were reported in the Wiley and Mays Valley areas.
<b>January 9, 2017</b>	Boulder, El Paso, Fremont, Huerfano, Jefferson, Larimer, Las Animas, Pueblo, and Teller	A long-lasting high wind episode occurred across the eastern part of the area. Strong winds aloft, and a long-lasting mountain top stable layer generated widespread high winds and damage. Damage included downed power poles, causing numerous power outages to tens of thousands of customers, uprooted trees, roof damage, and numerous overturned semi-trailers in El Paso County. Winds gusted between 58 and 75 mph across many locations across the eastern mountains and Interstate 25 corridor. Areas in the immediate lee of the eastern mountains experienced gusts between 80 and 100 mph. Gusts over 100 mph occurred on the southwest side of Colorado Springs, causing widespread damage. Two people were injured and then perished after being hit by flying debris in southwest Colorado Springs.

Date	Affected Counties	Description
<b>May 7, 2017</b>	Adams, Arapahoe, Denver, Lincoln, and Yuma	Damaging microburst winds downed trees and power poles across parts of Adams, Arapahoe, Denver, and Douglas Counties. Electrical lines and branches were also snapped causing scattered power outages. During the evening hours strong thunderstorms moved northeast across Yuma County. Two of these thunderstorms caused damage. One blew an empty cattle trailer for a semi over on its side, and another storm caused an electrical pole to lean over at nearly a 45 degree angle.
<b>June 25, 2017</b>	Baca	Very large hail and severe winds in Walsh caused extensive damage to structures and vehicles. Power was knocked out for several hours and numerous businesses were closed for several days for clean-up. Severe microburst winds also occurred west of Walsh. Trees and tree limbs were downed, causing damage to power lines, structures, and vehicles. Two people sustained very minor injuries.

Source: NOAA

## 6. IMPACT ANALYSIS

Severe winds tend to impede transportation, causing slowed traffic and impaired control on roadways, and delays in the flight schedules for airlines. Structural collapse, and damages caused by falling trees/limbs can cause injury and impairment of residential and commercial use of affected properties. It is very common for winds to cause trees and their limbs to break communication and power lines, causing the types of impacts described for lightning hazards. The CDOT THIRA notes:

“The property damage from straight-line winds can be just as extreme as that of a tornado, since the damage from straight-line winds is more widespread and usually affects multiple counties. In addition to property damage to buildings (especially less sturdy structures such as storage sheds, outbuildings, etc.), there is a risk for infrastructure damage from downed power lines due to falling limbs and trees. Large-scale power failures, with hundreds of thousands of customers affected, are common during straight-line wind events.”

The 2016 Colorado Energy Assurance Emergency Plan furthermore states: “Wind storms have frequently downed electrical transmission and distribution lines in Colorado, and will continue to do so. Impacts are generally moderate but occasionally severe, and involve sustained damaging winds across a wider geographic area and for longer duration than most localized thunderstorm or tornado events.” Likewise, Chinook wind events can potentially cause more damage than a localized severe thunderstorm.

An overview of severe wind impact is provided in Table 3-74.

TABLE 3-74 SEVERE WIND EMAP IMPACT ANALYSIS SUMMARY

Consideration	Description
<b>General Public</b>	Motorists, air travelers, outdoor workers, outdoor recreationists; population of the counties determined most at risk.
<b>First Responders</b>	Some exposure exists to personnel performing routine duties when event occurs; otherwise, storm-related duties are typically post-event.
<b>Property</b>	Some instances of small amounts of property damage to structures and vehicles. Falling limbs or trees may impact property.
<b>Facilities and Infrastructure</b>	Buildings and equipment are exposed to windstorms. Value of state assets located in highest wind-prone counties is high.
<b>Economic</b>	None or limited loss of facilities or infrastructure function or accessibility, and limited uninsured damages.
<b>Environment</b>	Typically leaf and small limb removal from trees and plants; some microburst or straight-line winds will down large limbs or trees. Limited short-term impacts.
<b>Continuity of Government and Services</b>	None, or limited loss of facilities or infrastructure function or accessibility, or ability to provide services.
<b>Confidence in Government</b>	Characteristics of windstorms such as duration and speed of onset result in limited response and recovery functions for government beyond first responders.
<b>Critical Assets</b>	Potential exposure and short-term impact to buildings, and utility and communications infrastructure.

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

Windstorms are one of Colorado’s costliest hazards. From 1996 to 2016, wind events have caused a reported \$40 million in property and crop damage. Wind events have also resulted in 13 deaths and more than 200 injuries in the state since 1987. Table 3-75 shows a breakout of deaths, injuries, and property damage by county.

TABLE 3-75 SEVERE WIND EVENTS, DEATHS, INJURIES AND DAMAGE IN COLORADO BY COUNTY, 1996-2017

County	Number of Events	Deaths	Injuries	Property Damage (2017 Dollars)	Crop Damage (2017 Dollars)	Total Damage (2017 Dollars)
<b>Adams</b>	80	0	2	\$0	\$0	\$0
<b>Alamosa</b>	10	0	0	\$0	\$0	\$0
<b>Arapahoe</b>	89	0	22	\$29,376	\$0	\$29,376

County	Number of Events	Deaths	Injuries	Property Damage (2017 Dollars)	Crop Damage (2017 Dollars)	Total Damage (2017 Dollars)
Archuleta	11	1	1	\$88,544	\$0	\$88,544
Baca	60	1	0	\$172,069	\$0	\$172,069
Bent	39	1	1	\$232,675	\$0	\$232,675
Boulder	60	0	1	\$22,816	\$0	\$22,816
Broomfield	3	0	0	\$0	\$0	\$0
Chaffee	5	0	0	\$0	\$0	\$0
Cheyenne	131	0	2	\$292,573	\$0	\$292,573
Clear Creek	1	0	0	\$0	\$0	\$0
Conejos	0	0	0	\$0	\$0	\$0
Costilla	0	0	0	\$0	\$0	\$0
Crowley	20	0	0	\$0	\$0	\$0
Custer	3	0	0	\$0	\$0	\$0
Delta	13	0	7	\$2,243,925	\$0	\$2,243,925
Denver	82	0	1	\$22,816	\$0	\$22,816
Dolores	4	0	0	\$40,806	\$0	\$40,806
Douglas	35	1	2	\$25,908	\$0	\$25,908
Eagle	31	0	0	\$ 2,842	\$0	\$ 2,842
El Paso	110	0	8	\$1,622,350	\$0	\$1,622,350
Elbert	52	0	2	\$ 5,704	\$ 5,704	\$11,408
Fremont	7	0	0	\$0	\$0	\$0
Garfield	25	0	0	\$1,214	\$0	\$1,214
Gilpin	0	0	0	\$0	\$0	\$0
Grand	6	0	1	\$217,608	\$0	\$217,608
Gunnison	11	0	0	\$0	\$0	\$0
Hinsdale	2	0	0	\$62,647	\$0	\$62,647
Huerfano	1	0	0	\$0	\$0	\$0
Jackson	6	0	0	\$0	\$0	\$0
Jefferson	31	1	0	\$0	\$0	\$0
Kiowa	53	0	3	\$33,198	\$0	\$33,198
Kit Carson	186	0	2	\$1,322,387	\$0	\$1,322,387
La Plata	14	0	0	\$1,482,633	\$0	\$1,482,633
Lake	0	0	0	\$0	\$0	\$0
Larimer	115	2	17	\$28,520	\$0	\$28,520
Las Animas	31	0	103	\$0	\$0	\$0
Lincoln	87	0	3	\$28,520	\$0	\$28,520

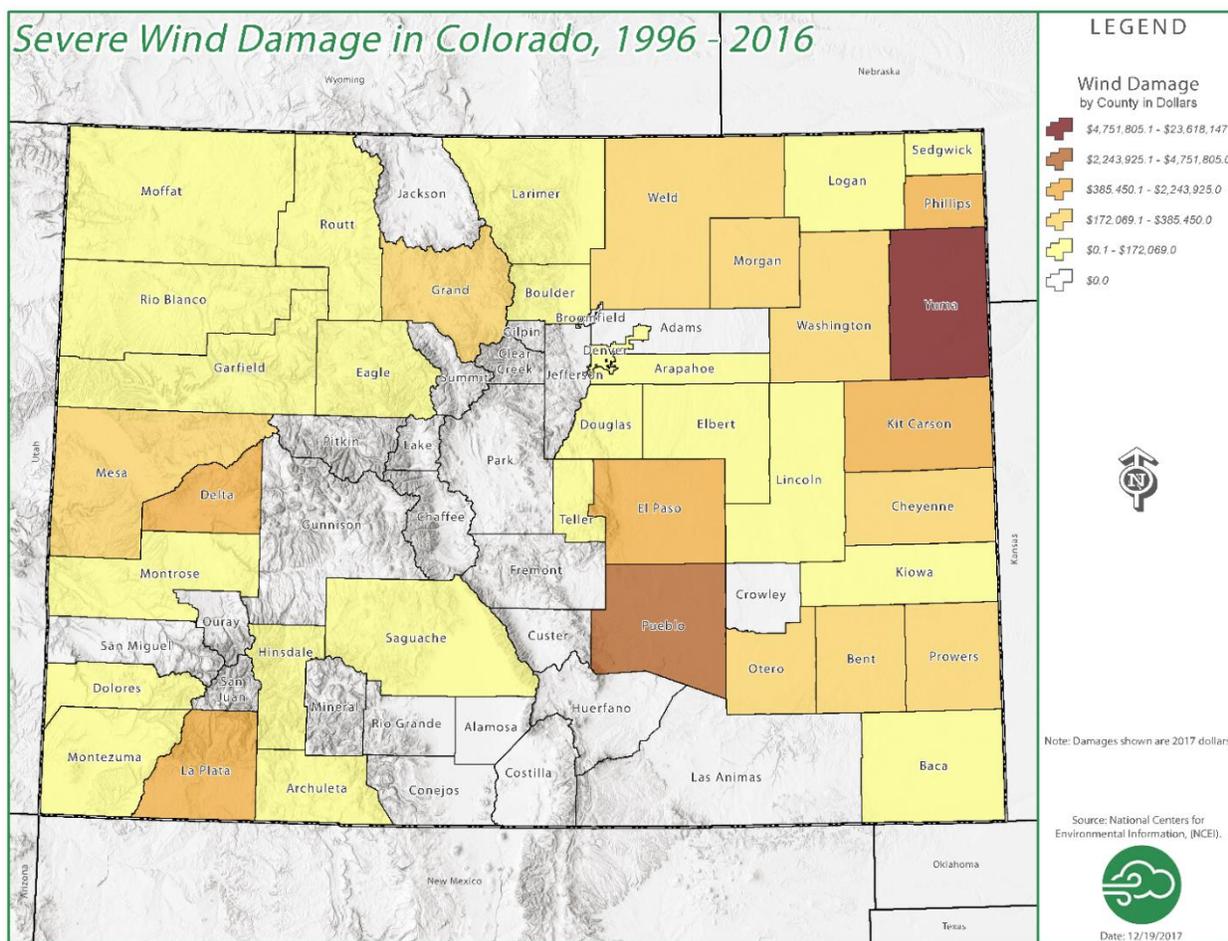
County	Number of Events	Deaths	Injuries	Property Damage (2017 Dollars)	Crop Damage (2017 Dollars)	Total Damage (2017 Dollars)
Logan	116	2	5	\$96,779	\$0	\$96,779
Mesa	99	0	0	\$332,844	\$0	\$332,844
Mineral	0	0	0	\$0	\$0	\$0
Moffat	19	0	0	\$11,804	\$0	\$11,804
Montezuma	20	0	4	\$126,123	\$0	\$126,123
Montrose	18	0	0	\$41,332	\$0	\$41,332
Morgan	135	1	13	\$188,480	\$57,040	\$245,519
Otero	102	1	0	\$306,695	\$0	\$306,695
Ouray	0	0	0	\$0	\$0	\$0
Park	2	0	0	\$0	\$0	\$0
Phillips	77	0	1	\$1,245,639	\$0	\$1,245,639
Pitkin	6	0	0	\$0	\$0	\$0
Prowers	103	0	0	\$385,450	\$0	\$385,450
Pueblo	116	0	3	\$4,751,805	\$0	\$4,751,805
Rio Blanco	23	0	0	\$114,706	\$0	\$114,706
Rio Grande	3	0	0	\$0	\$0	\$0
Routt	19	0	0	\$111,301	\$0	\$111,301
Saguache	6	0	0	\$135,797	\$0	\$135,797
San Juan	0	0	0	\$0	\$0	\$0
San Miguel	2	0	0	\$0	\$0	\$0
Sedgwick	35	0	0	\$5,683	\$0	\$5,683
Summit	1	0	0	\$0	\$0	\$0
Teller	4	0	0	\$4,130	\$0	\$4,130
Washington	136	1	2	\$326,932	\$0	\$326,932
Weld	231	1	1	\$269,394	\$11,220	\$280,614
Yuma	188	0	0	\$4,033,443	\$19,584,704	\$23,618,147
<b>Total</b>	<b>2,875</b>	<b>13</b>	<b>207</b>	<b>\$20,467,468</b>	<b>\$19,658,668</b>	<b>\$40,126,135</b>

Source: NOAA

Of the 207 wind events for which precise loss estimates are known, 46 percent caused less than \$10,000 in damages. A single event in Yuma County on June 19, 2011, accounts for more than half of the total damage since 1996 and nearly all of the crop losses. Two rounds of severe storms destroyed several large grain bins and thousands of acres of cropland, although the National Weather Service's written description of the storm indicates some or all of this damage may have been due to hail, not wind. This event's \$23 million damage estimate means Yuma County has total losses nearly five times that of Pueblo County, which has the next largest total.

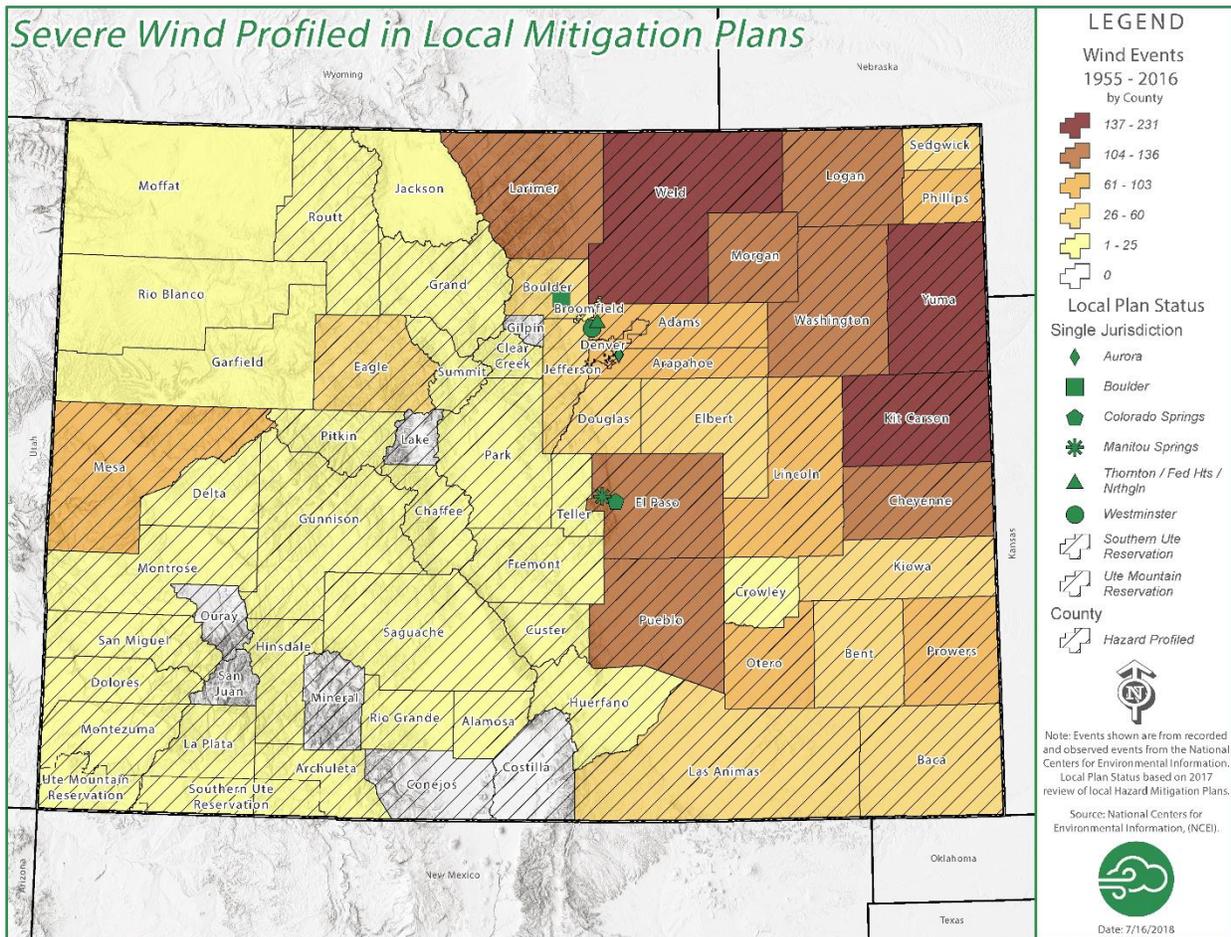
The National Weather Service’s database files do not yet incorporate 2017 data, meaning El Paso County’s total does not include the January 2017 Colorado Springs windstorm, which may have caused as much as \$20 million in damages. With these caveats in mind, the database files show that damage from severe wind is spread around the state. Counties that have at least \$1 million in total damages due to wind events include Delta and La Plata on the Western Slope; Kit Carson, Phillips, and Yuma on the Eastern Plains; and El Paso and Pueblo on the Front Range. Based on historical data, Figure 3-36 highlights damage totals (by county) from 1996 to 2016.

**FIGURE 3-36 DAMAGE FROM SEVERE WIND EVENTS BY COUNTY**



Based upon an updated (2017) review of local mitigation plans, Figure 3-37 illustrates which local jurisdictions profiled wind as a hazard, compared with historical wind events. Most counties have profiled wind, and several major single jurisdictions along the Front Range have profiled wind in local hazard mitigation plans.

FIGURE 3-37 SEVERE WIND HAZARD PROFILED IN LOCAL MITIGATION PLANS



Additionally, five jurisdictions profiled severe wind as one of their top four hazards. Within those jurisdictions, 87,034 structures or parcels have been identified in severe wind hazard areas, and 1,960 critical facilities have been identified in severe wind hazard areas. Table 3-76 describes this information in more detail, as well as the total estimated losses.

TABLE 3-76 LOCAL HAZARD MITIGATION PLANS

Jurisdiction	# of Structures/ Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate	Loss Estimate Methodology
Baca County	4,094	187			

Jurisdiction	# of Structures/Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate	Loss Estimate Methodology
<b>Boulder County</b>	30,000 to 60,000 (25-50% of 120,137 properties likely severely damaged)	1,405		\$3,400,000	avg annual losses
<b>Custer County</b>	4,486	61		\$3,000,000	avg annual loss
<b>Dolores County</b>	1,747	69		\$6,120	avg annual loss
<b>Fremont County</b>	16,707	238		\$522,230,652	10% damage
<b>Total</b>	<b>87,034 (using 60,000 in Boulder)</b>	<b>1,960</b>		<b>\$528,636,772</b>	

## 8. FUTURE DEVELOPMENT

Population growth and development contribute to increased exposure of people and property to the impacts of severe wind events. As higher numbers of people and property flow into an area, more assets and people are exposed to severe weather. In the context of severe wind, increased population and development elevates exposure of property and people to the impacts of severe wind.

Colorado continues to experience some of the largest population growth in the country, and future projections seem to indicate a similar trend should be expected. Table 3-77 presents the projected percent change in housing on a county scale from 2010 - 2030. Among the 12 counties with at least 100 reports of severe wind since 1955, eight are projected to see at least moderate housing growth. Weld and Larimer Counties are in the highest growth category, with projected housing increases of 93 percent and 47 percent, respectively.

TABLE 3-77 HOUSING PROJECTIONS (2010 TO 2030) AND HISTORICAL WIND EVENTS

County	Historical Wind Events	Housing Percent Change	Growth Rating
<b>Weld</b>	231	93%	<b>Highest</b>
<b>Larimer</b>	115	47%	<b>Highest</b>
<b>Arapahoe</b>	89	52%	<b>Highest</b>
<b>Adams</b>	80	60%	<b>Highest</b>
<b>Elbert</b>	52	120%	<b>Highest</b>
<b>Douglas</b>	35	67%	<b>Highest</b>

County	Historical Wind Events	Housing Percent Change	Growth Rating
Eagle	31	56%	Highest
Garfield	25	51%	Highest
Routt	19	46%	Highest
Montrose	18	61%	Highest
La Plata	14	50%	Highest
Archuleta	11	61%	Highest
Broomfield	3	78%	Highest
Park	2	65%	Highest
San Miguel	2	64%	Highest
Summit	1	49%	Highest
Pueblo	116	26%	High
El Paso	110	40%	High
Mesa	99	38%	High
Lincoln	87	26%	High
Denver	82	37%	High
Boulder	60	37%	High
Jefferson	31	30%	High
Montezuma	20	37%	High
Crowley	20	26%	High
Delta	13	35%	High
Gunnison	11	28%	High
Fremont	7	28%	High
Grand	6	44%	High
Pitkin	6	34%	High
Chaffee	5	38%	High
Custer	3	41%	High
Yuma	188	17%	Moderate
Kit Carson	186	20%	Moderate
Morgan	135	26%	Moderate
Logan	116	21%	Moderate
Kiowa	53	12%	Moderate
Las Animas	31	23%	Moderate
Alamosa	10	25%	Moderate
Saguache	6	17%	Moderate
Teller	4	23%	Moderate
Hinsdale	2	19%	Moderate
Clear Creek	1	20%	Moderate
Huerfano	1	13%	Moderate
Lake	0	21%	Moderate
Conejos	0	14%	Moderate
Ouray	0	13%	Moderate

County	Historical Wind Events	Housing Percent Change	Growth Rating
Gilpin	0	12%	Moderate
Washington	136	8%	Low
Cheyenne	131	11%	Low
Prowers	103	3%	Low
Otero	102	6%	Low
Phillips	77	1%	Low
Baca	60	-6%	Low
Bent	39	7%	Low
Sedgwick	35	1%	Low
Rio Blanco	23	10%	Low
Moffat	19	7%	Low
Jackson	6	9%	Low
Dolores	4	4%	Low
Rio Grande	3	7%	Low
Costilla	0	10%	Low
Mineral	0	10%	Low
San Juan	0	10%	Low

Source: NOAA, Colorado State Demography Office, 2017

Table 3-80 provides county-scale wind exposure projections by comparing current wind risk and projected population change between 2010 and 2030, and Figure 3-38 displays the same information on a map. Below, Table 3-78 and Table 3-79 outline the methodology used to determine the exposure projections for each county. Weld, Larimer, El Paso, and Arapahoe Counties have the highest exposure projection when considering their projected population. These are all high-density counties at spanning Colorado’s Front Range urban corridor.

TABLE 3-78 WIND EXPOSURE PROJECTIONS

Future Wind Exposure Projections					
		County Population Percent Change Projections, 2010 to 2030			
Combined Risk (Wind)		-13% to 2%	3% to 17%	18% to 34%	35% to 89%
High ↑ Moderate	5-6	Moderate	High	Severe	Extreme
	3-4	Slight	Moderate	High	Severe
	0-2	Negligible	Slight	Moderate	High

The Combined Risk calculations are based on the methodology outlined in Table 3-79. Values (between zero and three) have been assigned to total deaths and injuries and total number of severe wind events per county. The Jenks Natural Breaks algorithm was used to classify these historical data sets. These values were summed to get a Combined Risk value for each county.

**TABLE 3-79 COMBINED RISK METHODOLOGY (WIND)**

Deaths and Injuries (1986 – 2017)	Value	# of Wind Events (1955-2017)	Value
23-103	3	137-231	3
9-22	2	61-136	2
3-8	1	24-60	1
0-2	0	0-23	0

Exposure to severe wind events are expected to intensify across the State of Colorado between 2010 and 2030 as population increases. The darker colors in the tables illustrate relative rates of increase in exposure between counties.

**TABLE 3-80 WIND EXPOSURE PROJECTIONS, 2010 TO 2030**

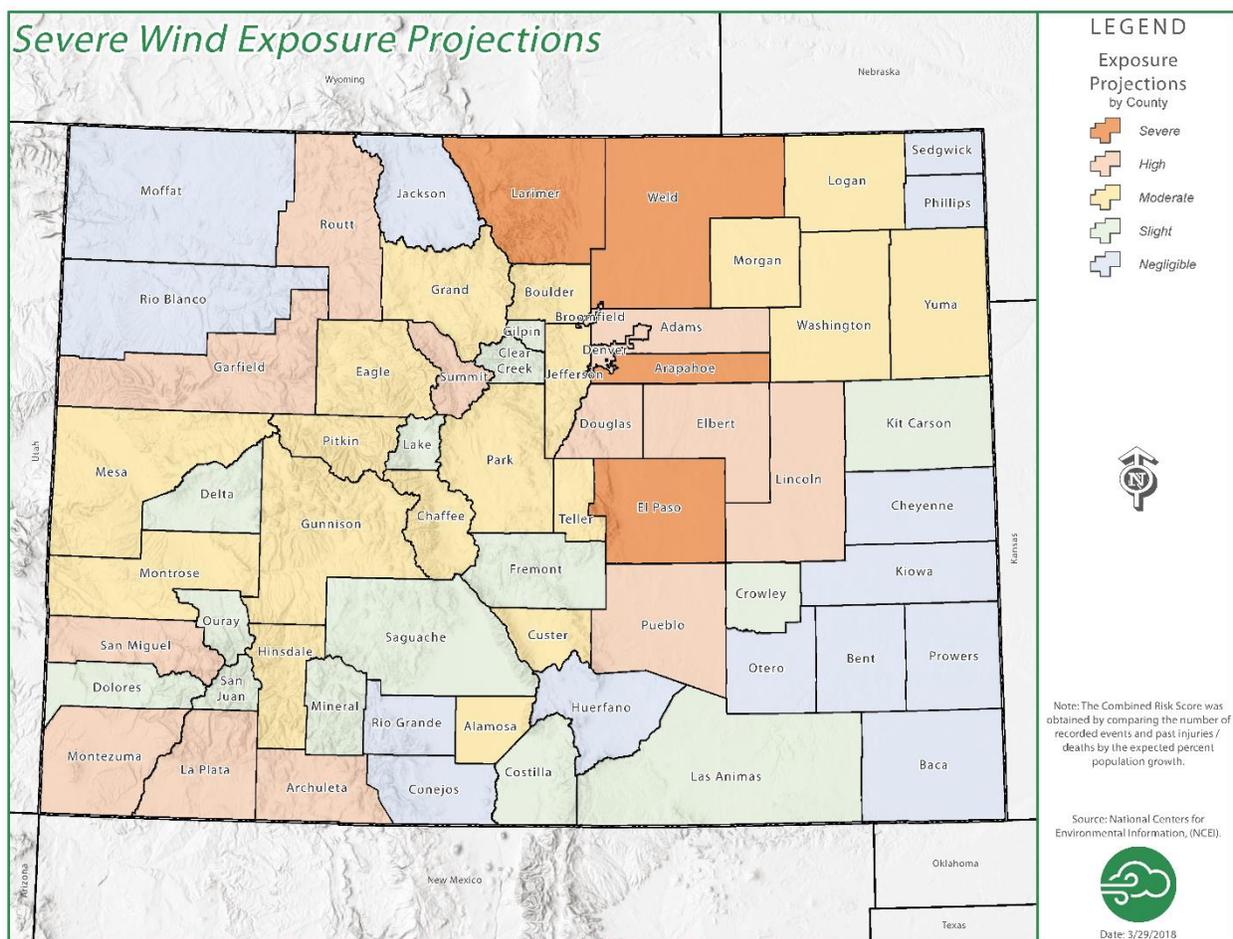
County	Combined Risk	Population Change	Exposure Rating
Weld	3	81%	Severe
Larimer	4	42%	Severe
El Paso	3	36%	Severe
Arapahoe	4	36%	Severe
Elbert	1	89%	High
Broomfield	0	71%	High
San Miguel	0	59%	High
Adams	2	48%	High
Douglas	2	44%	High
Denver	2	42%	High
La Plata	0	42%	High
Summit	0	41%	High
Routt	0	40%	High
Archuleta	0	40%	High
Garfield	1	38%	High
Montezuma	1	37%	High
Lincoln	3	21%	High
Pueblo	3	20%	High
Park	0	34%	Moderate

County	Combined Risk	Population Change	Exposure Rating
Eagle	1	34%	Moderate
Grand	0	32%	Moderate
Montrose	0	30%	Moderate
Hinsdale	0	29%	Moderate
Chaffee	0	29%	Moderate
Boulder	1	28%	Moderate
Gunnison	0	26%	Moderate
Teller	0	25%	Moderate
Mesa	2	24%	Moderate
Alamosa	0	22%	Moderate
Jefferson	1	21%	Moderate
Custer	0	20%	Moderate
Pitkin	0	18%	Moderate
Morgan	4	16%	Moderate
Logan	3	14%	Moderate
Yuma	3	7%	Moderate
Washington	3	5%	Moderate
Lake	0	17%	Slight
Ouray	0	17%	Slight
Mineral	0	16%	Slight
Clear Creek	0	14%	Slight
Gilpin	0	13%	Slight
Saguache	0	9%	Slight
Delta	1	8%	Slight
Costilla	0	7%	Slight
Fremont	0	5%	Slight
Dolores	0	5%	Slight
Crowley	0	5%	Slight
San Juan	0	5%	Slight
Kit Carson	3	-1%	Slight
Las Animas	4	-9%	Slight
Cheyenne	2	2%	Negligible
Rio Blanco	0	2%	Negligible
Conejos	0	1%	Negligible
Huerfano	0	-1%	Negligible
Sedgwick	1	-3%	Negligible

County	Combined Risk	Population Change	Exposure Rating
Phillips	2	-3%	Negligible
Moffat	0	-3%	Negligible
Rio Grande	0	-5%	Negligible
Bent	1	-5%	Negligible
Prowers	2	-5%	Negligible
Otero	2	-7%	Negligible
Jackson	0	-7%	Negligible
Kiowa	2	-8%	Negligible
Baca	1	-13%	Negligible

Source: NOAA, Colorado State Demography Office, 2017

FIGURE 3-38 SEVERE WIND EXPOSURE PROJECTIONS, 2010 TO 2030



In review of local hazard mitigation plans, Boulder County states the following regarding future development and severe wind:

- New construction designed in accordance with the Boulder County wind load map should be able to withstand wind damage, if properly constructed.

## 9. CLIMATE CHANGE

According to the best data available at the time of this plan update, the future impacts of climate change on severe wind events are unclear. The following Table 3-81 presents a breakdown of these projected changes in terms of hazard: location, extent/intensity, frequency, and duration. Ongoing efforts to reduce Colorado’s greenhouse gas emissions and adapt to a changing climate, such as the Colorado Climate Plan, will help to reduce the impacts of climate change on severe wind.

TABLE 3-81 CLIMATE CHANGE IMPACTS

Impact	Projected Change
<b>Location</b>	Severe wind events occur across much of the state. The area at risk to severe wind events is not projected to change.
<b>Extent/Intensity</b>	It is unknown if or how the intensity of severe wind events will change. Extent is not projected to change.
<b>Frequency</b>	The frequency of severe wind events is not projected to change.
<b>Duration</b>	It is unknown if or how the duration of severe wind events will change.

Source: FEMA 2017 and Childress et al. 2015

## 10. RISK TO STATE ASSETS

General observations suggest that the relationship of Colorado’s most severe winds occurring along the Front Range, and the concentration of state assets with the hazard extent, relates to high vulnerability.

The most vulnerable state asset that is susceptible to high winds are the Digital Trunked Radio System (DTRS) towers that are scattered across the state. These towers are positioned in specific areas where there is little geographic protection against high winds due to the requirement that these towers have “line-of-sight” capability.

Since 2008, there have been 134 property losses reported on state assets due to wind, 23 of which occurred in 2017. During this time, a total of \$3.0 million was paid to cover losses due to wind. Another \$1.9 million is currently in reserve to cover estimated damages for 23 reported losses incurred in 2016 and 2017. If paid in full, the average loss over the last 10 years would be about \$36,720 per event. Reported damages tended to involve signs, fences, power lines, trees falling into buildings, gutters, and minor roof damage. The largest expense was \$777,619 to replace the roof of a residence hall at Colorado Northwestern Community College’s Rangely campus in Rio Blanco County, which was torn off by a 2011 windstorm. It is important to note that state asset loss data is only available for state assets included in the 2017 Office of Risk

Management (ORM) database. These numbers exclude many Higher Education assets, and therefore may under-represent actual losses.

This relatively low cost event average suggests superficial damage and that state buildings, typically of moderate to heavy construction, are not particularly vulnerable to this hazard. Repairs are likely to be more cost effective than systematic mitigation. Where vulnerabilities are present on a case-by-case basis, regular maintenance of building exteriors and minor strengthening of light structures may be adequate to reduce losses. Table 3-82 describes the state asset exposure projections from 2010 to 2030.

**TABLE 3-82 STATE ASSET EXPOSURE PROJECTIONS, 2010 TO 2030**

<b>County</b>	<b>State Assets</b>	<b>Asset Valuation</b>	<b>Exposure Rating</b>
Larimer	931	\$2,520,380,927	Severe
Weld	270	\$723,621,025	Severe
El Paso	252	\$664,445,003	Severe
Arapahoe	231	\$539,093,242	Severe
Denver	479	\$2,631,589,250	High
Adams	225	\$2,161,277,205	High
Pueblo	391	\$1,100,717,917	High
Garfield	227	\$935,656,624	High
La Plata	199	\$459,565,269	High
Summit	54	\$210,520,143	High
Lincoln	80	\$115,435,435	High
Douglas	139	\$41,437,868	High
Montezuma	92	\$26,250,957	High
Routt	153	\$19,636,862	High
Archuleta	68	\$12,576,015	High
Broomfield	7	\$7,925,505	High
San Miguel	36	\$6,959,484	High
Elbert	16	\$6,135,197	High
Boulder	288	\$3,184,873,780	Moderate
Jefferson	481	\$1,220,747,270	Moderate
Mesa	316	\$571,483,873	Moderate
Alamosa	123	\$361,142,477	Moderate
Logan	174	\$321,168,914	Moderate
Gunnison	146	\$297,472,630	Moderate
Chaffee	196	\$135,641,023	Moderate
Morgan	168	\$67,190,695	Moderate
Eagle	148	\$22,080,215	Moderate

County	State Assets	Asset Valuation	Exposure Rating
Montrose	65	\$19,168,190	Moderate
Park	120	\$17,071,984	Moderate
Yuma	84	\$14,101,083	Moderate
Grand	69	\$12,702,273	Moderate
Teller	53	\$9,932,426	Moderate
Washington	31	\$4,317,254	Moderate
Hinsdale	19	\$1,605,114	Moderate
Custer	6	\$1,130,092	Moderate
Pitkin	14	\$712,333	Moderate
Fremont	360	\$762,885,780	Slight
Las Animas	118	\$152,450,902	Slight
Clear Creek	75	\$117,846,308	Slight
Crowley	28	\$99,475,999	Slight
Delta	116	\$39,890,610	Slight
Mineral	21	\$30,302,497	Slight
Gilpin	39	\$10,009,237	Slight
Ouray	46	\$8,684,296	Slight
Saguache	49	\$5,188,186	Slight
San Juan	22	\$4,603,609	Slight
Dolores	20	\$4,252,291	Slight
Costilla	28	\$4,179,435	Slight
Kit Carson	27	\$4,146,763	Slight
Lake	21	\$2,881,105	Slight
Rio Grande	155	\$134,839,206	Negligible
Bent	173	\$116,882,345	Negligible
Otero	83	\$79,711,658	Negligible
Prowers	86	\$73,450,933	Negligible
Rio Blanco	66	\$63,910,055	Negligible
Huerfano	66	\$35,640,305	Negligible
Moffat	90	\$15,349,886	Negligible
Jackson	85	\$13,799,847	Negligible
Conejos	41	\$6,598,803	Negligible
Sedgwick	30	\$1,827,494	Negligible
Baca	14	\$1,559,394	Negligible
Kiowa	8	\$1,308,651	Negligible
Cheyenne	9	\$712,471	Negligible

County	State Assets	Asset Valuation	Exposure Rating
Phillips	5	\$196,988	Negligible

Source: Colorado State Demography Office, 2017; Office of Risk Management, 2017 and 2013

## 11. RESOURCES

- Childress, A., Gordon, E., Jedd, T., Klein, R., Lukas, J., and McKeown, R. (2015). Colorado Climate Change Vulnerability Study.
- Colorado Department of Transportation (CDOT) Threat and Hazard Identification and Risk Assessment (THIRA)
- Colorado Energy Assurance Emergency Plan (CEAEP), 2016
- Colorado Resiliency Framework
- Federal Emergency Management Agency (FEMA)
- Federal Emergency Management Agency (FEMA). (2017). Assessing Future Conditions, Colorado.
- National Climate Data Center (NCDC)
- National Renewable Energy Laboratory (NREL)
- National Weather Service (NWS)
- Rocky Mountain Weather Network (RMWN)

# SEVERE WINTER WEATHER



## 1. DEFINITION

Hazardous winter weather includes events related to heavy snow, blowing snow, ice, sleet or freezing rain, and extreme cold temperatures. Severe winter weather can cause hazardous driving conditions, communications and electrical power failure, community isolation, and can adversely affect business continuity. Roads, rail systems, and airports can be disrupted by snow, ice, and wind-blown debris. Disruption of key local transportation nodes can lead to cascading impacts on the larger regional transportation networks. Emergency response and recovery efforts are also impacted by snow and debris following a winter storm.

These types of severe winter weather may include one or more of the following factors:

**Blizzards**, as defined by the National Weather Service, are a combination of sustained winds or frequent gusts of 35 mph or greater, and visibilities of less than a quarter mile from falling or blowing snow for three hours or more. A blizzard, by definition, does not indicate heavy amounts of snow, although they can happen together. Falling or blowing snow usually creates large drifts from the strong winds. The reduced visibilities make travel, even on foot, particularly treacherous. The strong winds may also support dangerous wind chills. Ground blizzards can develop when strong winds lift snow off the ground and severely reduce visibilities. Roads, rail systems, and airports can be disrupted because of the snow, ice, and wind-blown debris caused by blizzards. Disruption of key local transportation nodes can lead to cascading impacts on the larger regional transportation networks. Transportation systems are also important to emergency response and recovery efforts during and following a winter storm.

**Extreme Cold**, in extended periods, occurs throughout Colorado. Though heating systems largely compensate for the cold, extreme temperatures can overload or damage utilities, causing these systems to be inoperable. Most people limit their time outside during extreme cold conditions, but common complaints usually include pipes freezing and cars refusing to start. When cold temperatures and high wind combine, dangerous wind chills can develop.

**Freezing Rain** is rain that falls on a surface that has a temperature below freezing. Freezing rain is made entirely out of liquid droplets, unlike sleet or hail. A glaze is then formed that can cause extremely dangerous situations, particularly for vehicles. Even one-quarter inch of ice is enough to cause significant traffic delays, and problems for emergency personnel. Substantial accumulations of freezing rain can break trees and down power lines.

**Heavy snow** may fall in large quantities during winter storms. Six inches or more in a span of 12 hours, or eight inches or more in 24 hours constitutes conditions that may significantly hamper travel or create hazardous conditions. The National Weather Service issues warnings for such events. Smaller amounts can also make travel hazardous, but in most cases, may only result in minor inconveniences. Heavy wet snow before leaves fall from trees in autumn, or after

trees have leafed out in the spring may cause problems with broken tree branches and power outages.

**Ice storms** develop when a layer of warm (above freezing), moist air aloft coincides with a shallow cold (below freezing) pool of air at the surface. As snow falls into the warm layer of air, it melts to rain, and then freezes on contact when hitting the frozen ground or cold objects at the surface, creating a smooth layer of ice. This phenomenon is called freezing rain or ice accretion. Similarly, sleet occurs when the rain in the warm layer subsequently freezes into pellets while falling through a cold layer of air at or near the Earth’s surface. Extended periods of freezing rain can lead to accumulations of ice on roadways, walkways, power lines, trees, and buildings. Almost any accumulation can make driving and walking hazardous. Thick accumulations can bring down trees and power lines.

Table 3-83 describes the hazard summary for severe winter weather.

**TABLE 3-83 HAZARD SUMMARY**

<b>Consideration</b>	<b>Impact</b>	<b>Description</b>
<b>Location</b>	Statewide	Snowfall amounts vary with elevation, with greater amounts in the mountains, lower amounts on the plains and select southern and western regions.
<b>Previous Occurrence</b>	Seasonal	September through April is primary season for significant snowfalls, with December/January producing colder and dryer snow storms while March/April producing wet and heavy snowfall. Snowfall may occur at high elevations throughout the year.
<b>Probability</b>	Expected	Atmospheric activity producing conditions prone to winter weather such as ice, snow, extreme cold, blizzard, and high winds are expected to occur as in the past.
<b>Extent</b>	Extensive	Isolated but potentially major property damage that threatens structural stability, isolated deaths and/or injuries, potential impact to critical services or facilities.

## 2. LOCATION

The entire State of Colorado can be impacted by winter storms; there is nowhere that is immune to their effects. Figure 3-39 shows that average snowfall is 72 inches or greater in the central (including the Front Range foothills) and western areas of the state.

FIGURE 3-39 WINTER STORM LOCATION



Source: NOAA

### 3. EXTENT (MAGNITUDE/STRENGTH)

In general, the snowstorm season runs from November to April each year. Although snow does fall outside of this “season,” such snowfall would be comparatively light or would melt quickly, rather than the sort of snowstorm event that is being considered here as a hazard. Several times a year, Colorado receives heavy snow, blowing snow, and spells of extremely cold temperatures. It is common throughout the winter season for at least one part of the state to be under a winter weather advisory or winter storm/blizzard watch or warning. Table 3-84 shows the Winter Storm Severity Index. This index standardizes the potential levels of impacts from winter storms.

TABLE 3-84 WINTER STORM SEVERITY INDEX

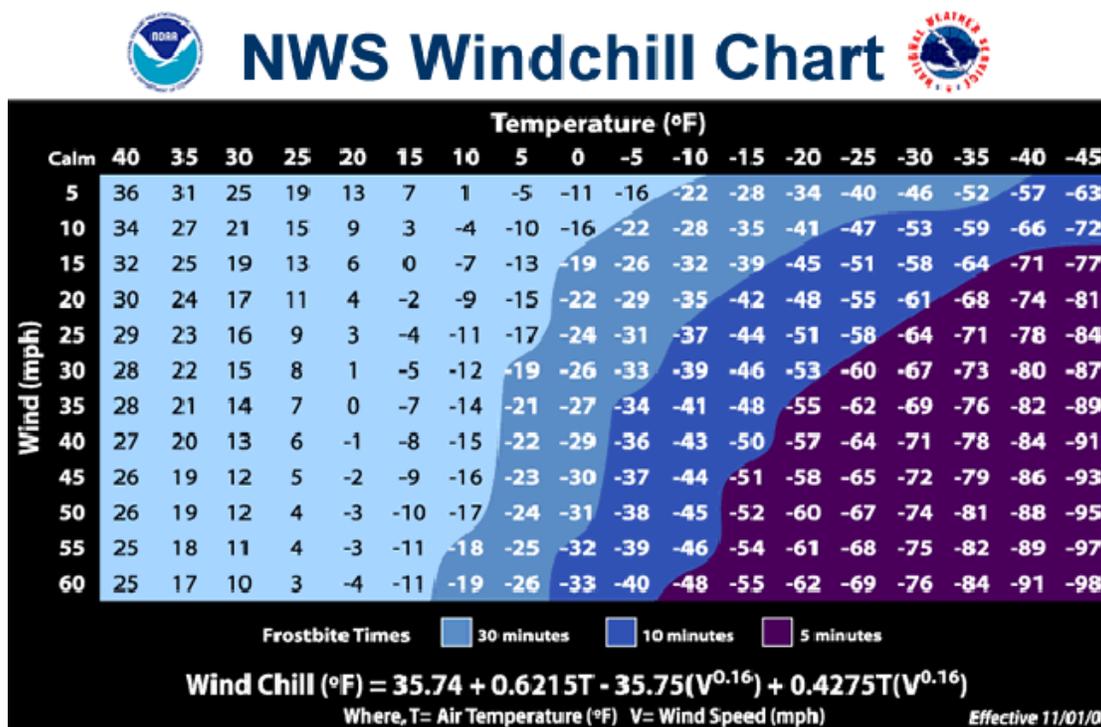
WSSI Descriptor	General Description of Expected Storm Severity and Impacts
<b>None</b>	No snow or ice forecast. No potential for ground blizzard conditions.
<b>Limited</b>	Small accumulations of snow or ice forecast. Minimal impacts, if any, expected. In general, society goes about their normal routine.
<b>Minor</b>	Roughly equates to NWS Advisory Level criteria. Minor disruptions, primarily to those who were not prepared. None, to minimal recovery time needed.
<b>Moderate</b>	Roughly equates to NWS Warning Level criteria. Definite impacts to those with little preparation. Perhaps a day or two of recovery time for snow and/or ice accumulation events.

WSSI Descriptor	General Description of Expected Storm Severity and Impacts
Major	Significant impacts, even with preparation. Typically, several days recovery time for snow and/or ice accumulation events.
Extreme	Historic. Widespread severe impacts. Many days to at least a week of recovery time needed for snow and/or ice accumulation events.

Source: NOAA

Wind Chill is how cold it “feels” and is based on the rate of heat loss on exposed skin from wind and cold (Figure 3-40). As the wind increases, it draws heat from the body, driving down skin temperature, and eventually, internal body temperature. This makes it feel much colder than the actual temperature. For example, if the temperature is 0°F and the wind is blowing at 15 mph, the wind chill is -19°F. At this wind chill, exposed skin can freeze in 30 minutes. Wind chill does not affect inanimate objects.

FIGURE 3-40 NATIONAL WEATHER SERVICE WIND CHILL CHART



Source: NOAA

## 4. PROBABILITY

Conditions that produce severe winter weather occur annually. Every county in Colorado has experienced winter weather every year on record. There is currently no reason to assume that this will change. Atmospheric activity will continue to produce severe winter weather throughout the state on an annual basis, largely occurring between October and March. Some late season storms may occur, extending into April or May.

## 5. PREVIOUS OCCURRENCES

Colorado has a history of significant winter storm events. The past 10 years have seen an estimated 17,615 events across all Colorado counties. Property damage has been estimated at nearly \$1.5 million. There have been no deaths or injuries in this span of time. Table 3-85 shows property damage, injuries, and deaths resulting from severe winter weather events each year from 2007 to 2017. Additionally, since 1955, four severe winter storms received presidential disaster or emergency declarations, including storms in 2001, 2003, and two in 2006.

**TABLE 3-85 SEVERE WINTER WEATHER EVENTS, DEATHS, INJURIES, AND PROPERTY DAMAGE, 2007 TO 2017**

Year	Reported Events	Deaths	Injuries	Property Damage
2007	1,626	0	0	\$ 353,000
2008	1,925	0	0	\$ 180,000
2009	1,879	0	0	\$ 0
2010	1,923	0	0	\$ 0
2011	2,154	0	0	\$ 66,000
2012	1,411	0	0	\$ 0
2013	1,680	0	0	\$ 25,000
2014	1,551	0	0	\$ 45,000
2015	1,294	0	0	\$ 0
2016	1,224	0	0	\$ 0
2017*	948	0	0	\$ 805,000
<b>Total</b>	<b>17,615</b>	<b>0</b>	<b>0</b>	<b>\$ 1,474,000</b>

\*Up to November 2017  
Source: NOAA

Table 3-86 shows the winter weather events per county between 1960 and 2017. Winter events often “stack” on each other, meaning that one type of event may occur simultaneously alongside others. For example, extreme cold may occur at the same time as a winter storm, which may also be part of a larger blizzard. On average, Colorado has moderate to heavy snowfall and extreme cold 87 days per year. This same information is presented as a map in Figure 3-41.

**TABLE 3-86 WINTER WEATHER EVENTS, 1960 TO 2017**

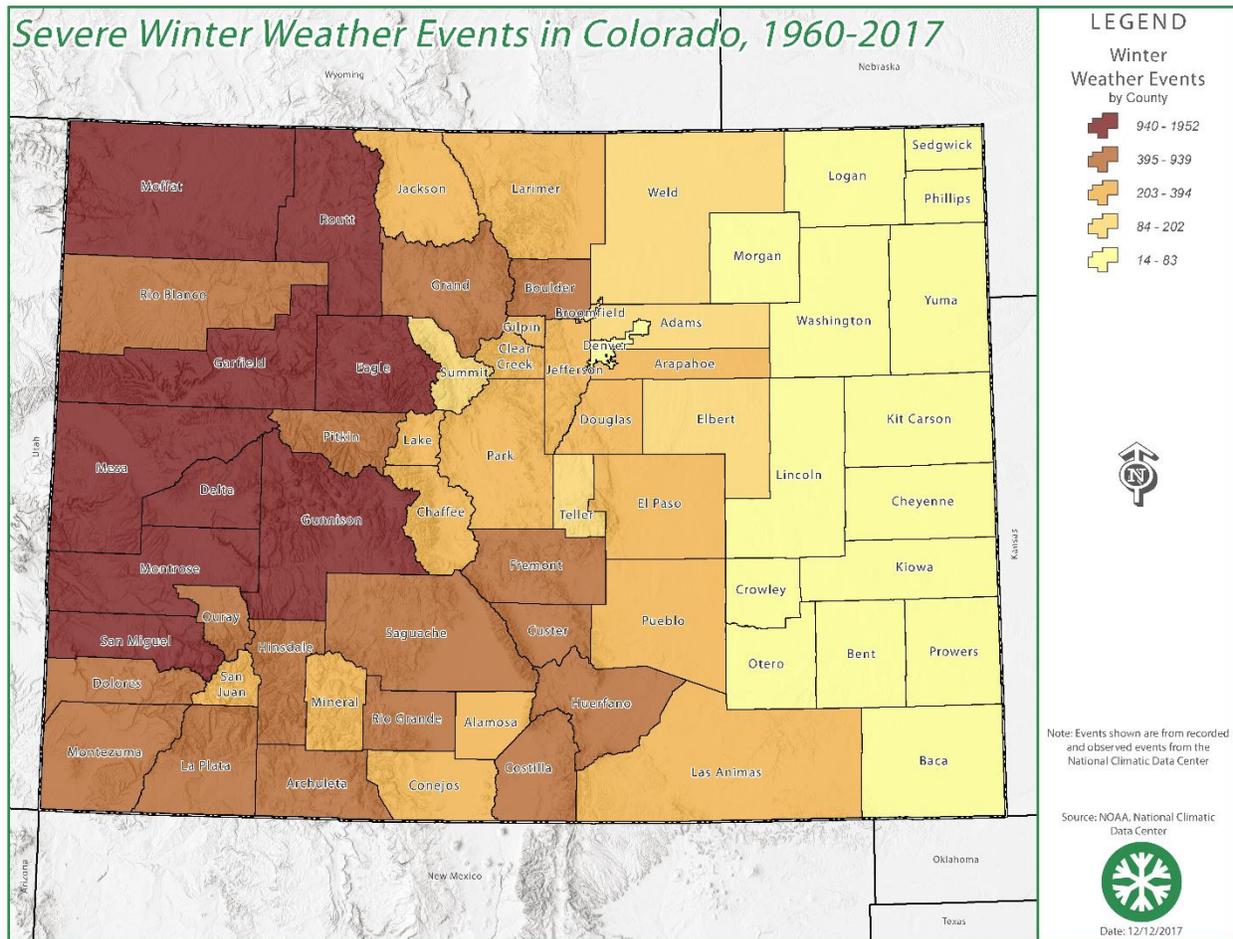
County	Blizzard	Cold/ Wind Chill	Extreme Cold/ Wind Chill	Ice Storm	Winter Storm	Winter Weather	Grand Total
Adams	25	5	1	-	72	33	136
Alamosa	6	12	-	-	215	11	244
Arapahoe	39	5	1	-	121	55	221
Archuleta	9	1	-	-	255	264	529
Baca	4	-	-	1	12	1	18
Bent	4	-	-	1	9	-	14

County	Blizzard	Cold/ Wind Chill	Extreme Cold/ Wind Chill	Ice Storm	Winter Storm	Winter Weather	Grand Total
Boulder	12	-	1	-	303	173	489
Broomfield	11	2	2	-	104	39	158
Chaffee	7	8	-	-	327	19	361
Cheyenne	9	4	3	1	13	11	41
Clear Creek	5	-	-	-	169	90	264
Conejos	5	7	-	-	224	11	247
Costilla	11	27	-	-	384	23	445
Crowley	4	-	-	1	9	-	14
Custer	12	29	-	-	396	35	472
Delta	9	3	1	-	513	704	1,230
Denver	7	2	1	-	54	19	83
Dolores	9	3	1	-	248	305	566
Douglas	22	2	1	-	174	68	267
Eagle	3	1	1	1	400	698	1,104
El Paso	15	6	-	-	172	29	222
Elbert	37	6	-	-	70	35	148
Fremont	14	33	-	-	399	38	484
Garfield	9	6	5	3	700	1,229	1,952
Gilpin	5	-	-	-	169	90	264
Grand	9	-	-	-	249	178	436
Gunnison	13	3	1	-	437	644	1,098
Hinsdale	18	-	-	-	389	423	830
Huerfano	19	39	-	-	615	51	724
Jackson	4	-	-	-	140	99	243
Jefferson	9	-	1	-	219	110	339
Kiowa	10	-	-	2	20	1	33
Kit Carson	16	4	6	-	17	13	56
Lake	5	-	-	-	204	21	230
La Plata	9	1	-	1	245	258	514
Larimer	9	-	1	-	191	103	304
Las Animas	16	10	-	1	234	18	279
Lincoln	23	6	-	-	21	13	63
Logan	14	4	-	-	20	6	44
Mesa	8	7	3	2	434	785	1,239
Mineral	7	1	-	-	297	12	317
Moffat	5	2	3	-	507	745	1,262
Montezuma	9	2	1	-	231	260	503
Montrose	15	5	1	-	558	851	1,430
Morgan	10	3	-	-	19	8	40
Otero	4	-	-	1	11	-	16

County	Blizzard	Cold/ Wind Chill	Extreme Cold/ Wind Chill	Ice Storm	Winter Storm	Winter Weather	Grand Total
Ouray	11	1	-	-	297	396	705
Park	5	-	-	-	188	98	291
Phillips	10	-	-	-	10	4	24
Pitkin	2	1	1	1	215	410	630
Prowers	4	-	-	1	11	1	17
Pueblo	8	12	-	-	178	25	223
Rio Blanco	4	3	3	-	326	603	939
Rio Grande	9	3	-	-	411	15	438
Routt	4	2	3	1	547	883	1,440
Saguache	12	13	-	-	480	19	524
San Juan	9	-	-	-	196	189	394
San Miguel	20	4	1	-	545	701	1,271
Sedgwick	13	4	-	-	12	6	35
Summit	5	-	-	-	116	81	202
Teller	4	6	-	-	129	14	153
Washington	19	4	-	-	17	3	43
Weld	22	4	1	-	75	29	131
Yuma	16	4	7	-	14	11	52

Source: NOAA

FIGURE 3-41 SEVERE WINTER WEATHER EVENTS IN COLORADO, 1960-2017



Heavy snowfall is common in Colorado, though some events are record-producing. The largest event on record was in December of 1913, when 45.7 inches fell over the state. Since then, the next heaviest snowfall was a mid-March blizzard in 2003 that dropped 31.8 inches in Denver. Table 3-87 shows heavy snowfall events in Colorado.

TABLE 3-87 HEAVY SNOWFALL EVENTS IN COLORADO

Snow Amount	Dates
45.7 inches	December 1 – 5, 1913
31.8 inches	March 17 – 19, 2003
30.4 inches	November 2 – 4, 1946
23.8 inches	December 24, 1982
23.0 inches	April 23, 1885
22.7 inches	October 20 – 23, 1906
21.9 inches	October 24 – 24, 1997
21.5 inches	November 26 – 27, 1983
20.7 inches	December 20 – 21, 2006

Snow Amount	Dates
19.3 inches	January 29 – 31, 1883
19.0 inches	April 24 – 25, 1935
18.7 inches	March 5 – 6, 1983
18.5 inches	March 20 – 22, 1944
18.2 inches	April 17 – 19, 1920
18.0 inches	March 19 – 20, 1907
18.0 inches	March 31 – April 1, 1891
17.7 inches	November 19 – 21, 1979

Source: NOAA, Denver Post

Hazardous winter weather may result from bitterly cold temperatures rather than snow events. Table 3-88 shows winter weather events related to extreme cold temperatures that impacted property and agricultural crops across the state.

TABLE 3-88 EXTREME COLD EVENTS IN COLORADO, 1983 TO 2017

Date	Description: Including Deaths, Injuries, Crop and Property Damage (\$ Million)
1983	Cold spell. Readings to -21F, coldest recorded temperature in 20 years.
1989	Extreme cold, snow, wind. Main airport closed. Poor visibility; 46-car pile-up on Interstate 25.
Mar-1995	Freeze in western Colorado. Readings below critical values in orchard areas; 10% of crops damaged.
Apr-1995	Extreme cold in the City of Arapahoe area. Readings to 13F. Wheat damaged. ~ \$1M crop damage.
Jan-1996	Extreme wind chill in southeast Colorado. Wind chills from -30F to -50F.
Feb-1996	Extreme wind chill in the southeast plains. Wind chill -25F to -50F. Lows in Pueblo -26F, Colorado Springs -18F.
Mar-1996	Extreme wind chill in southeast Colorado. Bitter cold, gusty. Wind chill -25F to -40F.
Dec-1996	Extreme wind chill in southeast Colorado. Wind chills of -20 to -35F.
Dec-1996	Extreme wind chill in east central and northeast Colorado. Readings -30F to -45F. In south-central and southeast Colorado wind chill -20F to -40F. Denver area with a low -9F.
Jan-1997	Extreme wind chill in southeast Colorado and foothills. Wind chills -25F to -35F. Northeast. Wind chill -25F to -50F.
Apr-1997	Freeze in western Colorado. Temperatures dropped below critical levels for most fruit varieties. Majority of stone fruits lost, most apples and pears survived. ~ \$9M crop damage.
Apr-1997	Extreme cold in east central Colorado. Single digit temperatures, highs below freezing, freezing drizzle, light snow. Schools closed one to two days for ice. Many car accidents.
Oct-97	Blizzard in the eastern Front Range. Snow to four inches in foothills. Gusts to 70 mph. Wind chill -25F to -40F. State of Emergency declared. Five deaths; two injuries; >24,000 cattle lost.

Date	Description: Including Deaths, Injuries, Crop and Property Damage (\$ Million)
Jun-1998	Extreme cold in east central Colorado. Record cold morning temperatures, lows below freezing. Crop and garden damage.
Dec-1998	Extreme cold in northeast Denver. Six days dipped below 0F. Low -19 F. Power outages, cracked water pipes. Five deaths; 15 injuries.
Jan-1999	Extreme wind chill. Far eastern Colorado. Readings below -35F.
Apr-1999	Extreme cold in Mesa County. Ruined part of fruit crop. Lows 10s to 20sF. ~\$8.8M crop damage.
Jun-1999	Extreme cold in southwest Colorado. Late freeze destroyed grapes and vegetables. ~\$0.004M crop damage.
Jun-2001	Extreme cold. Hard freeze in southwest Colorado. Widespread damage to pinto bean and tomato crops near Cortez.
Dec-2005	Extreme cold and wind chill. Record breaking cold temperatures in western Colorado. Frozen water pipes burst in many areas.
Dec-2009	Extreme wind chill. Wind chill values of -25F to -30F. Temps from -5F to -15F.
Feb-2011	Wind chill temperatures ranged from -30F to -50F, as winds gusted 25 to 40 mph.
Feb-2011	An Arctic high pressure area swept into the Tri-State area behind the winter storm on February 8th. The combination of cold air temperatures and strong wind resulted in wind chill values between -25F and -30F. Wind chill values dropped to -27F at the Burlington Automated Surface Observing System (ASOS).
Dec-2014	Wind chills of -25F or colder were reported from the evening through the following morning.
Dec-2016	Wind chills ranged between -25F and -30F for much of Colorado.

Source: NOAA

While the entire state experiences cold temperatures, geographic considerations can make some areas more prone to these events than others. Yuma County has experienced the most extreme cold events at seven, with Kit Carson County and Garfield experiencing six and five events, respectively. Table 3-89 shows extreme cold for counties that have recorded one or more. Those that had zero were excluded from this table.

TABLE 3-89 COUNTIES EXPERIENCING EXTREME COLD EVENTS, 1960 TO 2017

County	Extreme Cold / Wind Chill
Yuma	7
Kit Carson	6
Garfield	5
Cheyenne	3
Mesa	3
Moffat	3
Rio Blanco	3

County	Extreme Cold / Wind Chill
Routt	3
Broomfield	2
Adams	1
Arapahoe	1
Boulder	1
Delta	1
Denver	1
Dolores	1
Douglas	1
Eagle	1
Gunnison	1
Jefferson	1
Larimer	1
Montezuma	1
Montrose	1
Pitkin	1
San Miguel	1
Weld	1

Source: NOAA

Below are descriptions of historic winter weather events from 1978 to 2017. Storm descriptions are sourced from NOAA unless otherwise stated.

**March 3<sup>rd</sup>, 1978** - Riding winds up to 40 mph dumped up to 16 inches of snow in the Colorado Rockies ski country, 10 inches on Kansas and Nebraska, and eight inches in southern Iowa. It lay down a belt of ice south of the snow belt. The National Weather Service deemed it a “dangerous winter storm.” From [Late Winter Storm Lashes Rockies, Plains, Midwest, The Times from Shreveport, Louisiana](#)

**December 26<sup>th</sup>, 1982** - A storm that buried Colorado in up to four feet of snow moved on Saturday, leaving behind closed roads and airports and thousands of stranded travelers, as rain and record warm temperatures in many Midwestern cities melted hopes for a white Christmas. At least two people in Colorado froze. From [Winter Storm Leaves Colorado Buried, Southern Illinoisan](#)

**November 28<sup>th</sup>, 1983** - A major winter storm lingered unexpectedly over Denver and eastern Colorado Sunday, all but isolating about two million people. Blizzard warnings were posted Sunday night for northeast Colorado and winter storm warnings were issued in the southeastern part of the state. From [2 Million All but Isolated by Colorado Storm, LA Times.](#)

**December 14<sup>th</sup>, 1984** - A winter storm already blamed for 11 deaths stretched from the southern Rockies to the Great Lakes today after burying parts of Arizona and Colorado under

20 inches of snow, unleashing tornadoes in Texas and downing ice laden power lines in Kansas. From [Winter Storm Extends to Great Lakes. Santa Cruz Sentinel](#)

**November 13<sup>th</sup>, 1985** - Winter storm warnings were issued for much of Utah, Colorado and southern Wyoming, with up to two feet of snow predicted for the Colorado mountains by tonight. In Wyoming, five inches of snow fell Tuesday night at Rawlins. Afton received three inches of snow in just one hour. From [Rockies Remain Under Winter Storm Warnings. The Paris News.](#)

**February 27<sup>th</sup>, 1987** - Alpine, Ariz., had a winter snow cover of 82 inches, and snow was still falling at midday, National Weather Service officials said. Thirty avalanches were reported in the Colorado mountains as the storm slowly moved eastward. Colorado Springs received 14 inches of snow. From [Rockies, Plains Get More Snow From Tenacious Winter Storm. LA Times.](#)

**December 31<sup>st</sup>, 2006** - DENVER — A fleet of small planes canvassed snow-covered roads in Colorado on Sunday, searching for stranded travelers after a powerful winter storm piled drifts up to 10 feet high across much of the plains. National Guard troops have rescued 44 people from the storm.

**December 26<sup>th</sup>, 2007** - By Peter M. Fredin, AP. DENVER (AP) — Snow was falling again in Colorado on Thursday as the second winter storm in two days moved across the state. The latest storm is expected to pile as much as 20 inches of new snow in areas that have already been hit a series of year-end storms. From [Winter storm dumps more snow on Colorado - USATODAY.com](#)

**December 22<sup>nd</sup>, 2009** - DENVER, Colo. - A Winter Weather Advisory was issued for the Denver metro area Tuesday as the first of two storms moved into Colorado, promising measurable snowfall for much of the state in time for the Christmas holiday. [From Winter Storm will make Christmas white, or white-ish, in Colorado - KDVR](#)

**February 2012** - A slow moving and powerful storm system brought heavy snow to areas in and near the Front Range foothills, with blizzard conditions over the northeastern plains of Colorado. In the Front Range foothills, the snow piled up to over four feet in some areas. Across the Palmer Divide, the combination of snow and gusty winds resulted in road closures with snow drifts ranging from two to five feet in depth. Northerly winds 15 to 25 mph were common with gusts to 40 mph. Several snowfall records were also set in Denver.

At Denver International Airport, 12.5 inches of snow fell on the 3<sup>rd</sup> and shattered the previous record of 7.5 inches for the date. It also set a new daily record for the entire month of February. A new three-day record was also established for Denver. The three-day storm total from February 2<sup>nd</sup> to the 4<sup>th</sup> was 15.9 inches, which broke the previous record of 14.1 inches in 1912. In contrast, storm totals generally ranged from one to three inches in the mountains west of the Continental Divide. Denver International Airport canceled more than six hundred flights.

In addition, snow and blowing snow produced near zero visibilities, forcing officials to close the westbound lanes of Interstate 70, between the Kansas state line and Denver, as well as the eastbound lanes from Denver to Limon. Other road closures included: State Highway 86, between Kiowa and Interstate 70, U.S. Highway 40, between Limon and Eads, and State Highway 71, from Last Chance to Limon to Ordway. Storm totals along the Front Range mountains and foothills included: 51 inches at Coal Creek Canyon, 45.5 inches, 4.6 miles northeast of Ward; 44.5 inches, three miles west of Jamestown; 38 inches, three miles north of Blackhawk; 37 inches, three miles west-southwest of Conifer and four miles east-northeast of Nederland; 35.5 inches, 3.6 miles west-northwest of Boulder; 34 inches, 5.2 miles east-southeast of Aspen Springs; 33 inches near Evergreen, 32 inches at Genesee; 31 inches, 10.3 miles west of Bellvue and Eldora Mountain Ski Resort; 30 inches, 10.6 miles west of Livermore; 28 inches; 3.2 miles north-northwest of Horsetooth Mountain; 27 inches at Deadman Hill; 24 inches at Echo Mountain Ski Resort; 21 inches at Niwot Ridge SNOTEL; 19 inches at Gross Reservoir; 15 inches at Bear Lake State Park; with 14 inches near Estes Park and Glen Haven. Along the urban corridor storm totals included: 22 inches in Broomfield; 21 inches at Lafayette, Louisville, and Westminster; 20 inches at Northglenn; 19 inches at the National Weather Service in Boulder, Castle Rock, Centennial, and Parker; 18 inches in Arvada, 16.5 inches in Erie, 13.5 inches near Longmont; 11.5 inches in Fort Collins and Loveland; 11 inches in Lyons, and 10 inches in Frederick. Along the Palmer Divide, storm totals included: 26 inches, 14 miles east-northeast of Kiowa; 25 inches, 10 miles south-southwest of Buckley Air Force Base, and eight miles southeast of Watkins; 20 inches near Strasburg; 16 inches at Agate, 12 inches near Elizabeth; and eight inches, five miles south-southeast of Sedalia. Across the northeast plains of Colorado, storm totals included: 13 inches, 11 miles east-southeast of Holyoke; 11 inches, four miles north of Arriba; 10 inches, 6.4 miles west-northwest of Otis and Woodrow; 9.5 inches near Amherst; 6.5 inches in Sterling; six inches in Brush; with 5.5 inches in Karval.

**January 27<sup>th</sup> – 31<sup>st</sup>, 2013** - This January snowfall event generally began on the 27th under a moist southwest flow which followed on the heels of a storm that vacated the area earlier on the same day. However, snowfall actually began for some lower elevations of northwest Colorado late on the 26th. The potent Pacific trough which moved over the region on January 28th and 29th generally produced the greatest amount of snowfall for most areas during the five-day period which included a moist northwest flow on January 30th and 31st.

During this five-day event, January 27th through January 31st, there were two significant events: one event was with the moist southwest flow and upper trough passage, and the second event was the moist northwest flow. For some zones the snowfall persisted unabated through both events (COZ004-013). However, in some other zones snowfall occurred during both events, though the snowfall was separated by an interlude of little or no snowfall which required two separate highlights for those zones.

**April 2013** - A strong upper level jetstream moved over northern Colorado and produced bands of very heavy snow. The heaviest snowfall was concentrated along and north of the Interstate

70 Corridor and extended from the mountains and high valleys to the urban corridor and northeast plains of Colorado.

The snow fell at a rate of two to three inches per hour during the late afternoon and evening hours of the 15th and forced the cancellation of 25 flights at Denver International Airport. Interstate 25 was closed in both directions between Wellington and Cheyenne due to snow and blowing snow. In the mountain, high valley, and foothill locations storm totals included: 21 inches near Estes Park; 18 inches at Bear Lake; 17 inches at Willow Park; 16 inches near Ward; 15.5 inches at Genesee; 15 inches at Grand Lake and near Nederland; 14.5 inches near Idaho Springs; 14 inches near Idledale; 13.5 inches in Bergen Park; 13 inches near Allenspark, Blackhawk, Conifer and six miles northwest of Lyons; 11.5 inches near Silverthorne. Across the urban corridor and northeast plains, storm totals included: 16.5 inches, five miles east of Boulder; 16 inches, five miles northeast of Westminster; 15.5 inches in Lafayette; 15 inches in Frederick and Louisville; 14.5 inches in Broomfield; 13.5 inches at the National Weather Service Office in Boulder; 13 inches, five miles west-northwest of Brighton; 12.5 inches in Wheat Ridge; 12 inches near Arvada and Greeley; 11.5 inches near Loveland; 10 inches near Commerce City, Northglenn and Superior; nine inches near Thornton; 7.5 inches at Denver International Airport; seven inches near Crook; with six inches near Fort Collins and Fort Morgan.

**March 22<sup>nd</sup> – 23<sup>rd</sup>, 2016** - A powerful blizzard developed across the Front Range of Colorado late on the 22nd and continued through much of the 23rd. The storm tracked east-southeast across Utah on the 22nd, and then into southeast Colorado by the morning of the 23rd. The storm rapidly intensified as it reached eastern Colorado, producing extremely heavy and intense snowfall with snowfall rates exceeding three inches per hour at times. In addition to heavy snow, strong winds gusting in excess of 50 mph east of Interstate 25 produced widespread blizzard conditions and zero visibilities. The storm initially began with rain on the plains, but quickly changed over to snow during the early morning hours of the 23rd. Snowfall rates of one to two inches per hour were common, with several inches of snow already accumulating for the morning commute. Many roads became impassable due to the depth of fallen snow, drifting snow, and near zero visibilities during the day.

During the peak of the storm, snowfall rates reached or exceeded three inches per hour. Widespread road closures occurred, including Interstate 76 from northeast of Denver to the Nebraska state line, Interstate 70 east of Denver to the Kansas state line, and much of Interstate 25, from near Castle Rock to Colorado Springs and from Highway 7 north to the Wyoming border. The Colorado Department of Transportation estimated over 2,000 vehicles became trapped on Interstate 25 near Monument Hill alone, with hundreds of stuck or abandoned cars elsewhere. Numerous power outages occurred as heavy wet snow accumulated on trees, despite the strong winds. At the peak, several hundred thousand residents along the Front Range were without power. Denver International Airport was closed for seven hours during and just after the peak of the blizzard, with around 1,300 cancelled

flights. The power outages shut down the fuel farm pumps and the deicing facility, as well as train service to the concourses at the airport.

The main road to the airport was impassable for much of the day. It was the first time since December 21, 2006 that Denver International Airport had been shut down due to snow conditions. One to two feet of snow fell across much of the Front Range urban corridor, with over 30 inches in some foothill locations. Most of the snow fell within a 12-hour period from the early morning into the afternoon. A peak wind gust of 59 mph was recorded at Denver International Airport. South of Denver, over the Palmer Ridge, 12 to 18 inches of snow was reported, with six to 10 inches across the northeast plains of Colorado. The official snowfall measurement at Denver International Airport was 13.1 inches. In addition, the snow was very heavy and wet, with many areas receiving one to two inches of precipitation. In the foothills, some locations received nearly three inches of water from this storm.

Storm totals included: 23.5 inches, four miles east-northeast of Nederland; 16 inches, four miles west of Eldorado Springs; 16 inches, four miles west of Berthoud; eight miles east of Four Corners; 14 inches, seven miles east of Virginia Dale; 11 inches, five miles northeast of Ward; with 10 inches at Black Mountain.

**January 8<sup>th</sup> – 10<sup>th</sup>, 2017** - Heavy snow fell across the state from January 8<sup>th</sup>, 2017, through January 10<sup>th</sup>. On the 9<sup>th</sup>, there was a period of freezing rain in some valleys, resulting in the paralysis of traffic in Mesa County, and portions of Garfield and La Plata Counties. After the storm had passed, Avalanche Warnings were issued for mountainous areas throughout the state.

### **Disaster Declarations**

Both the state and federal government have issued disaster declarations in Colorado relating to severe winter weather events. In October 1997, the state declared an emergency for severe snowfalls.

In April 2001, the state incurred severe winter storms that included high winds and ice, resulting in downed power lines and poles. This left numerous residences and businesses without power. The state requested and received a presidential disaster declaration as a result. Over \$550,000 was received in hazard mitigation funds for this storm.

In 2003, Colorado received a presidential declaration for snow emergency for the winter snowstorms of March 17th through the 20th. Twenty-nine counties requested assistance. The state and communities received \$6.2 million in federal funds through the public assistance program. No hazard mitigation funds were included with the emergency declaration.

Two major snowstorms in December 2006 resulted in both federal and state emergency declarations. Since these events, there have been no disaster declarations related to severe winter weather in Colorado.

## 6. IMPACT ANALYSIS

Severe winter weather has a number of both direct and secondary impacts. Direct impacts include pipes bursting from extremely cold temperatures, infrastructure damage or collapse from the weight of snow, and hypothermia. Secondary impacts include flooding from ice jams and increased snow melt, power outages from downed power lines, and increased response time for emergency personnel.

Heavy snow can immobilize a region and paralyze a city, stranding commuters, closing airports, stopping the flow of supplies, and disrupting emergency and medical services. Accumulations of snow can cause roofs to collapse, and can knock down trees and power lines. Homes and farms may be isolated for days, and unprotected livestock may be lost. Late season heavy snows will typically cause some plant and crop damages. In the mountains, heavy snow can lead to avalanches. The cost of snow removal, repairing damages, and loss of business can have severe economic impacts on cities and towns.

Ice can cause power or other infrastructure failure that interferes with activities, comfort, and safety. This is most often through the impact of infrastructure failure on needed medical and emergency response capabilities. Direct physical effects may include frostbite, hypothermia, and other medical conditions, necessitating additional warm clothing and shelter for some residents.

The Rocky Mountain Insurance Institute estimates the blizzard of March 2003 was the most expensive winter storm from snow and ice damage in Colorado history. The estimated cost was at least \$93.3 million from more than 28,000 claims filed (\$120.5 million in 2015 dollars). Most of the larger insurance carriers activated their emergency catastrophe teams who specialize in handling disaster claims. This estimate is for damage to homes and automobiles, and excludes the large commercial building losses resulting from the blizzard.

The majority of the damage in 2003 was the result of wet, heavy snow causing collapses to roofs, porches, and other exterior portions of homes. Significant damage also resulted from downed trees and limbs, along with claims for wind and snow melt leakage. Other common issues involved food spoilage and out-of-pocket living expenses for people forced out of their homes due to storm damage.

Table 3-90 further describes impacts of winter storms in other areas.

**TABLE 3-90 WINTER WEATHER EMAP IMPACT SUMMARY**

Consideration	Description
<b>General Public</b>	Motorists, outdoor workers, outdoor recreationists, outdoor sporting participants; homeless persons; persons with energy dependent medical needs; persons with pre-existing medical conditions; statewide population.

Consideration	Description
<b>First Responders</b>	Exposure exists to personnel performing routine duties when event occurs; storm-related duties may be during event. Snow and blowing snow, ice, and extreme cold will provide adverse working conditions.
<b>Property</b>	Buildings, vehicles, and equipment are exposed to winter weather. Heavy snow and ice, complicated by strong winds, may result in structural damage, collapse, or instability.
<b>Facilities and Infrastructure</b>	Buildings, equipment, and utility infrastructure are exposed to heavy snow and ice, sometimes complicated by strong winds. Majority of state losses attributable to precipitation-related events, many winter related. Limited access to, or ability to maintain operations of public transportation, or access to transportation hubs.
<b>Economic</b>	Potential loss of facilities or infrastructure function or accessibility and uninsured damages. Impact to transportation sector and movement of goods. Lost revenue due to decreased business patronage or inability of workers to reach employment locations.
<b>Environment</b>	Impact related to tree damage, particularly ice and snow buildup resulting in downed limbs. May serve as precursor to other hazards such as avalanche.
<b>Continuity of Government and Services</b>	Potential loss of facilities or infrastructure function or accessibility, or ability to provide services. May have power interruption if not adequately equipped with backup generation. Regional limitations to mobility from heavy snowfall affecting workforce/essential personnel.
<b>Confidence in Government</b>	Public holds high expectations of government capabilities for reducing impact of snow and ice events related to transportation (roads, bridges, airports, rail). High expectations for rapid power restoration.
<b>Critical Assets</b>	Buildings, equipment, and utility infrastructure are exposed to heavy snow and ice, sometimes complicated by strong winds. Majority of state losses attributable to precipitation-related events, many winter related. Limited access to, or ability to maintain operations of public transportation, or access to transportation hubs.

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

In addition to snowfall, Colorado experiences extremely cold temperatures. While every county in the state has an average annual temperature below freezing, some are significantly colder than others. For example, Alamosa and Lake Counties have an average winter temperature of just three degrees Fahrenheit. This indicates that they are prone to extremely low temperatures each year. Those with the highest, and thus lowest risk, of low temperatures are Broomfield, Baca, and Denver Counties, all of which have an average annual temperature of 19 degrees Fahrenheit. Average winter temperatures are represented in Table 3-91.

TABLE 3-91 AVERAGE ANNUAL MINIMUM TEMPERATURE RECORD BY COUNTY

County	Average Temperature (° F)	County	Average Temperature (° F)
Adams	16	Kit Carson	18
Alamosa	3	La Plata	12
Arapahoe	16	Lake	3
Archuleta	10	Larimer	12
Baca	19	Las Animas	18
Bent	18	Lincoln	14
Boulder	16	Logan	14
Broomfield	19	Mesa	16
Chaffee	9	Mineral	5
Cheyenne	16	Moffat	12
Clear Creek	9	Montezuma	16
Conejos	5	Montrose	16
Costilla	9	Morgan	14
Crowley	16	Otero	18
Custer	12	Ouray	10
Delta	16	Park	7
Denver	19	Phillips	16
Dolores	12	Pitkin	7
Douglas	16	Prowers	18
Eagle	9	Pueblo	18
El Paso	16	Rio Blanco	12
Elbert	16	Rio Grande	5
Fremont	14	Routt	9
Garfield	14	Saguache	5
Gilpin	12	San Juan	5
Grand	7	San Miguel	12
Gunnison	7	Sedgwick	16
Hinsdale	5	Summit	5
Huerfano	16	Teller	10
Jackson	7	Washington	16
Jefferson	16	Weld	16
Kiowa	16	Yuma	16

Source: USDA, Southwest Climate Hub

Based on an updated (2017) review of local mitigation plans, Figure 3-42 shows how severe winter weather is represented in local hazard mitigation plans. Nearly all counties have profiled severe winter weather in local mitigation plans. Counties with the most total damage from winter weather have addressed this hazard in the local mitigation plan.

Severe winter weather can affect every Colorado community, meaning that they should all be mindful of this hazard when engaging in hazard mitigation planning and other types of emergency planning. Any planning and preparedness effort should include the identification of mass care facilities and any necessary resources, such as cots, blankets, food supplies, and generators, as well as snow clearance and removal equipment and services.

**FIGURE 3-42 SEVERE WINTER WEATHER PROFILED IN LOCAL MITIGATION PLANS**

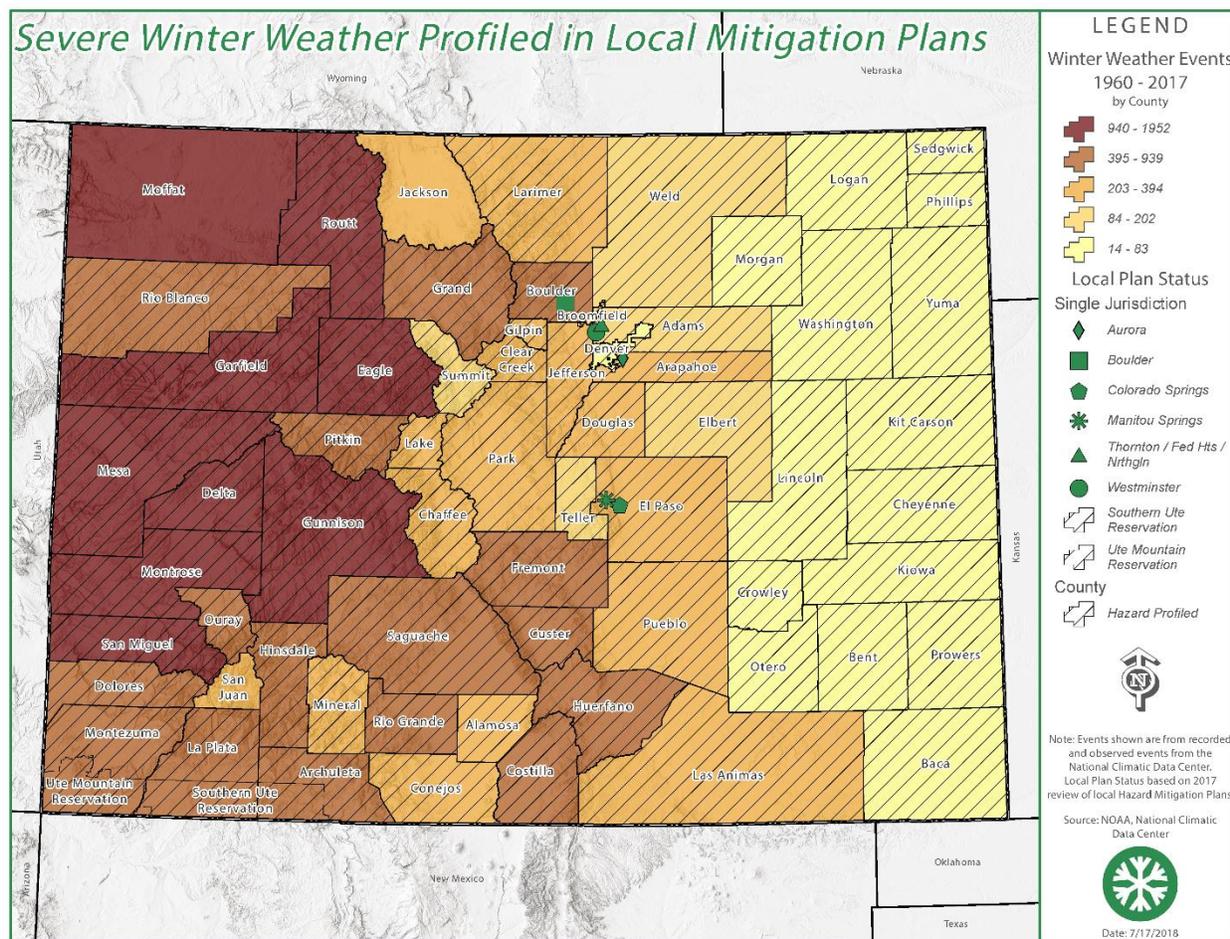


Table 3-92 shows that total damage from this hazard since 1960 is reported at over \$383 million. In addition to property damage, winter weather in Colorado has resulted in the reported deaths of 45 persons and injuries to 105 since 1960. These same data are reflected in Figure 3-43.

Based upon historical data, Garfield County has the highest recorded instances of winter weather, though Douglas County has the highest damages, at \$49.6 million. Adams, Denver, and Lincoln Counties, who have experienced the next three highest damages, have each incurred losses between \$29 and \$33 million. These each equate to ten percent of the statewide historical damages.

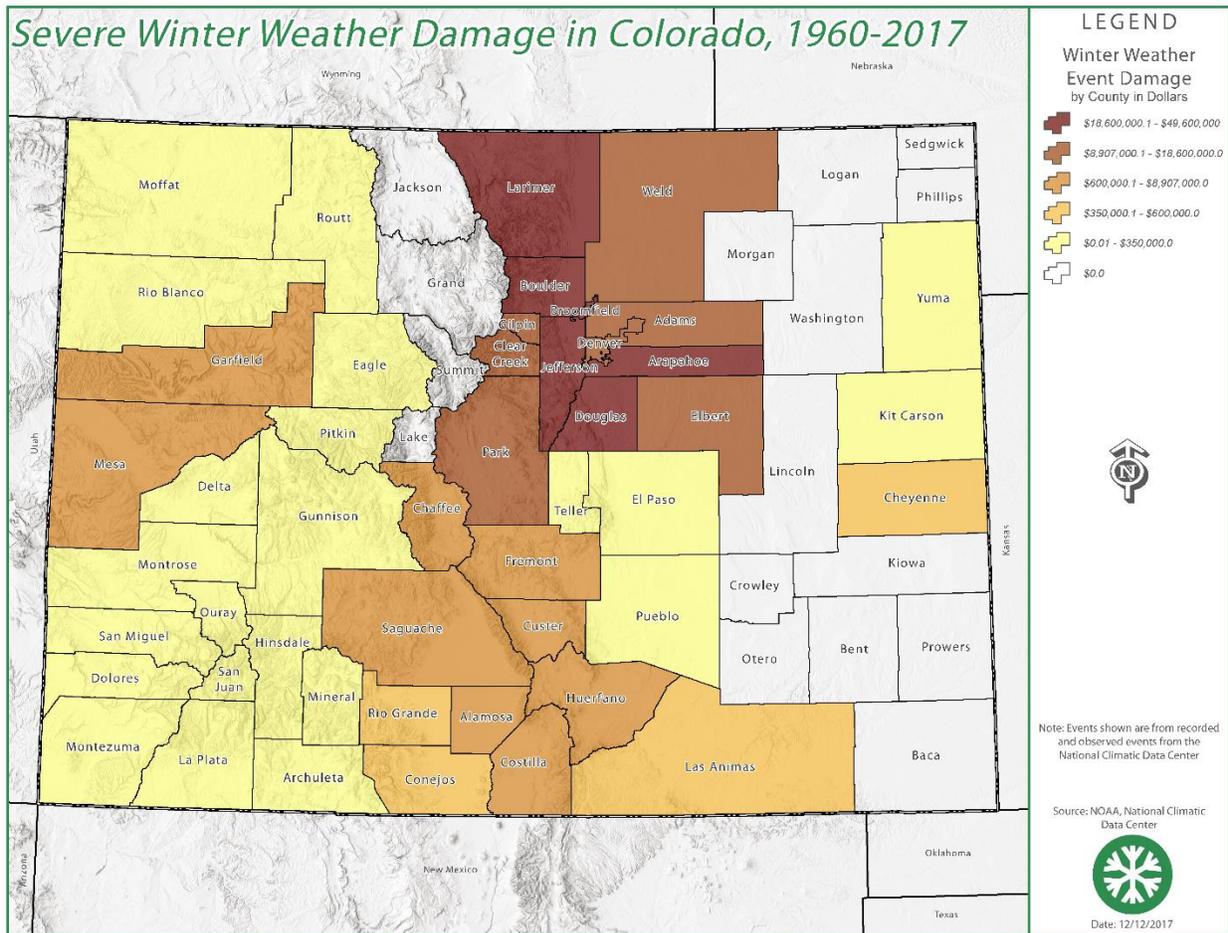
TABLE 3-92 DAMAGES BY COUNTY

County	# of Events	Deaths	Injuries	Property Damage	Crop Damage	Total
Adams	136	4	17	\$ 18,600,000	\$ -	\$ 18,600,000
Alamosa	244	1	-	\$ 4,450,000	\$ -	\$ 4,450,000
Arapahoe	221	4	17	\$ 34,100,000	\$ -	\$ 34,100,000
Archuleta	529	-	-	\$ 45,000	\$ -	\$ 45,000
Baca	18	-	-	\$ -	\$ -	\$ -
Bent	14	-	-	\$ -	\$ -	\$ -
Boulder	489	1	-	\$ 31,000,000	\$ -	\$ 31,000,000
Broomfield	158	4	17	\$ 34,100,000	\$ -	\$ 34,100,000
Chaffee	361	-	-	\$ 4,200,000	\$ -	\$ 4,200,000
Cheyenne	41	-	-	\$ 600,000	\$ -	\$ 600,000
Clear Creek	264	-	-	\$ 15,500,000	\$ -	\$ 15,500,000
Conejos	247	5	2	\$ 420,000	\$ -	\$ 420,000
Costilla	445	5	2	\$ 5,000,000	\$ -	\$ 5,000,000
Crowley	14	-	-	\$ -	\$ -	\$ -
Custer	472	2	-	\$ 5,700,000	\$ -	\$ 5,700,000
Delta	1,230	-	-	\$ 112,000	\$ -	\$ 112,000
Denver	83	4	17	\$ 18,600,000	\$ -	\$ 18,600,000
Dolores	566	-	-	\$ 10,000	\$ 254,000	\$ 264,000
Douglas	267	4	17	\$ 49,600,000	\$ -	\$ 49,600,000
Eagle	1,104	-	5	\$ 2,000	\$ -	\$ 2,000
El Paso	222	-	-	\$ 350,000	\$ -	\$ 350,000
Elbert	148	1	-	\$ 15,500,000	\$ -	\$ 15,500,000
Fremont	484	3	-	\$ 4,800,000	\$ -	\$ 4,800,000
Garfield	1,952	-	5	\$ 2,000	\$ 8,800,000	\$ 8,802,000
Gilpin	264	-	-	\$ 15,500,000	\$ -	\$ 15,500,000
Grand	436	-	-	\$ -	\$ -	\$ -
Gunnison	1,098	-	-	\$ 147,000	\$ -	\$ 147,000
Hinsdale	830	-	-	\$ 45,000	\$ -	\$ 45,000
Huerfano	724	2	-	\$ 6,000,000	\$ -	\$ 6,000,000
Jackson	243	-	-	\$ -	\$ -	\$ -
Jefferson	339	-	-	\$ 31,000,000	\$ -	\$ 31,000,000
Kiowa	33	-	-	\$ -	\$ -	\$ -
Kit Carson	56	1	1	\$ 259,000	\$ -	\$ 259,000
Lake	230	-	-	\$ -	\$ -	\$ -
La Plata	514	-	-	\$ 340,000	\$ -	\$ 340,000
Larimer	304	1	-	\$ 31,000,000	\$ -	\$ 31,000,000
Las Animas	279	-	-	\$ 550,000	\$ -	\$ 550,000
Lincoln	63	1	-	\$ -	\$ -	\$ -
Logan	44	-	-	\$ -	\$ -	\$ -
Mesa	1,239	-	-	\$ 107,000	\$ 8,800,000	\$ 8,907,000

County	# of Events	Deaths	Injuries	Property Damage	Crop Damage	Total
Mineral	317	1	-	\$ 170,000	\$ -	\$ 170,000
Moffat	1,262	-	-	\$ 10,000	\$ -	\$ 10,000
Montezuma	503	-	-	\$ 10,000	\$ 254,000	\$ 264,000
Montrose	1,430	-	-	\$ 147,000	\$ -	\$ 147,000
Morgan	40	-	-	\$ -	\$ -	\$ -
Otero	16	-	-	\$ -	\$ -	\$ -
Ouray	705	-	-	\$ 35,000	\$ -	\$ 35,000
Park	291	-	-	\$ 15,500,000	\$ -	\$ 15,500,000
Phillips	24	-	-	\$ -	\$ -	\$ -
Pitkin	630	-	5	\$ 2,000	\$ -	\$ 2,000
Prowers	17	-	-	\$ -	\$ -	\$ -
Pueblo	223	1	-	\$ 300,000	\$ -	\$ 300,000
Rio Blanco	939	-	-	\$ 5,000	\$ -	\$ 5,000
Rio Grande	438	1	-	\$ 470,000	\$ -	\$ 470,000
Routt	1,440	-	-	\$ 12,500	\$ -	\$ 12,500
Saguache	524	1	-	\$ 4,700,000	\$ -	\$ 4,700,000
San Juan	394	-	-	\$ 10,000	\$ -	\$ 10,000
San Miguel	1,271	-	-	\$ 45,000	\$ 254,000	\$ 299,000
Sedgwick	35	-	-	\$ -	\$ -	\$ -
Summit	202	-	-	\$ -	\$ -	\$ -
Teller	153	-	-	\$ 100,000	\$ -	\$ 100,000
Washington	43	-	-	\$ -	\$ -	\$ -
Weld	131	2	-	\$ 15,602,000	\$ -	\$ 15,602,000
Yuma	52	-	-	\$ 45,000	\$ -	\$ 45,000
<b>Total</b>	<b>27,485</b>	<b>49</b>	<b>105</b>	<b>\$ 364,802,500</b>	<b>\$ 18,362,000</b>	<b>\$ 383,164,500</b>

Source: NOAA

FIGURE 3-43 SEVERE WINTER WEATHER DAMAGE IN COLORADO, 1960-2017



Based on review of local hazard mitigation plans, 52 jurisdictions have profiled severe winter weather as one of their top four hazards. Within those jurisdictions, a total of over 1.8 million structures or parcels were identified in severe winter weather hazard areas, and 13,357 critical facilities were identified in severe winter weather hazard areas. Table 3-93 describes this information in more detail, as well as the total estimated losses.

TABLE 3-93 LOCAL HAZARD MITIGATION PLANS

Jurisdiction	# of Structures/ Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate	Loss Estimate Methodology
Alamosa County		18			
Archuleta County	18,356	63			
City of Aurora	96,098	313		\$759,803	Avg Annual Losses

Jurisdiction	# of Structures/ Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate	Loss Estimate Methodology
<b>Boulder County</b>	60,000 (50% of 120,137 properties likely severely damaged)	1,405			
<b>City and County of Broomfield</b>	23,564 (total housing units)	20			
<b>Chaffee County</b>	9,943	107 (all critical facilities)		\$224,666	Avg annual losses
<b>Cheyenne County</b>	1,922	47			
<b>Clear Creek County</b>	5,244	9		\$815,800	Avg Losses per Year
<b>City of Colorado Springs</b>	All structures				
<b>Conejos County</b>	5,653	37			
<b>Costilla County</b>	2,613 (total homes in County)	36 (all critical facilities)			
<b>Crowley County</b>	2,143	117			
<b>Custer County</b>	4,486	61		\$285,000	Avg annual losses
<b>Delta County</b>	15,125	92			
<b>City and County of Denver</b>	211,619	2,618			
<b>Dolores County</b>	1,747	69		\$53,685	Avg annual crop losses
<b>Eagle County</b>	24,222				
<b>El Paso County (Unincorporated)</b>	234,843	1,044		\$11,715,435,338	10% damage
<b>Elbert County</b>	9,816	66			
<b>Gilpin County</b>	3,843	47		\$775,000	Avg annual losses
<b>Grand County</b>		170			
<b>Gunnison County</b>	15,455	127		\$19,225	Avg annual losses
<b>Hinsdale County</b>		34			
<b>Jefferson County</b>	205,858	1,499		\$12,299,742	Avg annual loss due to power outage
<b>Kiowa County</b>	1,474	42			
<b>Kit Carson County</b>	6,113	186			

Jurisdiction	# of Structures/ Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate	Loss Estimate Methodology
La Plata County	25,860 (only housing units)	99 (total critical facilities)			
Lake County	8,937 (total structures)	57 (total critical facilities)		\$14,437	avg annual losses
Larimer County	159,154 (total structures)	937 (total critical structures)			
Las Animas County	14,232	338		\$27,500	avg annual loss
Lincoln County	3,815	146			
Logan County	11,912	73			
City of Manitou Springs					
Mesa County		378 (total critical structures)			
Mineral County	1,575	3			
Montezuma County	38,904	124		\$1,053	avg annual losses
Montrose County (Unincorporated)		13			
Otero County	12,103	344			
Park County	334,741			\$234,708,300	10% damage
Phillips County	3,996	30			
Pitkin County	10,913	99			
Prowers County	7,933	287			
Rio Grande County	9,482	45			
San Miguel County	7,263	9			
Summit County	14,467	123			
Teller County	14,819	112		\$516,795,334	10% damage
Thornton/Federal Heights/Northglenn	64,000 (housing units)	395 (parcels containing critical facilities)			
Ute Mountain Ute					
Washington County	4,539	39			
Weld County	121,749	1,284			
City of Westminster		36			
Yuma County	7,511	159			
<b>Total</b>	<b>1,838,042</b>	<b>13,357</b>		<b>\$12.482 B</b>	

## 8. FUTURE DEVELOPMENT

Winter storms are indiscriminate in that they may result in severe impacts anywhere in the state. However, projected population through 2030 suggests that areas experiencing the most winter storm damage over the last 57 years will continue to experience growth faster than the statewide average.

Understanding future exposure of areas to winter storms is important in developing an effective mitigation strategy. Table 3-97 shows the results of an exposure analysis based on the number of deaths and injuries to total winter storm events and the relationship to expected population growth.

Table 3-95 and Table 3-96 summarize the methodology used for the exposure analysis.

Table 3-94 presents the projected percent change in housing from 2010 to 2030. Those counties that have a large expected housing percent change as well as a history of significant winter weather events are most at risk for future exposure. An increased building stock means that there are more homes and buildings that are threatened by winter weather.

Garfield, Routt, Montrose, San Miguel, and Eagle Counties all fall into the highest quarter of county growth ratings and have experienced more than 1,000 historical winter weather events. Mesa, Delta, and Gunnison Counties also have more than 1,000 events and fall into the second tier of county growth ratings.

TABLE 3-94 HOUSING PROJECTIONS (2010 TO 2030) AND HISTORICAL EVENTS

County	Historical Severe Winter Weather	Housing Percent Change	Growth Rating
Garfield	1,952	51%	Highest
Routt	1,440	46%	Highest
Montrose	1,430	61%	Highest
San Miguel	1,271	64%	Highest
Eagle	1,104	56%	Highest
Archuleta	529	61%	Highest
La Plata	514	50%	Highest
Larimer	304	47%	Highest
Park	291	65%	Highest
Douglas	267	67%	Highest
Arapahoe	221	52%	Highest
Summit	202	49%	Highest
Broomfield	158	78%	Highest
Elbert	148	120%	Highest
Adams	136	60%	Highest
Weld	131	93%	Highest
Mesa	1,239	38%	High

County	Historical Severe Winter Weather	Housing Percent Change	Growth Rating
Delta	1,230	35%	High
Gunnison	1,098	28%	High
Pitkin	630	34%	High
Montezuma	503	37%	High
Boulder	489	37%	High
Fremont	484	28%	High
Custer	472	41%	High
Grand	436	44%	High
Chaffee	361	38%	High
Jefferson	339	30%	High
Pueblo	223	26%	High
El Paso	222	40%	High
Denver	83	37%	High
Lincoln	63	26%	High
Crowley	14	26%	High
Hinsdale	830	19%	Moderate
Huerfano	724	13%	Moderate
Ouray	705	13%	Moderate
Saguache	524	17%	Moderate
Las Animas	279	23%	Moderate
Clear Creek	264	20%	Moderate
Gilpin	264	12%	Moderate
Conejos	247	14%	Moderate
Alamosa	244	25%	Moderate
Lake	230	21%	Moderate
Teller	153	23%	Moderate
Kit Carson	56	20%	Moderate
Yuma	52	17%	Moderate
Logan	44	21%	Moderate
Morgan	40	26%	Moderate
Kiowa	33	12%	Moderate
Moffat	1,262	7%	Low
Rio Blanco	939	10%	Low
Dolores	566	4%	Low
Costilla	445	10%	Low
Rio Grande	438	7%	Low
San Juan	394	10%	Low
Mineral	317	10%	Low
Jackson	243	9%	Low
Washington	43	8%	Low
Cheyenne	41	11%	Low

County	Historical Severe Winter Weather	Housing Percent Change	Growth Rating
Sedgwick	35	1%	Low
Phillips	24	1%	Low
Baca	18	-6%	Low
Prowers	17	3%	Low
Otero	16	6%	Low
Bent	14	7%	Low

Source: NOAA, Colorado State Demography Office, 2017

TABLE 3-95 SEVERE WINTER WEATHER EXPOSURE PROJECTIONS

County Population Percent Change Projections, 2010 to 2030					
County Population Percent Change Projections, 2010 to 2030					
Combined Risk (Severe Winter Weather)		-13% to 2%	3% to 17%	18% to 34%	35% to 89%
High ↑ Moderate	5-6	Moderate	High	Severe	Extreme
	3-4	Slight	Moderate	High	Severe
	0-2	Negligible	Slight	Moderate	High

The Combined Risk calculations in Table 3-95 are based on the methodology outlined in Table 3-96. Values (between zero and three) have been assigned to total deaths and injuries and total number of winter weather events per county. The Jenks Natural Breaks algorithm was used to classify these historical data sets. The sum of these values then arrive at the Combined Risk value for each county.

TABLE 3-96 COMBINED RISK METHODOLOGY

Deaths and Injuries (1950 – 2017)	Value	# of Winter Storm Events (1950-2017)	Value
8-21	3	940-1,952	3
4-7	2	395-939	2
1-3	1	1-394	1
0	0	0	0

Exposure to winter storms is expected to intensify across the State of Colorado between 2010 and 2030 as population increases. The darker, more red colors in Table 3-95 illustrate relative

rates of increase in exposure between counties. This same information is also shown on the following Table 3-97 by county. As Colorado's population increases, infrastructure and businesses will follow these population centers. This further adds to the potential future exposure that counties face from winter storms. Colorado's population and related business and infrastructure is concentrated in, and will continue to intensify, in areas of high winter weather activity. Figure 3-44 presents this same information on a statewide map.

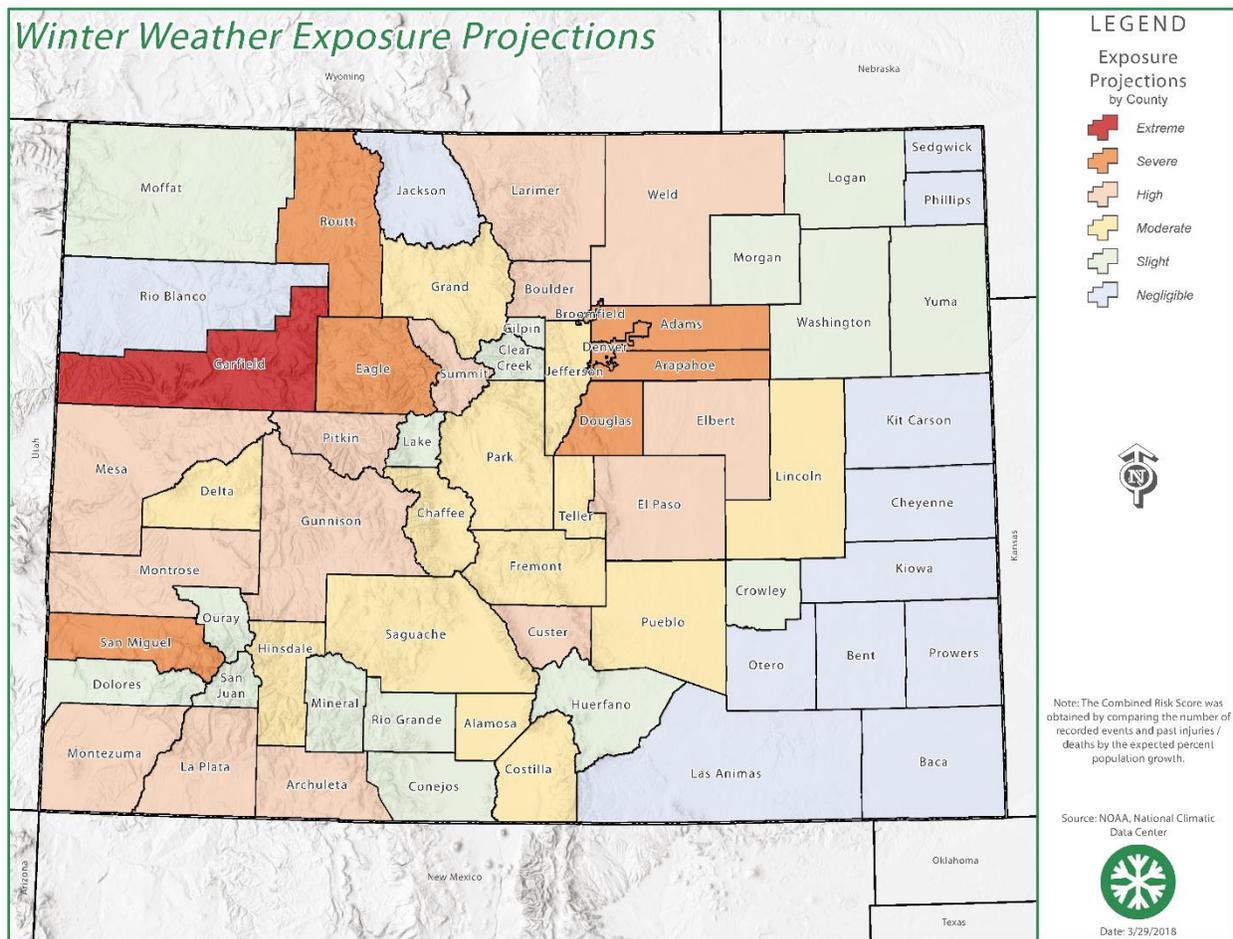
TABLE 3-97 SEVERE WINTER WEATHER EXPOSURE PROJECTIONS, 2010 TO 2030

County	Combined Risk	Population Change	Exposure Rating
Garfield	5	38%	Extreme
Broomfield	4	71%	Severe
San Miguel	3	59%	Severe
Adams	4	48%	Severe
Douglas	4	44%	Severe
Denver	4	42%	Severe
Routt	3	40%	Severe
Arapahoe	4	36%	Severe
Eagle	5	34%	Severe
Elbert	2	89%	High
Weld	2	81%	High
La Plata	2	42%	High
Larimer	2	42%	High
Summit	1	41%	High
Archuleta	2	40%	High
Montezuma	2	37%	High
El Paso	1	36%	High
Montrose	3	30%	High
Boulder	3	28%	High
Gunnison	3	26%	High
Mesa	3	24%	High
Custer	3	20%	High
Pitkin	4	18%	High
Park	1	34%	Moderate
Grand	2	32%	Moderate
Hinsdale	2	29%	Moderate
Chaffee	1	29%	Moderate
Teller	1	25%	Moderate
Alamosa	2	22%	Moderate
Lincoln	2	21%	Moderate
Jefferson	1	21%	Moderate
Pueblo	2	20%	Moderate
Saguache	3	9%	Moderate
Delta	3	8%	Moderate
Costilla	4	7%	Moderate
Fremont	3	5%	Moderate
Lake	1	17%	Slight
Ouray	2	17%	Slight
Mineral	2	16%	Slight
Morgan	1	16%	Slight
Logan	1	14%	Slight
Clear Creek	1	14%	Slight

County	Combined Risk	Population Change	Exposure Rating
Gilpin	1	13%	Slight
Yuma	1	7%	Slight
Washington	1	5%	Slight
Dolores	2	5%	Slight
Crowley	1	5%	Slight
San Juan	1	5%	Slight
Conejos	3	1%	Slight
Huerfano	3	-1%	Slight
Moffat	3	-3%	Slight
Rio Grande	3	-5%	Slight
Cheyenne	1	2%	Negligible
Rio Blanco	2	2%	Negligible
Kit Carson	2	-1%	Negligible
Sedgwick	1	-3%	Negligible
Phillips	1	-3%	Negligible
Bent	1	-5%	Negligible
Prowers	1	-5%	Negligible
Otero	1	-7%	Negligible
Jackson	1	-7%	Negligible
Kiowa	1	-8%	Negligible
Las Animas	1	-9%	Negligible
Baca	1	-13%	Negligible

Source: NOAA, Colorado State Demography Office, 2017

FIGURE 3-44 SEVERE WINTER WEATHER EXPOSURE PROJECTIONS, 2010 TO 2030



In reviewing local hazard mitigation plans, the following information was provided regarding severe winter weather and future development:

- Boulder County - As building and population trends continue to increase, more persons will be exposed to the winter storm hazard, therefore increasing pressure on local government snow removal and emergency services.
- Clear Creek County - Clear Creek County is a historic mining district that has only seen modest land development since that period. However, there is extensive large-lot development in the eastern-most areas of the county adjoining Jefferson County. Most all of the commercial development is located within the towns and cities along Interstate 70 bordering Clear Creek.
- City of Colorado Springs - Continuing development pressures along the Front Range will likely increase the overall vulnerability. New development should be able to withstand significant snow loads.

- Grand County - Population growth in the county and growth in visitors will increase problems with road, business, and school closures and increase the need for snow removal and emergency services related to severe winter weather events.
- La Plata County - New structures built in La Plata County should be able to withstand significant snow loads when constructed to current building codes. There have been several local amendments to the international codes, including a formula to establish the roof snow load based on the elevation of a building site. Development in more remote areas of the county may be more susceptible to access issues for emergency services and road crews.

## 9. CLIMATE CHANGE

According to the best data available at the time of this plan update, the future impacts of climate change are expected to influence future severe winter weather events. The following Table 3-98 presents a breakdown of these projected changes in terms of hazard: location, extent/intensity, frequency, and duration. Ongoing efforts to reduce Colorado’s greenhouse gas emissions and adapt to a changing climate, such as the Colorado Climate Plan and the Climate Change in Colorado Report, will help to reduce the impacts of climate change on severe winter weather.

**TABLE 3-98 CLIMATE CHANGE IMPACTS**

Impact	Projected Change
<b>Location</b>	The area at risk to winter storms is not projected to change.
<b>Extent/Intensity</b>	It is unknown if or how the intensity of winter storm events will change. Extent is projected to increase. Winter precipitation events are projected to increase in magnitude.
<b>Frequency</b>	Winter precipitation events are projected to increase in frequency.
<b>Duration</b>	It is unknown if or how the duration of severe winter weather events will change.

Source: FEMA 2017 and Childress et al. 2015

## 10. RISK TO STATE ASSETS

Adams and Denver Counties have some of the highest number of reported winter weather events in Colorado. They also have a significant number of state assets that are vulnerable. Denver County has 479 assets that have a cost of over \$2.5 billion, and Adams County has 225 assets worth \$2.1 billion. Garfield County has an extreme future exposure rating to severe winter weather, and contains 227 state assets at a value of over \$9 million.

Since 2008, 33 state asset real property losses were attributable to freezing temperatures or winter weather including snow, ice, and sleet. The greatest vulnerability to state assets was when freezing temperatures resulted in water pipes bursting, with resulting plumbing infrastructure and water damages. This vulnerability is also the result of a building not having

the proper amount of insulation, or exacerbated by a prolonged power outage or power surges that damage electronics.

In other cases, structural vulnerabilities to buildings came in to play as damages were a result of heavy snow and/or ice buildup on roofs or other structures resulting in collapse and related secondary issues such as water damage. This vulnerability may be the result of infrequent and abnormally high volume wet snow events exceeding design requirements, or structural failure due to age or inferior design. Of particular concern is the relationship between the number of state assets and critical facilities along the Front Range and the low frequency, yet potentially high impact, upslope snow events occurring along the Interstate 25 foothills corridor.

Total losses incurred for the severe winter weather events between 2008 and 2017 was just over \$1,893,279, a relatively low number that may be low enough that comprehensive loss-prevention measures across all state buildings are not warranted. Winter weather or extreme cold events are not anticipated to have a greater proportional impact in the future, but rather as new state facilities are built with superior materials and structural design, the proportion of loss per total number of facilities and related value is expected to decline. It is important to note that state asset loss data is only available for state assets included in the 2017 Office of Risk Management (ORM) database. These numbers exclude many Higher Education assets, and therefore may under-represent actual losses.

It is challenging to develop a comprehensive winter weather data layer due to the need to include extreme cold, snow, ice, sleet, and winds. There is currently not a comprehensive winter weather data layer to adequately perform analysis on a statewide basis relative to state asset location. In future State Plan updates, if availability of geographic extent maps remains unavailable, other methods such as relating state asset location to counties with disaster declarations will be used. Table 3-99 shows state asset exposure projections from 2010 to 2030 by county.

**TABLE 3-99 STATE ASSET EXPOSURE PROJECTIONS, 2010 TO 2030**

County	State Assets	Asset Valuation	Future Exposure Rating
Garfield	227	\$935,656,624	Extreme
Denver	479	\$2,631,589,250	Severe
Adams	225	\$2,161,277,205	Severe
Arapahoe	231	\$539,093,242	Severe
Douglas	139	\$41,437,868	Severe
Eagle	148	\$22,080,215	Severe
Routt	153	\$19,636,862	Severe
Broomfield	7	\$7,925,505	Severe
San Miguel	36	\$6,959,484	Severe
Boulder	288	\$3,184,873,780	High
Larimer	931	\$2,520,380,927	High

County	State Assets	Asset Valuation	Future Exposure Rating
Weld	270	\$723,621,025	High
El Paso	252	\$664,445,003	High
Mesa	316	\$571,483,873	High
La Plata	199	\$459,565,269	High
Gunnison	146	\$297,472,630	High
Summit	54	\$210,520,143	High
Montezuma	92	\$26,250,957	High
Montrose	65	\$19,168,190	High
Archuleta	68	\$12,576,015	High
Elbert	16	\$6,135,197	High
Custer	6	\$1,130,092	High
Pitkin	14	\$712,333	High
Jefferson	481	\$1,220,747,270	Moderate
Pueblo	391	\$1,100,717,917	Moderate
Fremont	360	\$762,885,780	Moderate
Alamosa	123	\$361,142,477	Moderate
Chaffee	196	\$135,641,023	Moderate
Lincoln	80	\$115,435,435	Moderate
Delta	116	\$39,890,610	Moderate
Park	120	\$17,071,984	Moderate
Grand	69	\$12,702,273	Moderate
Teller	53	\$9,932,426	Moderate
Saguache	49	\$5,188,186	Moderate
Costilla	28	\$4,179,435	Moderate
Hinsdale	19	\$1,605,114	Moderate
Logan	174	\$321,168,914	Slight
Rio Grande	155	\$134,839,206	Slight
Clear Creek	75	\$117,846,308	Slight
Crowley	28	\$99,475,999	Slight
Morgan	168	\$67,190,695	Slight
Huerfano	66	\$35,640,305	Slight
Mineral	21	\$30,302,497	Slight
Moffat	90	\$15,349,886	Slight
Yuma	84	\$14,101,083	Slight
Gilpin	39	\$10,009,237	Slight
Ouray	46	\$8,684,296	Slight
Conejos	41	\$6,598,803	Slight
San Juan	22	\$4,603,609	Slight
Washington	31	\$4,317,254	Slight
Dolores	20	\$4,252,291	Slight

County	State Assets	Asset Valuation	Future Exposure Rating
Lake	21	\$2,881,105	Slight
Las Animas	118	\$152,450,902	Negligible
Bent	173	\$116,882,345	Negligible
Otero	83	\$79,711,658	Negligible
Prowers	86	\$73,450,933	Negligible
Rio Blanco	66	\$63,910,055	Negligible
Jackson	85	\$13,799,847	Negligible
Kit Carson	27	\$4,146,763	Negligible
Sedgwick	30	\$1,827,494	Negligible
Baca	14	\$1,559,394	Negligible
Kiowa	8	\$1,308,651	Negligible
Cheyenne	9	\$712,471	Negligible
Phillips	5	\$196,988	Negligible

Source: Colorado State Demography Office, 2017; Office of Risk Management, 2017 and 2013

## 11. RESOURCES

- Childress, A., Gordon, E., Jedd, T., Klein, R., Lukas, J., and McKeown, R. (2015). Colorado Climate Change Vulnerability Study.
- Colorado Climate Center (CCC)
- Colorado Department of Transportation (CDOT) Emergency Operations Plan (EOP)
- Colorado Department of Transportation (CDOT) Threat and Hazard Identification and Risk Assessment (THIRA)
- Denver Public Library Western History Department (The Denver Post)
- Federal Emergency Management Agency (FEMA). (2017). Assessing Future Conditions, Colorado.
- National Weather Service (NWS)
- Rocky Mountain Insurance Information Association (RMIIA)
- University of Colorado Boulder

# THUNDERSTORMS AND LIGHTNING



## 1. DEFINITION

Thunderstorms are electrical storms capable of producing high winds, heavy rains, lightning, and hail. These events affect relatively small areas when compared with hurricanes and winter storms. Despite their small size, all thunderstorms are dangerous. The typical thunderstorm is 15 miles in diameter and is formed in what is known as a Cumulonimbus Cloud. They often occur in large groups or fronts, and thus are often felt over an entire county or regional area within a state. Of the estimated 100,000 thunderstorms that occur each year in the United States, about 10 percent are classified as severe. Every thunderstorm needs three basic components:

- 1) Moisture to form clouds and rain;
- 2) Unstable air which is warm air that rises rapidly; and,
- 3) Lift, which is a cold or warm front capable of lifting air to help form thunderstorms.

Lightning is a luminous, electrical discharge in the atmosphere caused by the electric-charge separation of precipitation particles within a thunderstorm. The sudden burst of heat caused by these discharges results in the expansion of air, causing a sound wave known as thunder.

Table 3-100 describes the hazard profile summary for thunderstorms and lightning.

**TABLE 3-100 HAZARD PROFILE SUMMARY**

Consideration	Impact	Description
<b>Location</b>	Statewide	Concentrated along the Front Range and higher elevations. All counties experience severe thunderstorms and lightning.
<b>Previous Occurrence</b>	Perennial	Colorado averages 529,000 cloud-to-ground lightning flashes per year. Reported deaths and/or injuries occur on a regular basis.
<b>Probability</b>	Expected	Colorado averages 529,000 cloud-to-ground lightning flashes per year. Atmospheric convection activity producing conditions prone to lightning are expected to occur as in the past.
<b>Extent</b>	Extensive	Limited property damage that does not threaten structural integrity; deaths (1-2 per year) and injuries (6-7 per year); little or no impact to critical services or facilities aside from occasional short-term power outages.

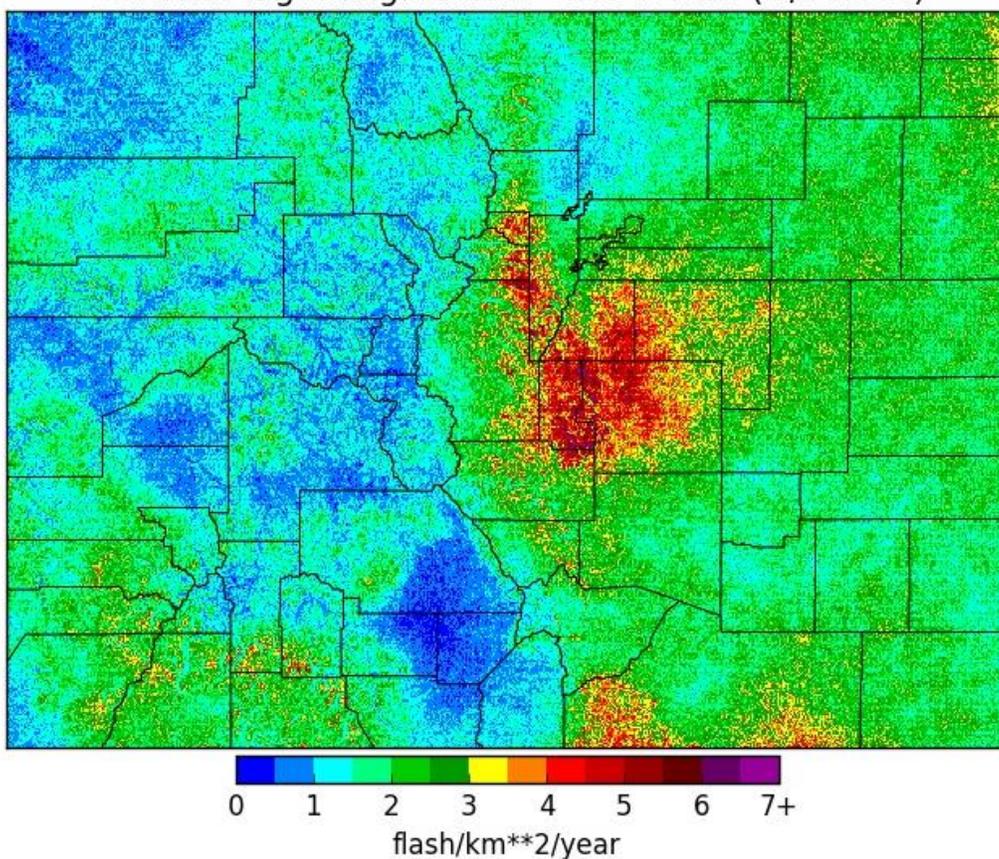
## 2. LOCATION

Thunderstorms can occur anywhere within the State of Colorado. These types of storms often cover large areas that can affect entire towns, cities, and counties. Larger systems and lines of storms can affect the entire state in the right conditions. Thunderstorms can produce damaging winds, hail, and lightning that can cause damage over a wide area, with severe localized affects.

Lightning has emerged as one of the greatest weather hazards in Colorado, and can occur anywhere there is a thunderstorm. Lightning strike statistics indicate that the most lightning-prone areas of Colorado are the foothills and plains areas between the Denver metro area and Colorado Springs, and the Raton Plateau south and southeast of Trinidad near the New Mexico border as shown in Figure 3-45. The reason why so much lightning occurs in these regions is due to a combination of topography, low level wind flow regime, and low level atmospheric moisture.

FIGURE 3-45 COLORADO LIGHTNING FLASHES

Colorado Lightning: Annual 1994-2014 (w/o 2000)



Source: NOAA

In areas of Colorado with the most lightning activity, more than seven cloud-to-ground lightning flashes can be expected to hit the ground in a one square kilometer area per year. Converting this to square miles, one can expect about 18 cloud-to-ground flashes to hit the riskiest areas of ground per square mile. The least amount of lightning activity occurs in the San Luis Valley, the central mountain regions, and the Upper Arkansas River Valley.

### 3. EXTENT (MAGNITUDE/STRENGTH)

The National Weather Service considers a thunderstorm severe if it produces hail at least 3/4 inch in diameter, winds of 58 mph or stronger, or a tornado. Storms of lesser scale can and do occur, and may still cause considerable damage under the right circumstances. The National Weather Service provides two levels of public notification for severe storms: watch and warning. These are described in Figure 3-46.

FIGURE 3-46 NATIONAL WEATHER SERVICE WATCH VS WARNING

#### SEVERE THUNDERSTORM WATCH:

*Be Prepared! Severe thunderstorms are possible in and near the watch area. Stay informed and be ready to act if a severe thunderstorm warning is issued. The watch area is typically large, covering numerous counties or even states.*

#### SEVERE THUNDERSTORM WARNING:

*Take Action! Severe weather has been reported by spotters or indicated by radar. Warnings indicate imminent danger to life and property. Take shelter in a substantial building. Avoid mobile homes that can blow over in high winds. Warnings typically encompass a much smaller area (around the size of a city or small county) that may be impacted by large hail or damaging wind identified by a NWS forecaster on radar or by a trained spotter/law enforcement who is watching the storm.*

Source: NOAA

Cloud-to-ground lightning is the most threatening risk from thunderstorms due to its ability to cause death, injury, wildfires, and damage to property. The extent of lightning is dependent upon a multitude of factors, some of which explain the geographic extent of the most frequent lightning strikes in Colorado. Ground elevation, ground humidity, and wind currents are all ingredients that may enhance the frequency of lightning.

### 4. PROBABILITY

Thunderstorms most often occur from late spring through summer, most notably from May through September. Regardless of the season or time of year, thunderstorms can occur at any point under proper conditions. The average number of thunderstorm events per month, as well

as lightning flashes for any given day, is shown in Table 3-101. In any given day in July or August, over 4,000 lightning flashes are expected to occur in Colorado.

**TABLE 3-101 AVERAGE LIGHTNING FLASHES IN COLORADO BY DAY/MONTH, 1950-2017**

Month	Number of Thunderstorm Events	Number of Flashes Per Day
January	1	1
February	6	4
March	27	39
April	129	225
May	482	1,203
June	986	2,621
July	1,020	4,035
August	584	4,215
September	183	1,457
October	46	261
November	3	11
December	1	1

Source: NOAA

Over the past 10 years, Colorado has experienced approximately 40 days with thunderstorms per year. There are a smaller number of known damaging lightning events per year (estimated to be at least 13 events on average, annually). Since 2007, thunderstorms have affected on average 29 counties per year. Table 3-102 shows the number of days with thunderstorms and the number of counties affected since 2007.

**TABLE 3-102 DAYS WITH THUNDERSTORM EVENTS**

Year	Days with Events	# Counties Affected
2007	49	30
2008	39	33
2009	49	29
2010	46	33
2011	52	38
2012	26	28
2013	37	31
2014	38	28
2015	33	22
2016	37	26
2017	28	21

Source: NOAA

## 5. PREVIOUS OCCURRENCES

Table 3-103 shows the total number of lightning and thunderstorm occurrences by county as reported by NOAA. It should be noted that NOAA event reporting only includes events that had “sufficient intensity to cause loss of life, injuries, significant property damage, and/or disruption to commerce” (NOAA NCEI). Weld County has the highest number of thunderstorm and lightning events out of any one county, at 270 total. It should also be noted that Weld County also has the highest instances of tornadoes out of any county in Colorado.

TABLE 3-103 THUNDERSTORM AND LIGHTNING EVENTS, 1950-2017

County	Number of Lightning	Number of Thunderstorms	Total	Total Deaths	Total Injuries
Adams	19	92	111	2	12
Alamosa	4	10	14	0	1
Arapahoe	29	97	126	0	14
Archuleta	10	14	24	1	5
Baca	1	61	62	1	2
Bent	0	40	40	1	1
Boulder	34	64	98	1	12
Broomfield	0	3	3	0	0
Chaffee	7	5	12	2	4
Cheyenne	0	135	135	0	2
Clear Creek	4	1	5	0	13
Conejos	N/A	N/A	N/A	0	0
Costilla	N/A	N/A	N/A	0	0
Crowley	1	19	20	0	5
Custer	2	3	5	2	1
Delta	3	14	17	0	0
Denver	18	88	106	2	15
Dolores	2	4	6	1	1
Douglas	25	33	58	2	10
Eagle	1	33	34	0	0
El Paso	51	117	168	6	68
Elbert	3	57	60	0	3
Fremont	5	7	12	0	0
Garfield	4	31	35	3	0
Gilpin	1	0	1	0	0
Grand	2	6	8	0	21
Gunnison	5	11	16	1	8
Hinsdale	1	2	3	0	2
Huerfano	3	1	4	0	5
Jackson	0	4	4	0	0
Jefferson	33	37	70	4	13

County	Number of Lightning	Number of Thunderstorms	Total	Total Deaths	Total Injuries
Kiowa	1	51	52	0	3
Kit Carson	1	193	194	0	2
Lake	5	0	5	0	3
La Plata	13	22	35	1	1
Larimer	45	119	164	11	72
Las Animas	0	32	32	0	3
Lincoln	3	92	95	0	4
Logan	2	117	119	2	6
Mesa	11	110	121	0	2
Mineral	1	0	1	1	0
Moffat	1	20	21	0	0
Montezuma	13	22	35	0	7
Montrose	5	21	26	2	1
Morgan	9	136	145	0	11
Otero	5	102	107	3	0
Ouray	2	1	3	1	0
Park	7	2	9	1	3
Phillips	0	76	76	0	1
Pitkin	4	7	11	1	3
Prowers	1	105	106	1	3
Pueblo	10	121	131	0	10
Rio Blanco	2	23	25	1	5
Rio Grande	0	3	3	0	0
Routt	2	24	26	0	0
Saguache	1	6	7	1	1
San Juan	1	3	4	0	4
San Miguel	2	2	4	0	0
Sedgwick	2	35	37	0	0
Summit	5	1	6	1	6
Teller	5	4	9	2	4
Washington	3	133	136	0	0
Weld	27	243	270	2	5
Yuma	1	191	192	0	0

Source: NOAA

Lightning events resulting in injuries or deaths provides a look at the risk to people across Colorado, and is presented in Figure 3-47. Denver, Larimer, Boulder, Jefferson, Arapahoe, and El Paso Counties have had over 20 lightning deaths and/or injuries since 1950. These are followed by Weld, Adams, Douglas, Grand, Eagle, and Huerfano Counties with 11 to 20 reported deaths and/or injuries during this time period.

## 5.1 CASE HISTORY

During a thunderstorm on **July 24, 1999** intense straight-line winds associated with a wet microburst blew six vehicles off Interstate 76, including a pickup pulling a horse trailer. Several windows were blown out of homes and vehicles in the Fort Morgan and Brush areas. As a result, 10 people were treated at area hospitals for cuts and bruises. In addition to the damage to property, numerous crops were reportedly flattened by the combination of heavy rain, hail, and damaging winds.

**On June 19, 2004**, 19 golfers were struck by lightning near the town of Kremmling. They were participating in the Kremmling Cliff Classic Golf Tournament which was located on a bluff a mile or two north of town. This "golf tournament" consisted of hitting golf balls off the edge of a cliff at targets in the valley below. Of the 19 golfers who were affected by the flashes, four were taken via helicopter to a hospital in Denver. Reports from the Grand County Dispatch Center indicated the first 911 call regarding this lightning incident was received at 2:46 pm. Eyewitnesses and victims to the event indicated two flashes actually hit the bluff where the 19 golfers were injured.

Between **July 2<sup>nd</sup> and 3<sup>rd</sup> in 2005**, severe thunderstorms battered Larimer County. Strong thunderstorm winds occurred at Boyd Lake. Two women drowned when the boat they were in capsized. Four others that were in the boat had to be hospitalized, one was in intensive care. On July 3<sup>rd</sup>, lightning struck near a beach area at Boyd Lake. Nine people were injured, five were treated at the park, and four others were hospitalized.

**On September 2, 2007**, a 21-year-old male was killed by lightning while inside a tent which was located in the foothills eight miles southwest of Colorado Springs. Three other people were also in the tent when the flash occurred, but they received only minor injuries. An autopsy report indicated the man who was killed was lying down on the ground inside the tent at the time of the flash. The autopsy report indicated the electrical current entered through his elbow on which he was leaning on at the time, traveled through his torso, and exited his buttocks. The other three occupants in the tent were standing at the time of the flash.

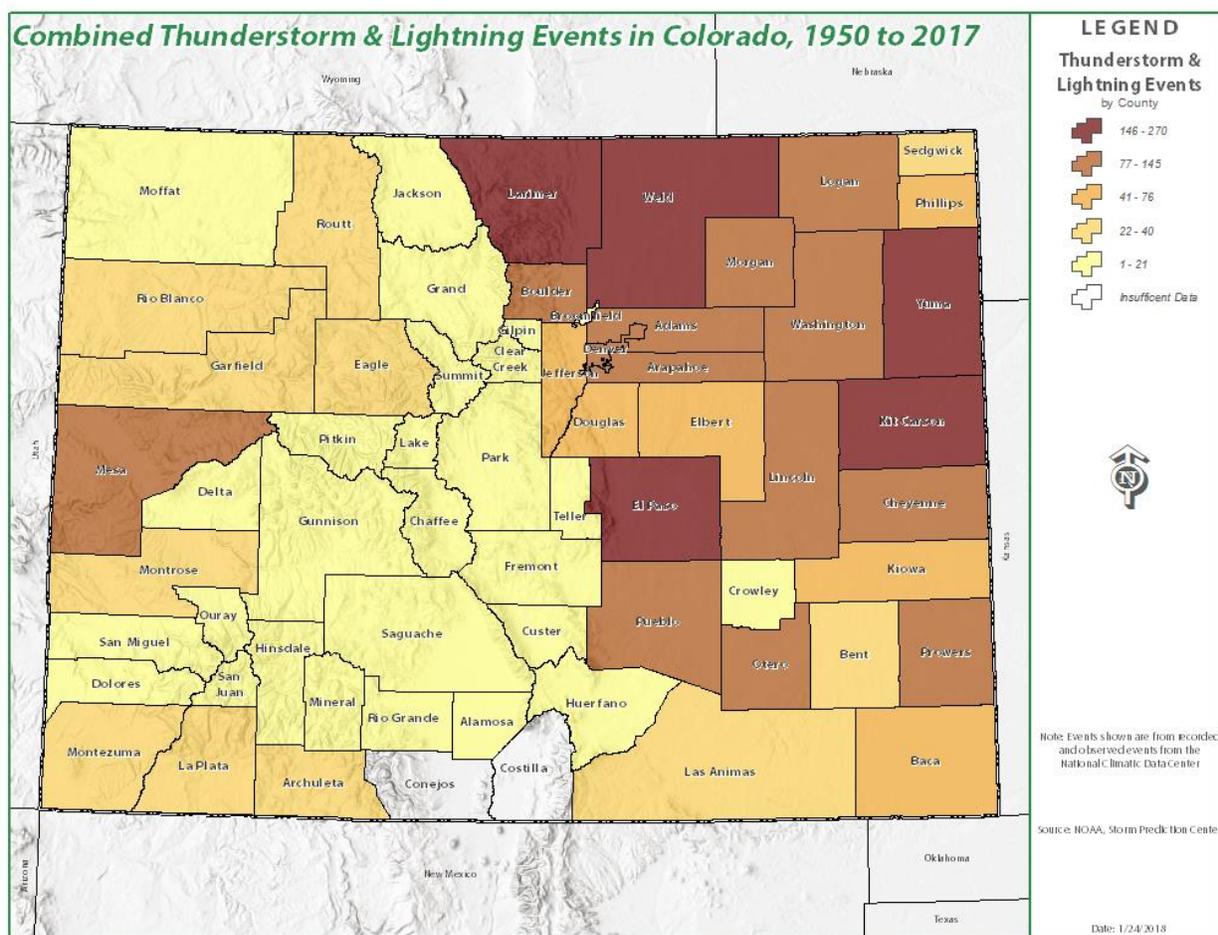
During the early evening of **July 24, 2008**, two graduate students were struck by lightning on the Colorado State University (CSU) campus in Fort Collins. According to CSU news media, they were struck in the "Sherwood Forest" area of the campus which is a heavily treed area just south of the Warner College of Natural Resources Building. One student was pronounced dead shortly after the incident. The other student survived for two days before succumbing to his injuries.

On **June 19, 2011**, two rounds of severe storms rolled across the northern third of Yuma County during the evening hours, resulting in widespread wind damage. Winds estimated to be around 90 mph destroyed grain bins, overturned irrigation sprinklers, tore off sections of roofs, broke windows, overturned a cattle trailer, and destroyed crops. Several weak tornadoes occurred over southwestern Nebraska as the storms continued east. In addition, thousands of acres of

cropland were impacted by the hail accompanying the storm, resulting in around \$18 million in damages. Dollar estimates of damage are approximate and based on figures from the USDA.

During a training exercise on **July 13<sup>th</sup>, 2013**, 12 soldiers were struck by lightning south of Butts Field on the north side of Fort Carson. Two soldiers were taken to a hospital in Colorado Springs, one in critical condition. The other ten soldiers were taken to the post hospital and later released.

**FIGURE 3-47 LIGHTNING EVENTS IN COLORADO**



## 6. IMPACT ANALYSIS

Thunderstorms and lightning have taken a large toll on Colorado in terms of injury, loss of life, and property damage. Undoubtedly, the fact that Colorado is an outdoor recreation-oriented state contributes heavily to its high lightning death and injury tolls.

Table 3-104 presents historical property and crop damages by county, since 1950. Despite that thunderstorms cover a significantly larger area than lightning, which is very point-specific, storms have only caused \$22 million in property damages, compared with lightning's \$11

million. This could be because lightning is more totally destructive, and is much harder to prepare for a direct strike, whereas building codes largely mitigate the effects of wind damage from thunderstorms. Crops have also suffered significantly more under thunderstorms as a whole.

According to the National Centers for Environmental Information (NCEI), over \$18 million in damages have been the result of thunderstorms. It should be noted that the vast majority of this damage was caused during a single event in Yuma County in 2011. This event is described in the Previous Occurrences section.

**TABLE 3-104 PROPERTY AND CROP DAMAGE BY COUNTY, 1950-2017**

County	Lightning		Thunderstorms		Total		
	County Name	Property Damage	Crop Damage	Property Damage	Crop Damage	Property Damage	Crop Damage
Adams		\$ 391,000	\$ -	\$ 76,500	\$ -	\$ 467,500	\$ -
Alamosa		\$ 42,000	\$ -	\$ -	\$ -	\$ 42,000	\$ -
Arapahoe		\$ 894,000	\$ 2,000	\$ 571,500	\$ -	\$ 1,465,500	\$ 2,000
Archuleta		\$ 153,250	\$ -	\$ 108,300	\$ -	\$ 261,550	\$ -
Baca		\$ 1,500	\$ -	\$ 2,218,000	\$ -	\$ 2,219,500	\$ -
Bent		\$ -	\$ -	\$ 341,000	\$ -	\$ 341,000	\$ -
Boulder		\$ 117,000	\$ -	\$ 25,510	\$ -	\$ 142,510	\$ -
Broomfield		\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Chaffee		\$ 100,000	\$ 2,000	\$ -	\$ -	\$ 100,000	\$ 2,000
Cheyenne		\$ -	\$ -	\$ 284,850	\$ -	\$ 284,850	\$ -
Clear Creek		\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Conejos		N/A	N/A	N/A	N/A	N/A	N/A
Costilla		N/A	N/A	N/A	N/A	N/A	N/A
Crowley		\$ 1,000	\$ -	\$ 10,050	\$ -	\$ 11,050	\$ -
Custer		\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Delta		\$ 36,000	\$ -	\$ 2,574,000	\$ -	\$ 2,610,000	\$ -
Denver		\$ 1,236,000	\$ -	\$ 25,000	\$ -	\$ 1,261,000	\$ -
Dolores		\$ 1,000	\$ -	\$ 35,000	\$ -	\$ 36,000	\$ -
Douglas		\$ 2,741,000	\$ 1,000	\$ 15,500	\$ -	\$ 2,756,500	\$ 1,000
Eagle		\$ 500,000	\$ -	\$ 14,000	\$ -	\$ 514,000	\$ -
El Paso		\$ 965,000	\$ -	\$ 1,731,300	\$ -	\$ 2,696,300	\$ -
Elbert		\$ 5,000	\$ -	\$ 10,500	\$ 5,000	\$ 15,500	\$ 5,000
Fremont		\$ 205,000	\$ -	\$ -	\$ -	\$ 205,000	\$ -
Garfield		\$ 113,000	\$ -	\$ 11,000	\$ -	\$ 124,000	\$ -
Gilpin		\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Grand		\$ -	\$ -	\$ 200,000	\$ -	\$ 200,000	\$ -
Gunnison		\$ 41,500	\$ -	\$ 50	\$ -	\$ 41,550	\$ -
Hinsdale		\$ 300	\$ -	\$ 50,000	\$ -	\$ 50,300	\$ -
Huerfano		\$ 40,000	\$ -	\$ -	\$ -	\$ 40,000	\$ -

<b>County</b>	<b>Lightning</b>		<b>Thunderstorms</b>		<b>Total</b>	
<b>County Name</b>	<b>Property Damage</b>	<b>Crop Damage</b>	<b>Property Damage</b>	<b>Crop Damage</b>	<b>Property Damage</b>	<b>Crop Damage</b>
Jackson	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Jefferson	\$ 1,437,000	\$ 12,000	\$ -	\$ -	\$ 1,437,000	\$ 12,000
Kiowa	\$ 50,000	\$ -	\$ 32,000	\$ -	\$ 82,000	\$ -
Kit Carson	\$ -	\$ -	\$ 1,179,250	\$ -	\$ 1,179,250	\$ -
Lake	\$ 15,000	\$ -	\$ -	\$ -	\$ 15,000	\$ -
La Plata	\$ 86,000	\$ -	\$ 1,102,500	\$ -	\$ 1,188,500	\$ -
Larimer	\$ 217,000	\$15,000	\$ 76,500	\$ -	\$ 293,500	\$ 15,000
Las Animas	\$ -	\$ -	\$ 1,500	\$ -	\$ 1,500	\$ -
Lincoln	\$ -	\$ -	\$ 26,500	\$ -	\$ 26,500	\$ -
Logan	\$ -	\$ -	\$ 85,000	\$ -	\$ 85,000	\$ -
Mesa	\$ 96,000	\$ -	\$ 266,400	\$ -	\$ 362,400	\$ -
Mineral	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Moffat	\$ 31,000	\$ -	\$ 20,000	\$ -	\$ 51,000	\$ -
Montezuma	\$ 251,500	\$ -	\$ 207,000	\$ 150,000	\$ 458,500	\$ 150,000
Montrose	\$ 1,000	\$ -	\$ 69,000	\$ -	\$ 70,000	\$ -
Morgan	\$ 22,000	\$ 5,600	\$ 763,520	\$ 50,000	\$ 785,520	\$ 55,600
Otero	\$ 17,000	\$ -	\$ 257,000	\$ -	\$ 274,000	\$ -
Ouray	\$ 1,000	\$ -	\$ 60,000	\$ -	\$ 61,000	\$ -
Park	\$ 11,000	\$ 30,000	\$ -	\$ -	\$ 11,000	\$ 30,000
Phillips	\$ -	\$ -	\$ 1,080,500	\$ -	\$ 1,080,500	\$ -
Pitkin	\$ 2,000	\$ -	\$ -	\$ -	\$ 2,000	\$ -
Prowers	\$ -	\$ -	\$ 365,500	\$ -	\$ 365,500	\$ -
Pueblo	\$ 455,000	\$ -	\$ 3,657,000	\$ -	\$ 4,112,000	\$ -
Rio Blanco	\$ 250	\$ -	\$ 255,500	\$ -	\$ 255,750	\$ -
Rio Grande	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Routt	\$ 40,000	\$ -	\$ 111,000	\$ -	\$ 151,000	\$ -
Saguache	\$ -	\$ -	\$ 110,000	\$ -	\$ 110,000	\$ -
San Juan	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
San Miguel	\$ 5,000	\$ -	\$ -	\$ -	\$ 5,000	\$ -
Sedgwick	\$ -	\$ -	\$ 5,000	\$ -	\$ 5,000	\$ -
Summit	\$ 20,000	\$ -	\$ -	\$ -	\$ 20,000	\$ -
Teller	\$ -	\$ -	\$ 4,000	\$ -	\$ 4,000	\$ -
Washington	\$ 25,000	\$ 1,800	\$ 230,500	\$ -	\$ 255,500	\$ 1,800
Weld	\$ 1,049,000	\$26,000	\$ 317,600	\$ 10,000	\$ 1,366,600	\$ 36,000
Yuma	\$ 6,000	\$ -	\$ 3,700,450	\$18,000,000	\$3,706,450	\$18,000,000
<b>Grand Total</b>	<b>\$11,421,300</b>	<b>\$95,400</b>	<b>\$22,285,280</b>	<b>\$18,215,000</b>	<b>\$33,706,580</b>	<b>\$18,310,400</b>

Source: NOAA

In a study in the Denver area, it was found that one out of every 52 lightning flash results in an insurance claim, while nationwide the ratio is one to 57. With Colorado averaging 529,000

flashes per year and an average of one insurance claim per 52 strikes, the state is averaging over 10,000 lightning-related insurance claims per year.

Damages from thunderstorms extend beyond those caused directly by lightning or high winds. Secondary hazards may also occur as a result of storms. Large amounts of rain can cause flooding, particularly in the spring when it mixes with snowmelt. Lightning strikes have the ability to set off wildfires, which during the drier seasons, can be devastating and cover huge swaths of land. Wildfires can result in the death of livestock and other animals, destroy thousands of acres of forests, and cause millions in damages to buildings, communications systems, and power infrastructure.

In terms of lightning risk around the state, central Colorado has the highest rate of lightning strikes. According to Vaisala (née Global Atmospheric, Inc.), common locations of lightning strikes include:

- Open fields, ball fields
- Under trees (not golf)
- Boats/water-related
- Golf course
- Near heavy equipment
- At telephone
- Other locations/unknown

Those who work outdoors are susceptible to thunderstorms and lightning, especially if there is not shelter or a vehicle nearby. This includes first responders who can be significantly delayed by heavy rain and wind. Downed power lines and trees can result in lengthy and otherwise unnecessary detours.

Large outdoor gatherings such as sporting events, fairs, and concerts are particularly vulnerable to thunderstorms and lightning. It can be difficult to find shelter for crowds of significant size, which can lead to leaving individuals in harm's way. Campgrounds, which are plentiful throughout the state, are also heavily vulnerable, as they tend to be in forested areas where shelter is likely not present.

These vulnerabilities underscore the importance of developing site-specific emergency procedures for these types of events, with particular emphasis on adequate early detection, monitoring, and warning of approaching thunderstorms. Early detection, monitoring, and warning, combined with prudent protective actions, can greatly reduce the likelihood of lightning injuries and deaths.

Maintaining close coordination between event organizers, local emergency management officials, and response agencies (i.e., police, fire, emergency medical services) can help prevent unnecessary (and often tragic) delays and mistakes in rendering care should a lightning incident occur. Table 3-105 provides an overview of the impacts of thunderstorms and lightning.

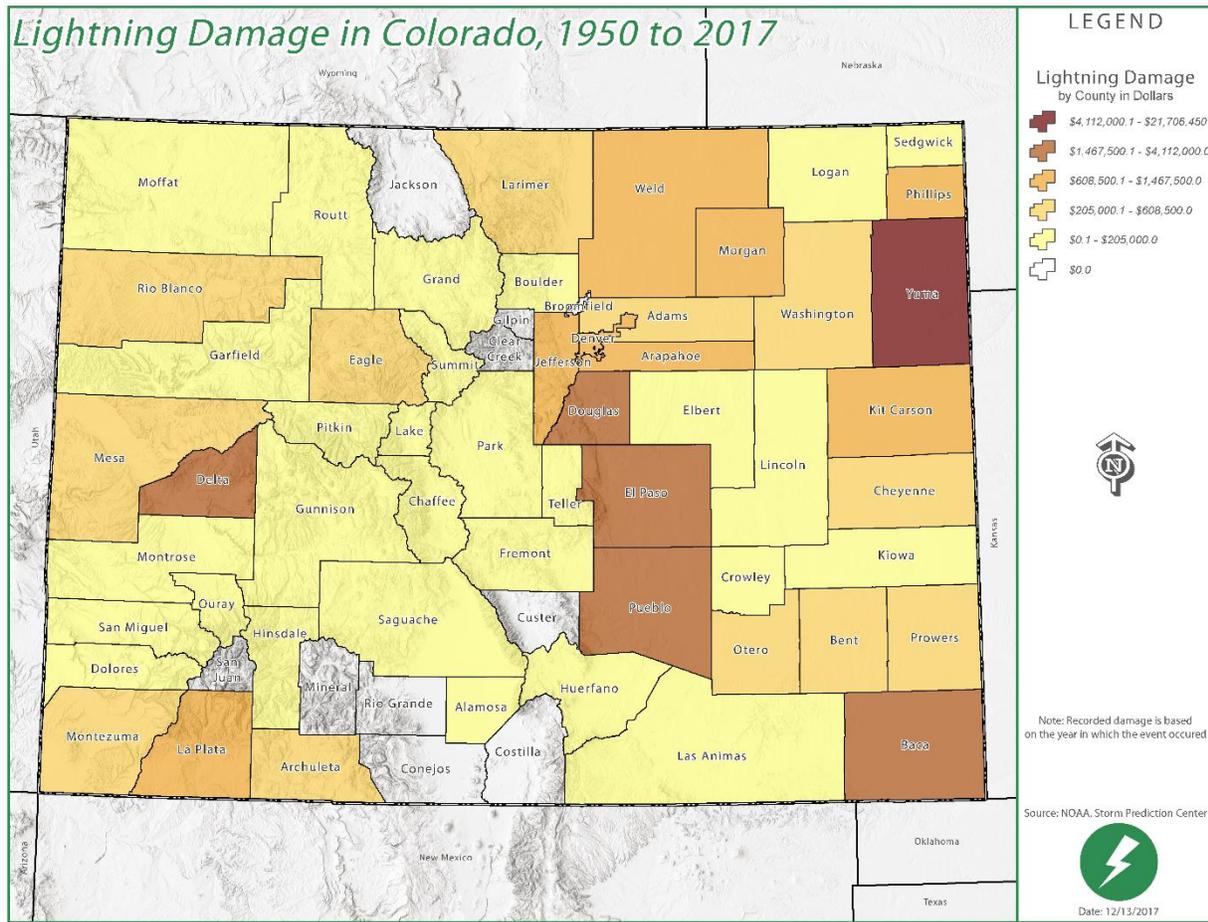
TABLE 3-105 THUNDERSTORM AND LIGHTNING EMAP IMPACT SUMMARY

Consideration	Description
<b>General Public</b>	Outdoor workers, outdoor recreationists, outdoor sporting participants; population of the counties determined most at risk.
<b>First Responders</b>	Some exposure exists to personnel performing routine duties when event occurs; otherwise storm-related duties are typically post-event.
<b>Property</b>	Instances of property losses due to trees or roof tops being struck. Power outages may occur if utility lines are downed by lightning or wind.
<b>Facilities and Infrastructure</b>	Buildings and equipment are exposed to lightning as well as utility infrastructure. Assets in areas with higher flash counts are at greater risk.
<b>Economic</b>	Extended power outages may cause delays in work, particularly in rural areas where problems are more widespread, but have fewer people responding to repair them.
<b>Environment</b>	Downed trees and branches. Some potential for flooding or flash flooding. Lightning strike may be precursor to wildfire under certain conditions.
<b>Continuity of Government and Services</b>	None, or limited loss of facilities or infrastructure function or accessibility, or ability to provide services. May have limited power interruption if not adequately equipped with backup generation.
<b>Confidence in Government</b>	Characteristics of lightning flashes such as duration and speed of onset result in limited response and recovery functions for government beyond first responders.
<b>Critical Assets</b>	Risk to any critical asset sector that is energy dependent without adequate backup generation.

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

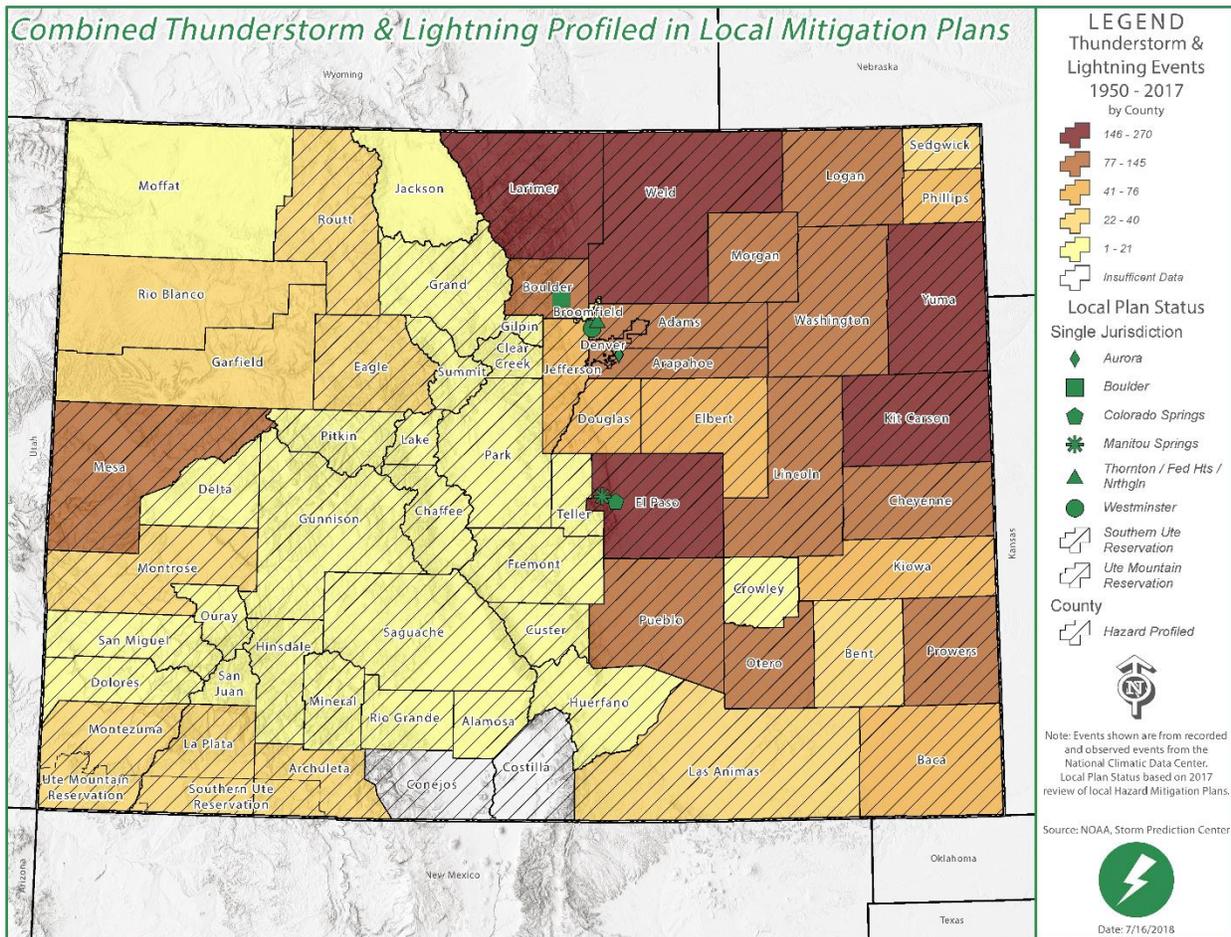
Total property damage reported from thunderstorms and lightning strikes in Colorado is \$52 million over the last 67 years. Based on the number of events reported, damages average over \$31,500 per damaging lightning event. Significant crop damage is also reported from lightning, totaling about \$2.0 million during this same timeframe. Figure 3-48 shows total damage from lightning events by county since 1950.

FIGURE 3-48 DAMAGE FROM THUNDERSTORMS BY COUNTY



Based upon a recent (2017) review of local mitigation plans, Figure 3-49 illustrates the number of lightning related actions the counties, and some municipalities, have identified to address lightning. Nearly all counties and major single jurisdictions along the Front Range, have profiled severe thunderstorms and lightning, as it is one of the more universal hazards across the state.

FIGURE 3-49 THUNDERSTORM AND LIGHTNING HAZARD IN LOCAL MITIGATION PLANS



Based on review of local hazard mitigation plans, 18 jurisdictions profile thunderstorms and lightning as one of their top four hazards. Within those 18 jurisdictions, a total of 954,373 structures or parcels are identified in thunderstorm and lightning hazard areas, and 6,533 critical facilities are identified in thunderstorm and lightning hazard areas. Table 3-106 describes this information in more detail, as well as the total estimated losses.

TABLE 3-106 LOCAL MITIGATION PLANS

Jurisdiction	# of Structures/ Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate	Loss Estimate Methodology
Adams County	154,314	518		\$8,976,895	avg losses per year
Arapahoe County	249,000	988			
Baca County	4,094	187			

Jurisdiction	# of Structures/ Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate	Loss Estimate Methodology
City of Colorado Springs	8,103		Colorado Geological Survey		
Crowley County	2,143	117			
City and County of Denver	211,619	2,618			
Elbert County	9,816	66			
Gilpin County	3,843	47		\$909,462	avg annual losses
Hinsdale County		34			
Kiowa County	1,474	42			
La Plata County	25,860 (only housing units)	99 (total critical facilities)		\$80,000	avg annual losses
Larimer County	159,154 (total structures)	937 (total critical structures)		Unknown	
Montezuma County	38,904	124		\$69,884	avg annual loss from hail, lightning, and wind
Montrose County (Unincorporated)		13			
Otero County	12,103	344			
Prowers County	7,933	287			
Pueblo County	51,194				
Teller County	14,819			\$516,795,334	10% damage
<b>Total</b>	<b>954,373</b>	<b>6,533</b>		<b>\$526,831,575</b>	

## 8. FUTURE DEVELOPMENT

Population growth and development contribute to increased exposure of people and property to thunderstorms and their related impacts. Understanding changes in hazard exposure over time is an important element of comprehensive hazard mitigation planning.

Colorado continues to experience some of the largest population growth in the country and future projections seem to indicate a similar trend should be expected. Table 3-107 presents the projected percent change in housing on a county scale from 2010 - 2030. Those counties that have a large expected percent change in housing as well as a history of significant

thunderstorm events are most at risk for future exposure. An increased building stock means that there are more homes and buildings threatened by thunderstorm.

Weld, Larimer, Arapahoe, and Adams Counties all fall into the highest quarter of county growth ratings and have experienced more than 100 historical thunderstorm and lightning events. El Paso, Morgan, Pueblo, Mesa, and Denver Counties also have more than 100 events and fall into the second tier of county growth ratings.

**TABLE 3-107 HOUSING PROJECTIONS (2010 TO 2030) AND HISTORICAL EVENTS**

County	Historical Thunderstorm and Lightning Events	Housing Percent Change	Growth Rating
Weld	270	93%	Highest
Larimer	164	47%	Highest
Arapahoe	126	52%	Highest
Adams	111	60%	Highest
Elbert	60	120%	Highest
Douglas	58	67%	Highest
Garfield	35	51%	Highest
La Plata	35	50%	Highest
Eagle	34	56%	Highest
Montrose	26	61%	Highest
Routt	26	46%	Highest
Archuleta	24	61%	Highest
Park	9	65%	Highest
Summit	6	49%	Highest
San Miguel	4	64%	Highest
Broomfield	3	78%	Highest
El Paso	168	40%	High
Morgan	145	26%	High
Pueblo	131	26%	High
Mesa	121	38%	High
Denver	106	37%	High
Boulder	98	37%	High
Lincoln	95	26%	High
Jefferson	70	30%	High
Montezuma	35	37%	High
Delta	17	35%	High
Gunnison	16	28%	High
Chaffee	12	38%	High
Fremont	12	28%	High
Pitkin	11	34%	High
Grand	8	44%	High
Custer	5	41%	High

County	Historical Thunderstorm and Lightning Events	Housing Percent Change	Growth Rating
Kit Carson	194	20%	Moderate
Yuma	192	17%	Moderate
Logan	119	21%	Moderate
Kiowa	52	12%	Moderate
Las Animas	32	23%	Moderate
Crowley	20	26%	Moderate
Alamosa	14	25%	Moderate
Teller	9	23%	Moderate
Saguache	7	17%	Moderate
Lake	5	21%	Moderate
Clear Creek	5	20%	Moderate
Huerfano	4	13%	Moderate
Hinsdale	3	19%	Moderate
Ouray	3	13%	Moderate
Gilpin	1	12%	Moderate
Conejos	0	14%	Moderate
Washington	136	8%	Low
Cheyenne	135	11%	Low
Otero	107	6%	Low
Prowers	106	3%	Low
Phillips	76	1%	Low
Baca	62	-6%	Low
Bent	40	7%	Low
Sedgwick	37	1%	Low
Rio Blanco	25	10%	Low
Moffat	21	7%	Low
Dolores	6	4%	Low
Jackson	4	9%	Low
San Juan	4	10%	Low
Rio Grande	3	7%	Low
Mineral	1	10%	Low
Costilla	0	10%	Low

Source: NOAA, Colorado State Demography Office, 2017

Table 3-110 provides county-scale exposure projections by comparing thunderstorm risk and population percent change between 2010 and 2030. Because it is virtually impossible to provide complete protection to individuals and structures from thunderstorms, this hazard will continue to be a problem for Colorado’s residents and communities. However, deaths, injuries, and property damage can be reduced through a combination of public education, safety provisions, and simple common sense.

TABLE 3-108 THUNDERSTORM AND LIGHTNING EXPOSURE PROJECTIONS

Future Thunderstorm and Lightning Exposure Projections					
		County Population Percent Change Projections, 2010 to 2030			
Combined Risk (Thunderstorms and Lightning)		-13% to 2%	3% to 17%	18% to 34%	35% to 89%
High ↑ Moderate	5-6	Moderate	High	Severe	Extreme
	3-4	Slight	Moderate	High	Severe
	0-2	Negligible	Slight	Moderate	High

The Combined Risk calculations in Table 3-108 are based on the methodology outlined in Table 3-109. Values (between zero and three) have been assigned to total deaths and injuries and total number thunderstorm and lightning events per county. The Jenks Natural Breaks algorithm was used to classify these historical data sets. These values were summed to get a Combined Risk value for each county.

TABLE 3-109 COMBINED RISK METHODOLOGY

Deaths and Injuries (1950 – 2017)	Value	# of Storm Events (1950-2017)	Value
22-83	3	99-270	3
11-21	2	33-98	2
1-10	1	1-32	1
0	0	0	0

Exposure to thunderstorms is expected to intensify across the State of Colorado between 2010 and 2030 as population increases. The darker colors in Table 3-110 and Figure 3-50 illustrate relative rates of increase in exposure between counties.

As the state’s population continues to grow, there will be an increase in business and infrastructure, as well. These additional assets will lead to greater exposure from thunderstorms as counties continue to grow. Adams County is at particular risk, as it has a proven record of deaths, injuries, and property damage. Further, with its population forecasted to grow by 48%, thunderstorms pose a significant threat. Denver, Larimer, El Paso, and Arapahoe Counties also have the state’s most extreme risk due to their historical events and losses, as well as their expected growth.

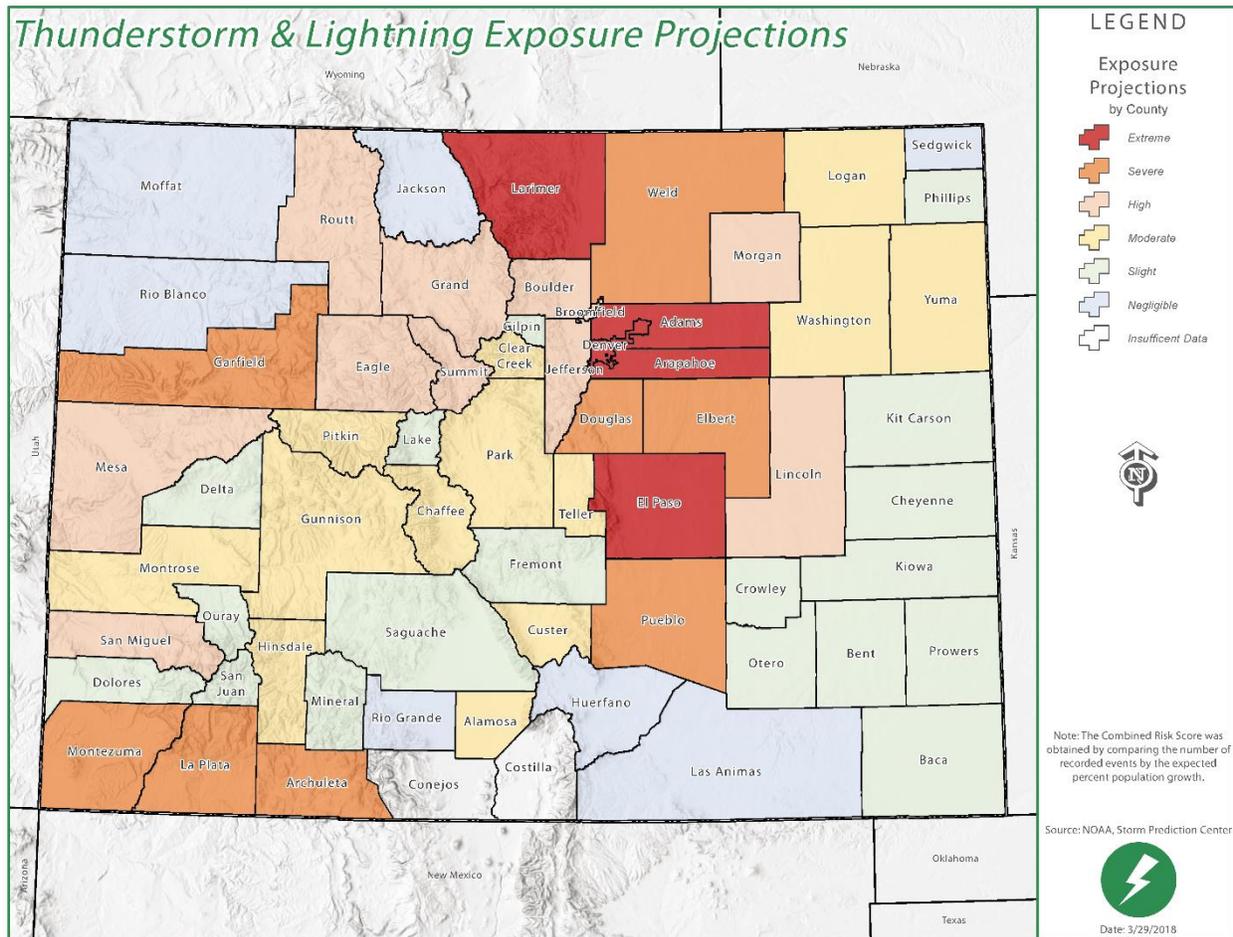
TABLE 3-110 THUNDERSTORM AND LIGHTNING EXPOSURE PROJECTIONS, 2010 TO 2030

County	Combined Risk	Population Change	Exposure Rating
Adams	5	48%	Extreme
Denver	5	42%	Extreme
Larimer	6	42%	Extreme
El Paso	6	36%	Extreme
Arapahoe	5	36%	Extreme
Elbert	3	89%	Severe
Weld	4	81%	Severe
Douglas	4	44%	Severe
La Plata	3	42%	Severe
Archuleta	3	40%	Severe
Garfield	3	38%	Severe
Montezuma	3	37%	Severe
Pueblo	5	20%	Severe
Broomfield	1	71%	High
San Miguel	1	59%	High
Summit	2	41%	High
Routt	1	40%	High
Eagle	3	34%	High
Grand	3	32%	High
Boulder	4	28%	High
Mesa	4	24%	High
Lincoln	3	21%	High
Jefferson	4	21%	High
Morgan	5	16%	High
Park	2	34%	Moderate
Montrose	2	30%	Moderate
Hinsdale	2	29%	Moderate
Chaffee	2	29%	Moderate
Gunnison	2	26%	Moderate
Teller	2	25%	Moderate
Alamosa	2	22%	Moderate
Custer	2	20%	Moderate
Pitkin	2	18%	Moderate
Logan	4	14%	Moderate
Clear Creek	3	14%	Moderate
Yuma	3	7%	Moderate
Washington	3	5%	Moderate
Lake	2	17%	Slight
Ouray	2	17%	Slight
Mineral	2	16%	Slight

County	Combined Risk	Population Change	Exposure Rating
Gilpin	1	13%	Slight
Saguache	2	9%	Slight
Delta	1	8%	Slight
Fremont	2	5%	Slight
Dolores	2	5%	Slight
Crowley	2	5%	Slight
San Juan	2	5%	Slight
Cheyenne	4	2%	Slight
Kit Carson	4	-1%	Slight
Phillips	3	-3%	Slight
Bent	3	-5%	Slight
Prowers	4	-5%	Slight
Otero	4	-7%	Slight
Kiowa	3	-8%	Slight
Baca	3	-13%	Slight
Rio Blanco	2	2%	Negligible
Huerfano	2	-1%	Negligible
Sedgwick	2	-3%	Negligible
Moffat	1	-3%	Negligible
Rio Grande	1	-5%	Negligible
Jackson	1	-7%	Negligible
Las Animas	2	-9%	Negligible
Costilla	-	7%	Insufficient Data
Conejos	-	1%	Insufficient Data

Source: NOAA, Colorado State Demography Office, 2017

FIGURE 3-50 THUNDERSTORM AND LIGHTNING EXPOSURE PROJECTIONS, 2010 TO 2030



In review of local hazard mitigation plans, the following information was provided in regard to future development and thunderstorms and lightning:

- La Plata County - Building standards can offer only limited protection from lightning and hail damage. Lightning rod/grounding systems can improve the performance of a building during such an event. Building codes seek to limit wind and tornado damage to structures. The design wind speed is 90 miles per hour for La Plata County. However, building standards can offer only limited protection. As development continues, the overall vulnerability to severe weather hazards will increase.

## 9. CLIMATE CHANGE

According to the best data available at the time of this plan update, the future impacts of climate change on thunderstorms and lightning are still unclear. The following Table 3-111 presents a breakdown of these projected changes in terms of hazard: location, extent/intensity, frequency, and duration. Ongoing efforts to reduce Colorado’s greenhouse gas emissions and adapt to a

changing climate, such as the Colorado Climate Plan and the Climate Change in Colorado Report, will help to reduce the impacts of climate change on thunderstorms and lightning.

**TABLE 3-111 CLIMATE CHANGE IMPACTS**

<b>Impact</b>	<b>Projected Change</b>
<b>Location</b>	Thunderstorm and lightning events occur across most of the state. The area at risk to lightning events is not projected to change.
<b>Extent/Intensity</b>	No clear projected trend in the frequency or intensity of warm-season convective storms has been identified for Colorado. Therefore, the intensity and extent of thunderstorm and lightning events is not projected to change.
<b>Frequency</b>	The frequency of thunderstorm and lightning events is not projected to change.
<b>Duration</b>	It is unknown if or how the duration of thunderstorms and lightning will change.

Source: FEMA 2017 and Lukas et al. 2014

## 10. RISK TO STATE ASSETS

Denver, Larimer, Adams, El Paso, and Arapahoe Counties have the most extreme risk rating for thunderstorms and lightning and collectively house over \$8.5 billion in state assets. This equates to 42 percent of the value of all statewide assets. Boulder County, whose future exposure rating is high, has the highest value for any county of state assets, at \$3.1 billion. Table 3-112 shows future exposure ratings for state assets by county.

Between 2008 and 2017, the Office of Risk Management (ORM) reports that 48 severe thunderstorm and lightning events damaged state assets. In this timeframe, these events resulted in \$1,041,989 in losses, some of which occurred to critical facilities such as within the state correctional system. Forty-five of the 48 events were due to lightning strikes, equating to \$1,010,944 of the \$1,041,989 in losses. These lightning strikes resulted in damages to building contents such as electric and power equipment connected to the electrical system more than causing structural damage. These content damages included items such as HVAC controls, alarm systems, breakers, general electrical panels, security cameras, and generators. There were two events where the losses to electrical equipment were around \$200,000. It is important to note that state asset loss data is only available for state assets included in the 2017 Office of Risk Management (ORM) database. These numbers exclude many Higher Education assets, and therefore may under-represent actual losses.

The Office of Risk Management has supported and encouraged state agencies with recurring lightning hazard losses in implementing mitigation actions on the structures. These recommendations and activities include lightning protection devices such as lightning rods and grounding, as well as surge protection. Departmental or programmatic budget limitations may be the largest impediment to these mitigation measures being implemented in a timely manner.

TABLE 3-112 STATE ASSETS EXPOSURE PROJECTIONS, 2010 TO 2030

County	State Assets	Asset Valuation	Future Exposure Rating
Denver	479	\$2,631,589,250	Extreme
Larimer	931	\$2,520,380,927	Extreme
Adams	225	\$2,161,277,205	Extreme
El Paso	252	\$664,445,003	Extreme
Arapahoe	231	\$539,093,242	Extreme
Pueblo	391	\$1,100,717,917	Severe
Garfield	227	\$935,656,624	Severe
Weld	270	\$723,621,025	Severe
La Plata	199	\$459,565,269	Severe
Douglas	139	\$41,437,868	Severe
Montezuma	92	\$26,250,957	Severe
Archuleta	68	\$12,576,015	Severe
Elbert	16	\$6,135,197	Severe
Boulder	288	\$3,184,873,780	High
Jefferson	481	\$1,220,747,270	High
Mesa	316	\$571,483,873	High
Summit	54	\$210,520,143	High
Lincoln	80	\$115,435,435	High
Morgan	168	\$67,190,695	High
Eagle	148	\$22,080,215	High
Routt	153	\$19,636,862	High
Grand	69	\$12,702,273	High
Broomfield	7	\$7,925,505	High
San Miguel	36	\$6,959,484	High
Alamosa	123	\$361,142,477	Moderate
Logan	174	\$321,168,914	Moderate
Gunnison	146	\$297,472,630	Moderate
Chaffee	196	\$135,641,023	Moderate
Clear Creek	75	\$117,846,308	Moderate
Montrose	65	\$19,168,190	Moderate
Park	120	\$17,071,984	Moderate
Yuma	84	\$14,101,083	Moderate
Teller	53	\$9,932,426	Moderate
Washington	31	\$4,317,254	Moderate
Hinsdale	19	\$1,605,114	Moderate
Custer	6	\$1,130,092	Moderate
Pitkin	14	\$712,333	Moderate
Fremont	360	\$762,885,780	Slight

County	State Assets	Asset Valuation	Future Exposure Rating
Bent	173	\$116,882,345	Slight
Crowley	28	\$99,475,999	Slight
Otero	83	\$79,711,658	Slight
Prowers	86	\$73,450,933	Slight
Delta	116	\$39,890,610	Slight
Mineral	21	\$30,302,497	Slight
Gilpin	39	\$10,009,237	Slight
Ouray	46	\$8,684,296	Slight
Saguache	49	\$5,188,186	Slight
San Juan	22	\$4,603,609	Slight
Dolores	20	\$4,252,291	Slight
Kit Carson	27	\$4,146,763	Slight
Lake	21	\$2,881,105	Slight
Baca	14	\$1,559,394	Slight
Kiowa	8	\$1,308,651	Slight
Cheyenne	9	\$712,471	Slight
Phillips	5	\$196,988	Slight
Las Animas	118	\$152,450,902	Negligible
Rio Grande	155	\$134,839,206	Negligible
Rio Blanco	66	\$63,910,055	Negligible
Huerfano	66	\$35,640,305	Negligible
Moffat	90	\$15,349,886	Negligible
Jackson	85	\$13,799,847	Negligible
Sedgwick	30	\$1,827,494	Negligible
Conejos	41	\$6,598,803	Insufficient Data
Costilla	28	\$4,179,435	Insufficient Data

Source: Colorado State Demography Office, 2017; Office of Risk Management, 2017 and 2013

## 11. RESOURCES

- Colorado Climate Center (CCC)
- Colorado Department of Transportation (CDOT) Emergency Operations Plan (EOP)
- Colorado Department of Transportation (CDOT) Threat and Hazard Identification and Risk Assessment (THIRA)
- Federal Emergency Management Agency (FEMA). 2017. Assessing Future Conditions, Colorado.
- Lukas, J., Barsugli, J., Doesken, N., Rangwala, I., and Wolter, K. 2014. Climate Change in Colorado: A Synthesis to Support Water Resources Management and Adaptation.
- National Climatic Data Center (NCDC)
- National Oceanic and Atmospheric Administration (NOAA)

- National Weather Service (NWS)
- Spatial Hazard Events and Losses Database for the United States (SHELDUS)

# TORNADOES



## 1. DEFINITION

Tornado can be defined as a localized, violently destructive windstorm occurring over land, especially in the Midwestern United States, and characterized by a long, funnel shaped cloud, composed of condensation and containing debris that extends to the ground and marks the path of greatest destruction. Tornadoes are generated by severe thunderstorms. Tornadoes in Colorado are most frequent in the spring and early summer when warm, moist air from the Gulf of Mexico collides with cold air from the Polar Regions to generate severe thunderstorms. These thunderstorms often produce the violently rotating columns of wind known as funnel clouds.

Colorado lies at the western edge of the nation's primary tornado belt, which extends from Texas and Oklahoma through Kansas and Nebraska. Table 3-113 describes the hazard profile summary for tornadoes.

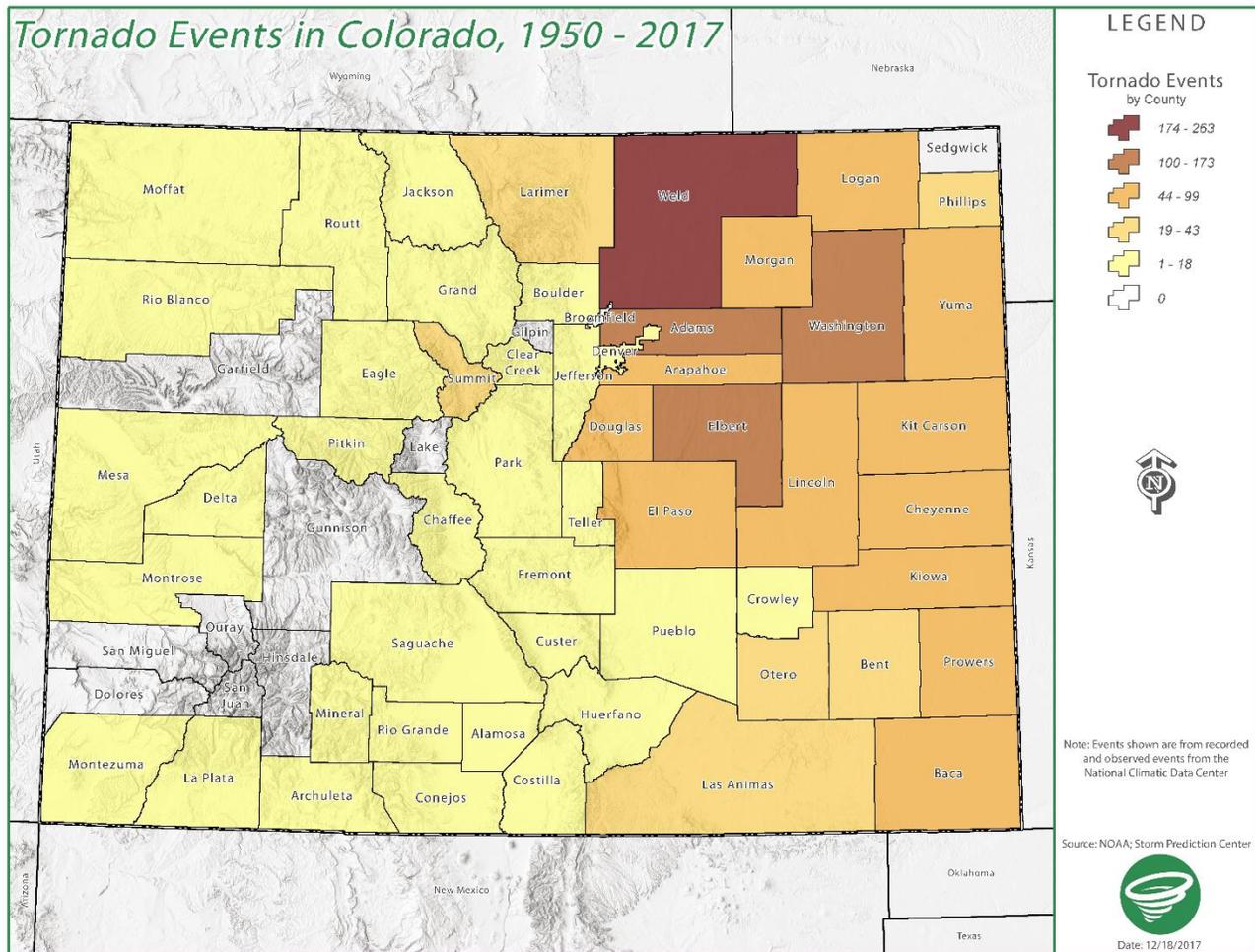
TABLE 3-113 HAZARD PROFILE SUMMARY

Consideration	Impact	Description
<b>Location</b>	Regional	Concentrated along the central and northern Front Range east to the Kansas Border. Includes east border counties. Most counties have recorded tornado events.
<b>Previous Occurrence</b>	Seasonal	Regular occurrences throughout the summer storm season, primarily from May to August, peaking in June.
<b>Probability</b>	Expected	Atmospheric activity producing conditions prone to tornadoes are expected to occur as in the past.
<b>Extent</b>	Catastrophic	Destroyed or damaged property that threatens structural stability, mass fatalities and/or casualties, impact to critical lifelines, impact to government's ability to provide service. Likely to overwhelm state and local resources and require federal assistance for full recovery.

## 2. LOCATION

In Colorado, the primary threat of tornado is east of the Continental Divide along the Front Range and across the Eastern Plains, although they have occurred statewide. Four counties, Adams, Elbert, Washington, and Weld, have experienced over 100 reported tornadoes between 1950 and 2017. Weld County has the highest number of reported tornadoes in the state with 263 during this timeframe. Figure 3-51 highlights tornado events across the state in recent years.

FIGURE 3-51 TORNADO EVENTS IN COLORADO



### 3. EXTENT (MAGNITUDE/STRENGTH)

Tornado intensity is measured on the Enhanced Fujita Scale (Table 3-114), which examines the damage caused by a tornado on homes, commercial buildings, and other human-constructed structures. The Enhanced Fujita Scale rates the intensity of a tornado based on damage caused, not by its size. It is important to remember that the size of a tornado is not necessarily an indication of its intensity. Large tornadoes can be weak, and small tornadoes can be extremely strong, and vice versa. It is very difficult to judge the intensity and power of a tornado while it is occurring. Generally, that can only be done after the tornado has passed, using the Enhanced Fujita Scale as the primary guide.

Most of Colorado's tornadoes are generally weak, as shown in Table 3-115, with wind speeds of less than 110 mph, or referred to as an EF1 or EF0 on the standardized Enhanced Fujita Scale. Of the 455 tornadoes that occurred between 2007 and 2017, a total of 377 were of these weaker classifications. However, strong tornadoes do occur in the state. During this same timeframe, four tornadoes were EF3 while another 13 were EF2.

TABLE 3-114 ENHANCED FUJITA SCALE OF TORNADO INTENSITY

EF-Scale Number	Wind Speed (MPH)	Type of Damage Possible
EF0	65-85	<b>Minor damage:</b> Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over. Confirmed tornadoes with no reported damage (i.e., those that remain in open fields) are always rated EF0.
EF1	86-110	<b>Moderate damage:</b> Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	111-135	<b>Considerable damage:</b> Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	136-165	<b>Severe damage:</b> Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.
EF4	166-200	<b>Devastating damage:</b> Well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.
EF5	>200	<b>Extreme damage:</b> Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 m (300 ft.); steel reinforced concrete structures badly damaged; high-rise buildings have significant structural deformation.

Source: NOAA

TABLE 3-115 COLORADO TORNADO NUMBERS AND STRENGTH, 2007 TO 2017

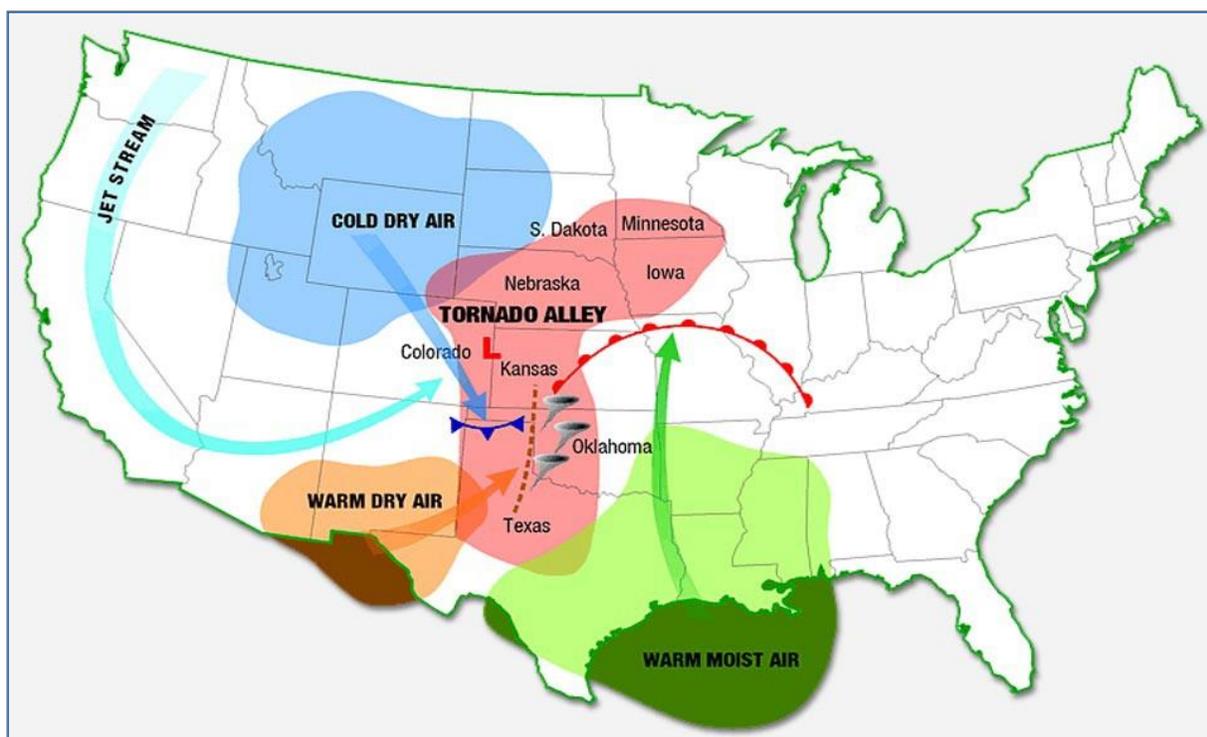
Enhanced Fujita Scale	EF Count	Percent	Description
EF0	377	83%	Gale Tornado
EF1	49	11%	Weak Tornado
EF2	13	3%	Strong Tornado
EF3	4	1%	Severe Tornado
EF4	0	0%	Devastating Tornado
EF5	0	0%	Incredible Tornado
Undetermined	12	3%	Undetermined Strength

Source: NOAA; Tornado Project Online

## 4. PROBABILITY

Tornadoes are an annual occurrence in Colorado. On average, most tornadoes in Colorado occur in June, followed by July and May, mainly during afternoon or evening hours. With increased coverage of Doppler radar, the increasing population, and greater attention to storm and tornado chasing, there is a resulting increase in the number of tornado reports over the past several decades. This can create the appearance of an increasing trend in tornado frequency when the increase in numbers can be attributed to advances in technology and reporting. Colorado is on the western edge of “Tornado Alley” which is shown in Figure 3-52.

FIGURE 3-52 NATIONAL ATMOSPHERIC FACTORS CONTRIBUTING TO TORNADOES



Source: Wikimedia Commons

## 5. PREVIOUS OCCURENCES

Since 2007, Colorado has averaged 41 tornadoes per year. This number can fluctuate drastically from year to year, with only a few being reported, up to several dozen. Within this timeframe, 2017 has had the fewest events, with only 13 as of November, and 2010 has had the highest, with a record of 71. The highest number of tornadoes on record for any one year was in 1996 when a total of 98 were reported. Increasing population, improved communications, and more trained spotters have all resulted in more reported tornadoes each decade since the 1950s. Additionally, two federal disaster declarations were made for tornadoes since 1955, one

in 1965 and another in 2008. Table 3-116 and Table 3-117 provide historic tornado data for the last 10 years and by decade since 1950.

**TABLE 3-116 TORNADO EVENTS, DEATHS, AND INJURIES, 2007-2017**

Year	Reported Events	Deaths	Injuries	Property Damage
2007	57	2	9	\$ 4,098,000
2008	40	1	79	\$ 147,080,000
2009	46	0	2	\$ 860,000
2010	71	0	0	\$ 550,000
2011	21	0	0	\$ 40,000
2012	34	0	8	\$ 1,160,000
2013	27	0	0	\$ 5,000
2014	50	0	2	\$ 8,000
2015	57	0	0	\$ 229,500
2016	39	0	4	\$ 213,500
2017	13	0	0	\$ 2,000
<b>Total</b>	<b>455</b>	<b>3</b>	<b>104</b>	<b>\$ 154,246,000</b>

Source: NOAA

**TABLE 3-117 TORNADO EVENTS, DEATHS, INJURIES, AND DAMAGE BY DECADE**

Years	Count	Deaths	Injuries	Property Damage	Crop Damage	Total Damage
1950-59	111	0	16	\$ 1,102,570	\$ 0	\$ 1,102,570
1960-69	137	2	20	\$ 1,261,520	\$ 0	\$ 1,261,520
1970-79	204	0	25	\$ 10,677,280	\$ 0	\$ 10,677,280
1980-89	340	0	62	\$ 68,991,570	\$ 0	\$ 68,991,570
1990-99	525	0	27	\$ 34,310,500	\$ 6,502,500	\$ 40,813,000
2000-09	443	3	111	\$ 170,596,000	\$ 2,000	\$ 170,598,000
2010-17	312	0	14	\$ 2,208,000	\$ 115,000	\$ 2,323,000
<b>Total</b>	<b>2,072</b>	<b>5</b>	<b>275</b>	<b>\$ 289,147,440</b>	<b>\$ 6,619,500</b>	<b>\$ 295,766,940</b>

Source: NOAA

Although Colorado’s overall death toll from tornadoes is relatively low over the last 60 years, the state’s total deaths has increased from two to five since 2000. These three deaths are the result of two events that occurred in 2007 and 2008. They are described below by the National Climatic Data Center (NCDC).

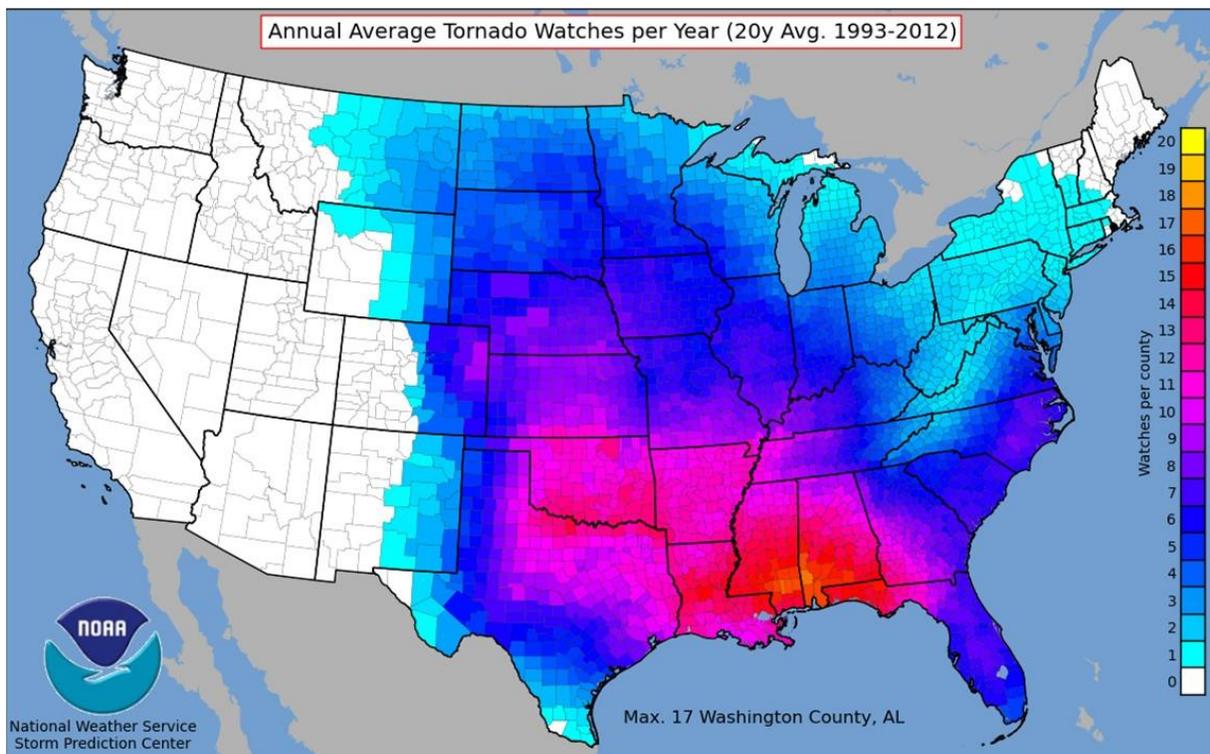
**Town of Holly - March 28, 2007:** “With a maximum rating of EF3 and a maximum damage path width of 900 yards, the tornado raced through Holly, causing two fatalities and nine injuries. Over 200 residences and other buildings were affected or destroyed. Two people were killed

and nine others were injured. The damage path was around 28 miles long...extending into Kiowa County. The last substantial damage with the tornado was 12 miles north of Holly...in northeast Prowers County...where a ranch sustained high end EF3 damage.”

**Weld and Larimer Counties - May 22, 2008:** “A powerful tornado swept north-northwestward across Weld County and into Larimer County, carving a path of destruction, nearly 39 miles in length. The tornado, up to one-mile wide at times, initially touched down northeast of Platteville and finally lifted six miles west-northwest of Wellington. A tornado assessment in the aftermath of the tornado revealed extensive areas of damage. On the enhanced Fujita Scale there were pockets of EF3 damage, mainly near the Missile Silo Park Campground, and to businesses and home in eastern Windsor. There was one fatality, and 78 injuries. One man was killed when he tried to escape the trailer park in his motor home. Preliminary estimates from FEMA indicated 850 homes were damaged, and nearly 300 homes were significantly damaged or destroyed. Privately insured damages totaled \$147 million, and the Poudre Valley Rural Electric Association reported \$1 million of damage to electric transmission lines.”

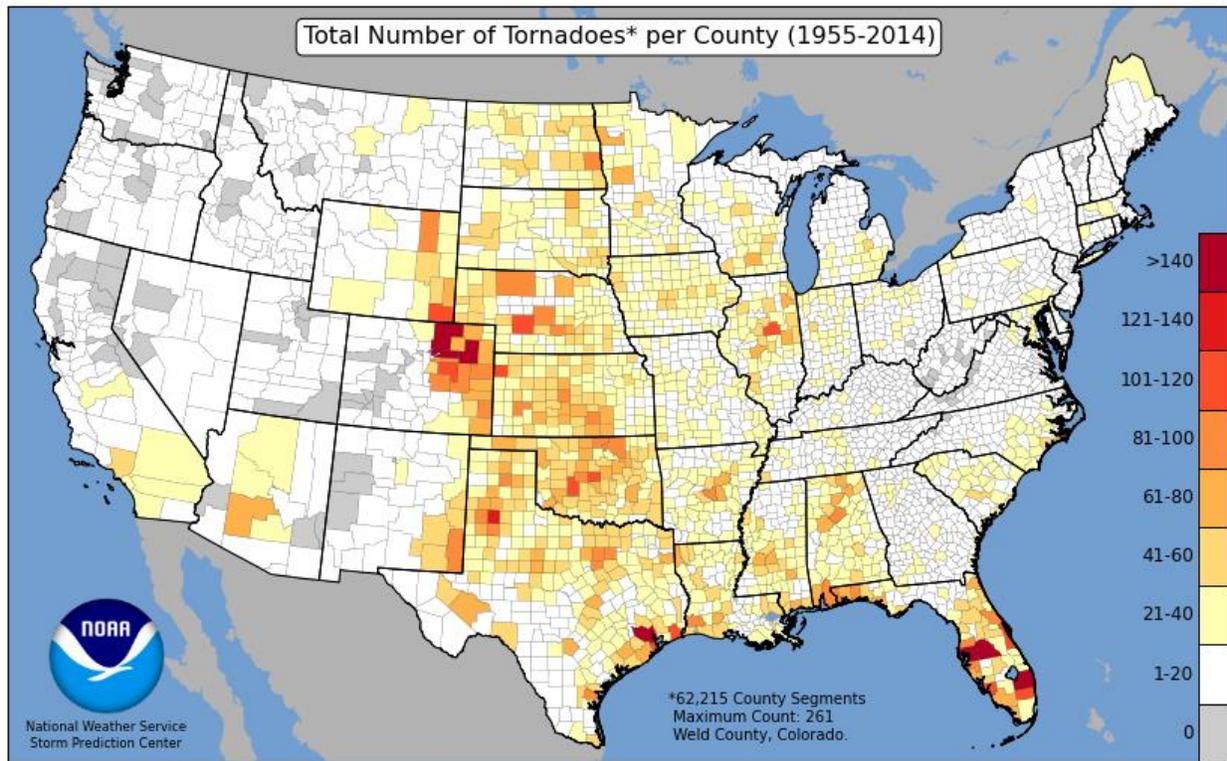
Below, Figure 3-53 and Figure 3-54 illustrate national tornado watches and actual tornadoes (per county) over the selected time periods. These figures remain the best available data presented on a national-scale map. These further support the concept of Colorado being in the “Tornado Alley.”

**FIGURE 3-53 ANNUAL AVERAGE TORNADO WATCHES PER YEAR, 1993-2012**



Source: NOAA

FIGURE 3-54 TORNADOES PER COUNTY, 1955-2014



Source: NOAA

## 6. IMPACT ANALYSIS

The greatest vulnerability to be faced would be in the event an EF3 or higher tornado were to hit a major metropolitan area such as Fort Collins, Denver, Colorado Springs, or Pueblo and their surrounding communities. Substantial damage could be incurred by state, local, and federal facilities, and the damage to infrastructure would be enormous with lost power, water, sewer, gas, and communications.

The regular functionality and continuity of government would be severely hampered. Emergency response would be largely dedicated to helping survivors, clearing debris, and responding to secondary hazards such as building collapse and fires; this would result in fire, police, and medical resources being stretched thin throughout the area.

Homes, businesses, and infrastructure would suffer extensive damage in such an event. Homes that are either in the direct path or are on the outer edges would likely be destroyed, resulting in severe injuries and death. People who are in vehicles, wildlife, and livestock, are also at a substantially greater risk to suffer fatal injuries than those inside. It is highly likely that some people would be permanently displaced, and would not return. This would leave empty or debris-riddled lots that would become the responsibility of the jurisdiction in which they reside.

Roads and bridges could be damaged due to either wind or debris damages, resulting in significant detours and blockages that would affect traffic patterns. Any such blockages would result in limited school bus and mail routes, and other government functions. Overpasses may become impassable due to debris. Power and water outages may also occur, which can in turn cause food spoilage and sanitation problems for communities. Schools, hospitals, grocery stores, and other critical-need and economically-important facilities could be damaged and closed for extended periods. Employment could also be affected because of businesses that close due to damage or loss of business commerce.

Such a scenario can still happen even with the advances in meteorology. Warning times are always short, but in some instances may not be possible at all.

An updated list (as of December 2017) of tornadoes causing death or significant injuries in Colorado are listed and described in Table 3-118. A further discussion of overall consequences of tornadoes follows Table 3-119.

**TABLE 3-118 TORNADOES CAUSING DEATH OR AT LEAST SEVEN INJURIES, 1915-2017**

<b>Date</b>	<b>Deaths and Injuries</b>	<b>Description</b>
<b>June 30, 1915</b>	1 dead, 5 injured	Three homes were destroyed on ranches and farms 20 miles southwest of Lamar, Bent County.
<b>Aug. 10, 1917</b>	1 dead, 7 injured	A man was killed when he took shelter in a dry goods store that was destroyed at Two Buttes, Baca County.
<b>Nov. 4, 1922</b>	4 dead, 25 injured	Unusual for the season, this tornado hit a farmhouse in Lincoln County, 20 miles north of Sugar City.
<b>Nov. 4, 1922</b>	1 dead, 3 injured	At the Pleasant Valley School 11 miles ESE of Holyoke a teacher was killed in her "teacherage" home.
<b>Aug. 10, 1924</b>	10 dead, 8 injured	Nine children and one woman died in a farmhouse near Thurman, Washington County.
<b>June 14, 1925</b>	1 dead, 2 injured	A small tornado destroyed a poultry house and killed a child in Pueblo.
<b>Aug. 10, 1926</b>	1 dead, 2 injured	Two homes were destroyed on farms north of Padroni, Logan County. A child was killed.
<b>June 8, 1928</b>	2 dead, 4 injured	Seven farms were devastated near the Colorado/Oklahoma border. Deaths were in Baca County.
<b>June 29, 1928</b>	2 dead, 50 injured	Women died in each of two farmhouses that were completely leveled. This tornado passed just west of Johnstown.
<b>Oct. 2, 1930</b>	3 dead, 4 injured	Three people left their car and sought shelter in a farmhouse 14 miles NW of Fowler; the home and car were destroyed.
<b>April 30, 1942</b>	4 dead, 12 injured	Near McClave, Bent County, and Eads, Kiowa County, people were killed in the destruction of four different homes.
<b>June 27, 1960</b>	2 dead, 4 injured	Ten miles north of Holyoke, Phillips County a massive tornado threw two cars a quarter mile.
<b>Oct. 17, 1971</b>	0 dead, 9 injured	A tornado struck a mobile home park in the main street business district of Wray, Yuma County.

Date	Deaths and Injuries	Description
June 3, 1981	0 dead, 42 injured	Nearly 800 homes suffered damage as a tornado cut a swath through the heart of Thornton, a suburb of Denver.
June 15, 1988	0 dead, 7 injured	Moving to the northeast then southeast and then to the south, a tornado cut an erratic path across south Denver.
June 6, 1990	0 dead, 14 injured	A tornado destroyed 80% of the business district of Limon, Lincoln County, as well as 228 of the town's 750 homes.
July 7, 1993	0 dead, 8 injured	The injuries were on farms that were torn apart near Bethune and Burlington, Kit Carson County.
March 28, 2007	2 dead, 9 injured	Over 200 residences and other buildings were affected or destroyed near the town of Holly, Prowers County and extending into Kiowa County. Two people were killed and nine others were injured. The damage path was around 28 miles long.
May 22, 2008	1 dead, 78 injured	A powerful tornado swept north-northwestward across Weld County and into Larimer County, carving a path of destruction, nearly 39 miles in length.
April 27, 2012	0 dead, 7 injured	Tornado touched down near Lamar, Prowers County at around 2 am.

Source: NOAA, Tornado History Project

TABLE 3-119 TORNADO EMAP IMPACT SUMMARY

Consideration	Description
<b>General Public</b>	Anyone without adequate shelter during an event; population of the counties determined most at risk. High risk of injury and death.
<b>First Responders</b>	Exposure exists to personnel performing routine duties when event occurs; storm-related duties are primarily post-event, however unsafe structural or environmental conditions may persist during the response period.
<b>Property</b>	Buildings, vehicles, signage, and/or any unsecured property may be affected during an event. Property may be destroyed or have significant damage.
<b>Facilities and Infrastructure</b>	Buildings, equipment, and utility infrastructure are exposed to tornadoes. Value of state assets located in highest tornado-prone counties totals over \$4 billion.
<b>Economic</b>	Potential loss of facilities or infrastructure function or accessibility and uninsured damages. Impact to transportation sector and movement of goods. Historic events in Colorado have impacted community business districts where a majority of businesses are lost.
<b>Environment</b>	Significant impact related to tree damage. Possible cascading water quality issues from damaged water treatment facilities.
<b>Continuity of Government and Services</b>	Loss of facilities or infrastructure function or accessibility, or ability to provide services. Power interruption is likely if not adequately equipped with backup generation.

Consideration	Description
<b>Confidence in Government</b>	Public holds high expectations of government capabilities for warning, public information, and response and recovery activities related to a tornado. High expectations for rapid restoration of critical lifelines.
<b>Critical Assets</b>	Potential impact to water treatment facilities, government buildings, public safety facilities and equipment, and healthcare services.

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

Since 1915, there are reports of 40 deaths and 561 injuries resulting from tornadoes in Colorado. The majority of deaths occurred prior to 1950. The number of deaths has significantly decreased as warning technology has advanced, and since 1950 only five deaths have been attributed to tornadoes. Similarly, only 267 injuries were reported from tornadoes over this same 60-year period. Table 3-120 describes the human and financial losses (in actual dollars at the time of the event) reported in Colorado between 1950 to 2017.

TABLE 3-120 TORNADO EVENTS, DEATHS, AND INJURIES BY COUNTY, 1950-2017

County	# of Reported Events	Deaths	Injuries	Property Damage	Crop Damage	Total Damage
<b>Adams</b>	173	0	43	\$ 26,801,270	\$ 6,500,000	\$ 33,301,270
<b>Alamosa</b>	17	0	0	\$ 21,840	\$ 0	\$ 21,840
<b>Arapahoe</b>	90	0	4	\$ 9,430,180	\$ 0	\$ 9,430,180
<b>Archuleta</b>	1	0	0	\$ 1,000	\$ 0	\$ 1,000
<b>Baca</b>	78	0	4	\$ 3,047,500	\$ 0	\$ 3,047,500
<b>Bent</b>	43	0	8	\$ 1,440,500	\$ 0	\$ 1,440,500
<b>Boulder</b>	11	0	0	\$ 282,500	\$ 0	\$ 282,500
<b>Broomfield</b>	0	0	0	\$ 0	\$ 0	\$ 0
<b>Chaffee</b>	1	0	0	\$ 25,000	\$ 0	\$ 25,000
<b>Cheyenne</b>	76	0	5	\$ 2,630,310	\$ 2,500	\$ 2,632,810
<b>Clear Creek</b>	2	0	0	\$ 0	\$ 0	\$ 0
<b>Conejos</b>	4	0	0	\$ 25,250	\$ 0	\$ 25,250
<b>Costilla</b>	6	0	0	\$ 5,000	\$ 0	\$ 5,000
<b>Crowley</b>	16	0	0	\$ 27,750	\$ 0	\$ 27,750
<b>Custer</b>	7	0	0	\$ 5,000	\$ 0	\$ 5,000
<b>Delta</b>	3	0	0	\$ 25,000	\$ 0	\$ 25,000
<b>Denver</b>	16	0	13	\$ 32,575,030	\$ 0	\$ 32,575,030
<b>Dolores</b>	0	0	0	\$ 0	\$ 0	\$ 0
<b>Douglas</b>	61	0	6	\$ 990,340	\$ 0	\$ 990,340
<b>Eagle</b>	2	0	0	\$ 25,000	\$ 0	\$ 25,000

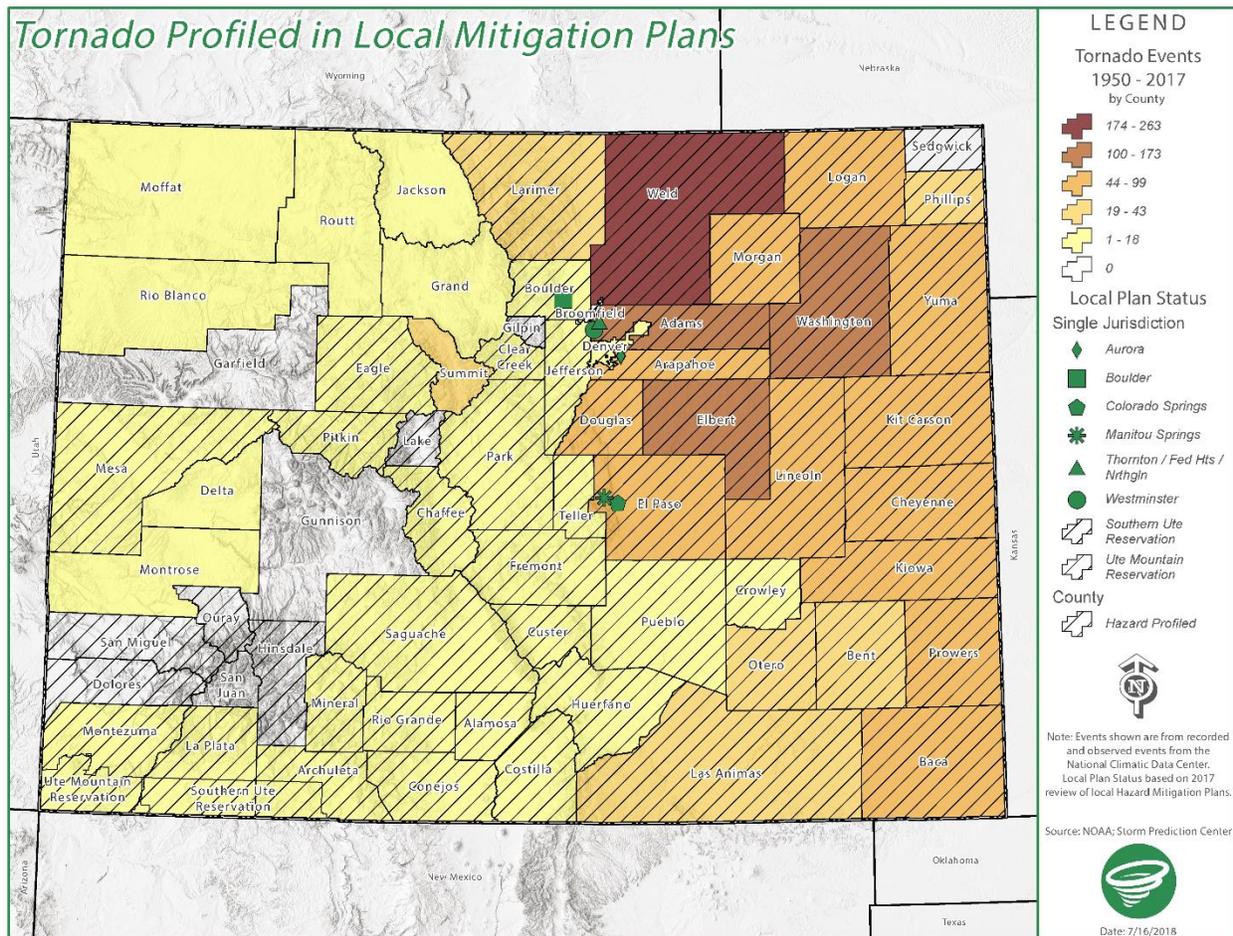
County	# of Reported Events	Deaths	Injuries	Property Damage	Crop Damage	Total Damage
El Paso	91	0	19	\$ 9,730,060	\$ 0	\$ 9,730,060
Elbert	122	0	0	\$ 585,930	\$ 0	\$ 585,930
Fremont	9	0	0	\$ 53,500	\$ 0	\$ 53,500
Garfield	0	0	0	\$ 0	\$ 0	\$ 0
Gilpin	0	0	0	\$ 0	\$ 0	\$ 0
Grand	1	0	0	\$ 2,500	\$ 0	\$ 2,500
Gunnison	0	0	0	\$ 0	\$ 0	\$ 0
Hinsdale	0	0	0	\$ 0	\$ 0	\$ 0
Huerfano	8	0	2	\$ 527,500	\$ 0	\$ 527,500
Jackson	1	0	0	\$ 0	\$ 0	\$ 0
Jefferson	13	0	0	\$ 2,500,090	\$ 0	\$ 2,500,090
Kiowa	87	0	2	\$ 739,090	\$ 0	\$ 739,090
Kit Carson	88	0	6	\$ 408,960	\$ 0	\$ 408,960
La Plata	5	0	0	\$ 85,000	\$ 2,000	\$ 87,000
Lake	0	0	0	\$ 0	\$ 0	\$ 0
Larimer	32	0	0	\$ 65,310	\$ 0	\$ 65,310
Las Animas	31	0	1	\$ 298,060	\$ 0	\$ 298,060
Lincoln	99	0	15	\$ 29,507,710	\$ 110,000	\$ 29,617,710
Logan	81	0	4	\$ 3,345,090	\$ 0	\$ 3,345,090
Mesa	10	0	0	\$ 1,000	\$ 0	\$ 1,000
Mineral	1	0	0	\$ 10,000	\$ 0	\$ 10,000
Moffat	7	0	0	\$ 28,000	\$ 0	\$ 28,000
Montezuma	3	0	0	\$ 50,000	\$ 0	\$ 50,000
Montrose	3	0	1	\$ 23,000	\$ 0	\$ 23,000
Morgan	73	0	0	\$ 1,090,650	\$ 0	\$ 1,090,650
Otero	25	0	0	\$ 160,750	\$ 0	\$ 160,750
Ouray	0	0	0	\$ 0	\$ 0	\$ 0
Park	5	0	0	\$ 30,000	\$ 0	\$ 30,000
Phillips	40	0	1	\$ 828,030	\$ 0	\$ 828,030
Pitkin	1	0	0	\$ 25,000	\$ 0	\$ 25,000
Prowers	81	2	17	\$ 5,600,280	\$ 0	\$ 5,600,280
Pueblo	18	0	0	\$ 132,030	\$ 0	\$ 132,030
Rio Blanco	3	0	0	\$ 37,500	\$ 0	\$ 37,500
Rio Grande	2	0	0	\$ 8,000	\$ 0	\$ 8,000
Routt	2	0	0	\$ 2,500	\$ 0	\$ 2,500
Saguache	5	0	0	\$ 252,500	\$ 0	\$ 252,500
San Juan	0	0	0	\$ 0	\$ 0	\$ 0
San Miguel	0	0	0	\$ 0	\$ 0	\$ 0
Summit	0	0	0	\$ 0	\$ 0	\$ 0
Sedgwick	34	2	10	\$ 358,310	\$ 0	\$ 358,310

County	# of Reported Events	Deaths	Injuries	Property Damage	Crop Damage	Total Damage
Teller	8	0	0	\$ 22,530	\$ 0	\$ 22,530
Washington	132	0	4	\$ 660,620	\$ 0	\$ 660,620
Weld	263	1	92	\$ 150,740,410	\$ 5,000	\$ 150,745,410
Yuma	81	0	18	\$ 3,879,060	\$ 0	\$ 3,879,060
<b>Total</b>	<b>2072</b>	<b>5</b>	<b>275</b>	<b>\$ 289,147,440</b>	<b>\$ 6,619,500</b>	<b>\$ 295,766,940</b>

Source: NOAA

Based upon an updated (2017) review of local hazard mitigation plans, Figure 3-55 illustrates which local jurisdictions profiled tornado as a hazard, compared with historical tornado events. Nearly all counties along and east of the Front Range, as well as several single jurisdictions have profiled tornadoes.

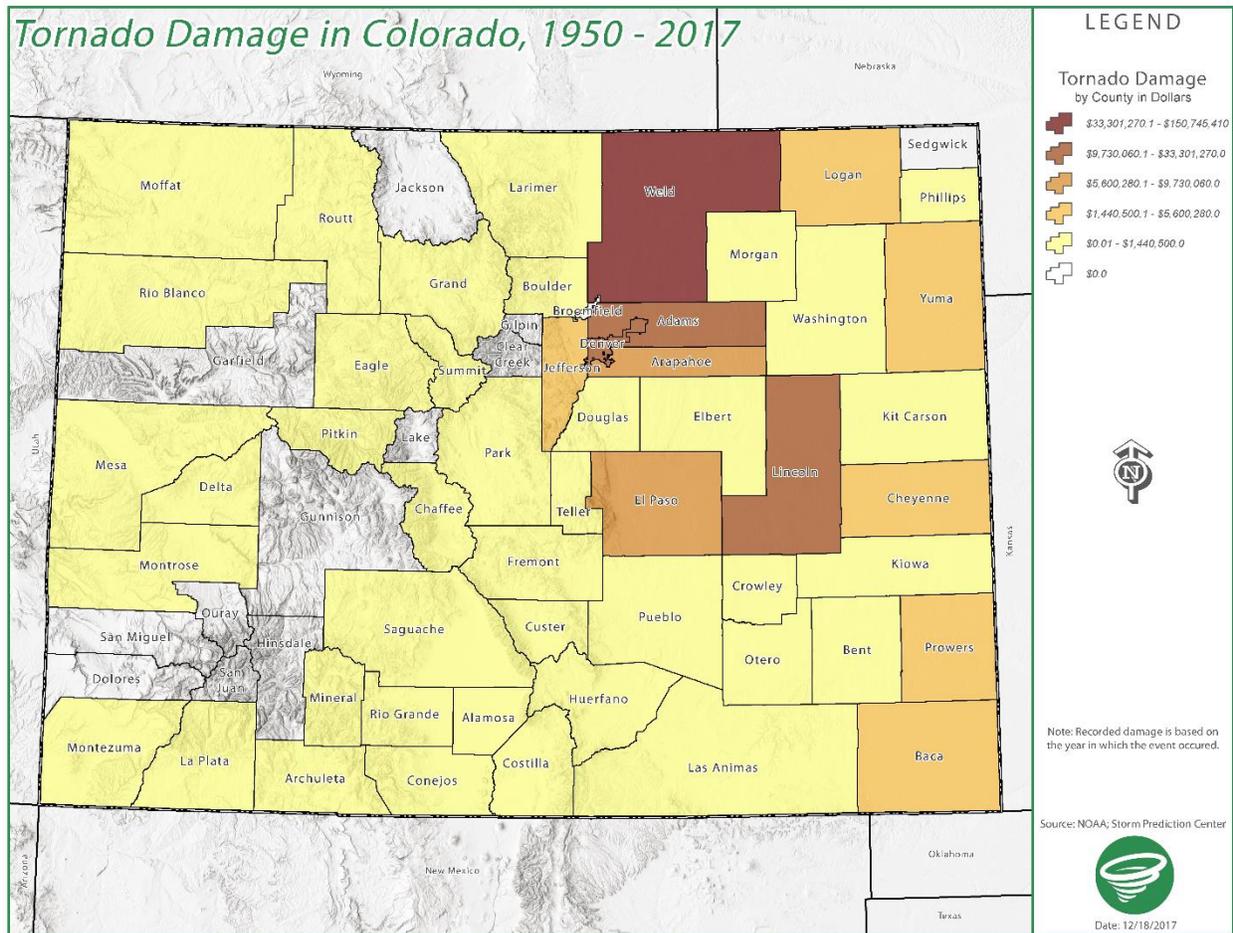
FIGURE 3-55 TORNADO HAZARD IN LOCAL MITIGATION PLANS



Based upon historical data, Figure 3-56 highlights damage totals (by county) for the past 67 years. Weld County, with the highest number of tornadoes reported for a Colorado county, also incurred the most damage totaling over \$150 million. This equates to over half of all recorded

damages experienced within the state combined. Adams, Denver, and Lincoln Counties, having experienced the next three highest damages, have each incurred losses between \$29 and \$33 million. These each equate to 10 percent of the statewide historical damages.

**FIGURE 3-56 TORNADO DAMAGES**



Based on review of local hazard mitigation plans, 12 jurisdictions profile tornadoes as one of their top four hazards. Within those 12 jurisdictions, a total of 375,845 structures and parcels are in tornado hazard areas, and 3,407 critical facilities are in tornado hazard areas. Table 3-121 describes this information in more detail, as well as the total estimated losses.

**TABLE 3-121 LOCAL HAZARD MITIGATION PLANS**

Jurisdiction	# of Structures/ Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate	Loss Estimate Methodology
Adams County	154,314	518		\$1,300,000	avg losses per year
Baca County	4,094	187			

Jurisdiction	# of Structures/ Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate	Loss Estimate Methodology
<b>Cheyenne County</b>	1,922	47			
<b>Crowley County</b>	2,143	117			
<b>Kiowa County</b>	1,474	42			
<b>Kit Carson County</b>	6,113	186			
<b>Montrose County (Unincorporated)</b>					
<b>Otero County</b>	12,103	344			
<b>Prowers County</b>	7,933	287			
<b>Southern Ute Indian Tribe</b>					
<b>Thornton/Federal Heights/Northglenn</b>	64,000 (housing units)	395 (parcels containing critical facilities)			
<b>Weld County</b>	121,749	1,284			
<b>Total</b>	<b>375,845</b>	<b>3,407</b>		<b>\$1,300,000</b>	

## 8. FUTURE DEVELOPMENT

Population growth and development contribute to increased exposure of people and property to tornadoes and their related impacts. Understanding changes in hazard exposure over time is an important element of comprehensive hazard mitigation planning.

Colorado continues to experience some of the largest population growth in the country and future projections seem to indicate a similar trend should be expected. Table 3-122 presents the projected housing growth on a county scale from 2010 to 2030. Those counties that have a large expected percent change in housing as well as a history of significant tornado events are most at risk for future exposure. An increased building stock means that there are more homes and buildings threatened by tornadoes.

Weld County has the highest number of past tornadoes, as well as an expected increase in housing of 93 percent. The next most at-risk county is Adams, with 173 previous tornadoes, and an increase of 60 percent for its housing stock. Elbert County has the highest percent increase in housing of any county, at 120 percent.

TABLE 3-122 HOUSING PROJECTIONS (2010 TO 2030) AND HISTORICAL EVENTS

County	Historical Tornadoes	Housing Percent Change	Growth Rating
<b>Weld</b>	263	93%	<b>Highest</b>

County	Historical Tornadoes	Housing Percent Change	Growth Rating
Adams	173	60%	Highest
Elbert	91	120%	Highest
Arapahoe	90	52%	Highest
Douglas	61	67%	Highest
Summit	34	49%	Highest
Larimer	32	47%	Highest
Park	5	65%	Highest
Montrose	3	61%	Highest
Eagle	2	56%	Highest
Routt	2	46%	Highest
Archuleta	1	61%	Highest
Broomfield	0	78%	Highest
San Miguel	0	64%	Highest
Garfield	0	51%	Highest
La Plata	0	50%	Highest
El Paso	122	40%	High
Lincoln	99	26%	High
Pueblo	18	26%	High
Denver	16	37%	High
Crowley	16	26%	High
Jefferson	13	30%	High
Boulder	11	37%	High
Mesa	10	38%	High
Fremont	9	28%	High
Custer	7	41%	High
Montezuma	3	37%	High
Delta	3	35%	High
Grand	1	44%	High
Chaffee	1	38%	High
Pitkin	1	34%	High
Gunnison	0	28%	High
Kit Carson	88	20%	Moderate
Kiowa	87	12%	Moderate
Logan	81	21%	Moderate
Yuma	81	17%	Moderate
Morgan	73	26%	Moderate
Las Animas	31	23%	Moderate
Alamosa	17	25%	Moderate
Teller	8	23%	Moderate
Huerfano	8	13%	Moderate
Lake	5	21%	Moderate

County	Historical Tornadoes	Housing Percent Change	Growth Rating
Saguache	5	17%	Moderate
Conejos	4	14%	Moderate
Clear Creek	2	20%	Moderate
Hinsdale	0	19%	Moderate
Ouray	0	13%	Moderate
Gilpin	0	12%	Moderate
Washington	132	8%	Low
Prowers	81	3%	Low
Baca	78	-6%	Low
Cheyenne	76	11%	Low
Bent	43	7%	Low
Phillips	40	1%	Low
Otero	25	6%	Low
Moffat	7	7%	Low
Costilla	6	10%	Low
Rio Blanco	3	10%	Low
Rio Grande	2	7%	Low
Mineral	1	10%	Low
Jackson	1	9%	Low
San Juan	0	10%	Low
Dolores	0	4%	Low
Sedgwick	0	1%	Low

Source: NOAA, Colorado State Demography Office, 2017

The following section provides county-scale tornado exposure projections by comparing current tornado risk with projected population data. Through this analysis, Weld, Adams, and El Paso Counties show the highest risk with respect to future development. The combination of a growing population and high tornado threat results in increasing exposure over that of today.

The Counties of Elbert, Douglas, Denver, Summit, Arapahoe, and Lincoln are projected to experience the next highest exposure to tornadoes through 2030.

TABLE 3-123 TORNADO EXPOSURE PROJECTIONS

Future Tornado Exposure Projections					
		County Population Percent Change Projections, 2010 to 2030			
Combined Risk (Tornado)		-13% to 2%	3% to 17%	18% to 34%	35% to 89%
High ↑ Moderate	5-6	Moderate	High	Severe	Extreme
	3-4	Slight	Moderate	High	Severe
	0-2	Negligible	Slight	Moderate	High

The Combined Risk calculations in Table 3-123 are based on the methodology outlined in Table 3-124. Values (between zero and three) have been assigned to total deaths and injuries and total number of tornado events per county. The Jenks Natural Breaks algorithm was used to classify these historical data sets. The sum of these values then arrive at the Combined Risk Value for each county.

TABLE 3-124 COMBINED RISK METHODOLOGY

Deaths and Injuries (1950 – 2017)	Value	# of Tornado Events (1950-2017)	Value
44-93	3	133-263	3
9-43	2	44-132	2
1-8	1	1-46	1
0	0	0	0

Exposure to tornadoes is expected to intensify across the State of Colorado between 2010 and 2030 as population increases. The darker, more red colors in Table 3-123 illustrate relative rates of increase in exposure between counties. This same information is also shown on the following Table 3-125 by county. As Colorado’s population increases, infrastructure and businesses will follow these population centers. This further adds to the potential future exposure that counties face from tornadoes. Colorado’s population and related business and infrastructure is concentrated in, and will continue to intensify, in areas of high tornado activity. Figure 3-57 presents this same information on a statewide map.

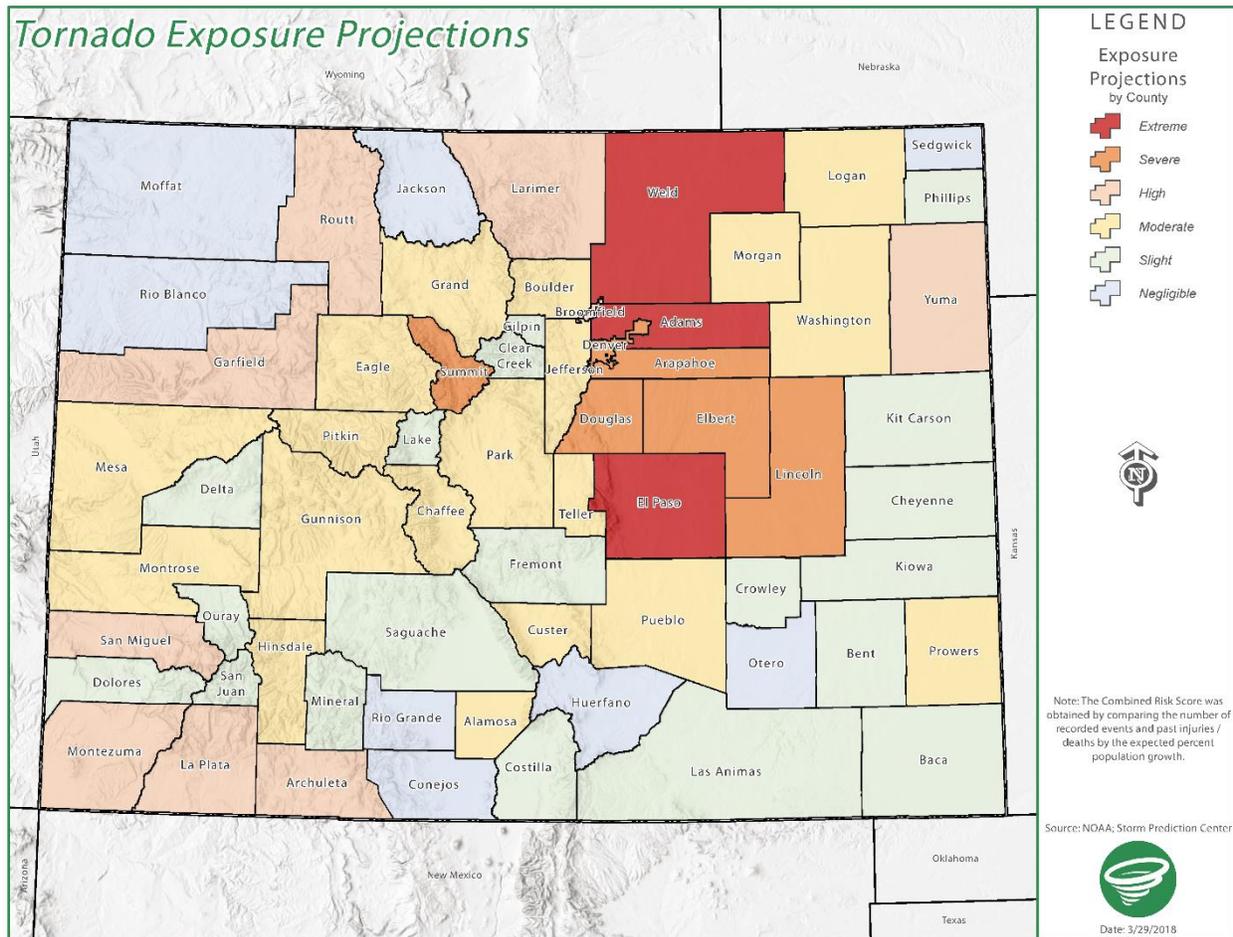
TABLE 3-125 TORNADO EXPOSURE PROJECTIONS, 2010 TO 2030

County	Combined Risk	Population Change	Exposure Rating
Weld	6	81%	Extreme
Adams	6	48%	Extreme
El Paso	5	36%	Extreme
Elbert	3	89%	Severe
Douglas	4	44%	Severe
Denver	3	42%	Severe
Summit	4	41%	Severe
Arapahoe	4	36%	Severe
Lincoln	5	21%	Severe
Broomfield	0	71%	High
San Miguel	0	59%	High
La Plata	1	42%	High
Larimer	2	42%	High
Routt	1	40%	High
Archuleta	1	40%	High
Garfield	0	38%	High
Montezuma	1	37%	High
Yuma	5	7%	High
Park	1	34%	Moderate
Eagle	1	34%	Moderate
Grand	1	32%	Moderate
Montrose	2	30%	Moderate
Hinsdale	0	29%	Moderate
Chaffee	1	29%	Moderate
Boulder	1	28%	Moderate
Gunnison	0	26%	Moderate
Teller	1	25%	Moderate
Mesa	1	24%	Moderate
Alamosa	1	22%	Moderate
Jefferson	1	21%	Moderate
Pueblo	1	20%	Moderate
Custer	1	20%	Moderate
Pitkin	1	18%	Moderate
Morgan	3	16%	Moderate
Logan	4	14%	Moderate
Washington	4	5%	Moderate
Prowers	5	-5%	Moderate
Lake	0	17%	Slight
Ouray	0	17%	Slight
Mineral	1	16%	Slight

County	Combined Risk	Population Change	Exposure Rating
Clear Creek	1	14%	Slight
Gilpin	0	13%	Slight
Saguache	1	9%	Slight
Delta	1	8%	Slight
Costilla	1	7%	Slight
Fremont	1	5%	Slight
Dolores	0	5%	Slight
Crowley	1	5%	Slight
San Juan	0	5%	Slight
Cheyenne	4	2%	Slight
Kit Carson	4	-1%	Slight
Phillips	3	-3%	Slight
Bent	4	-5%	Slight
Kiowa	4	-8%	Slight
Las Animas	3	-9%	Slight
Baca	4	-13%	Slight
Rio Blanco	1	2%	Negligible
Conejos	1	1%	Negligible
Huerfano	2	-1%	Negligible
Sedgwick	0	-3%	Negligible
Moffat	1	-3%	Negligible
Rio Grande	1	-5%	Negligible
Otero	1	-7%	Negligible
Jackson	1	-7%	Negligible

Source: NOAA, Colorado State Demography Office, 2017

FIGURE 3-57 TORNADO EXPOSURE PROJECTIONS, 2010 TO 2030



In review of local hazard mitigation plans, the following information was provided on future development trends in Colorado Springs in regard to tornadoes:

- Continuing development pressures along the Front Range will likely increase the overall vulnerability to tornadoes. Building codes in place can reduce the overall impacts; however significant tornadoes are unpredictable and are capable of destroying buildings with incredible structural integrity. As the city grows, development to the east will be particularly more vulnerable to tornadoes, as most of the tornadoes recorded in the county occurred further away from the foothills.

## 9. CLIMATE CHANGE

According to the best data available at the time of this plan update, the future impacts of climate change are not expected to influence future tornado events (FEMA 2017 and Lukas et al. 2014).

## 10. RISK TO STATE ASSETS

With the majority of state asset value located along Colorado's Front Range, it follows that many state assets located in this area and to the east are at risk from tornadoes. In counties with an extreme or severe future exposure rating to tornadoes, state asset valuations sum up to over \$7 billion, roughly 35 percent of the state's total valuations for all of its assets. Table 3-126 shows state asset exposure projections from 2010 to 2030.

With the exposure of state assets to the threat of tornado, damages and losses are expected from this hazard. However, since 2008, there has only been one state asset real property loss attributable to a tornado, resulting in \$422,189 in losses. Within the counties along the Front Range with high tornado frequency, the strength of the events tends to be on the lower end of the Enhanced Fujita Scale and further east of where state assets are concentrated along the foothills. The exception is the EF3 tornado occurring in Weld County near the Interstate 25 corridor that impacted the Town of Windsor and surrounding areas. It is important to note that state asset loss data is only available for state assets included in the 2017 Office of Risk Management (ORM) database. These numbers exclude many Higher Education assets, and therefore may under-represent actual losses.

Tornadoes cause the greatest damage to structures of light construction. This suggests that similar to vulnerability to strong wind, the result of state buildings being of moderate or heavy construction may lead to less vulnerability. Randomness of location and extent of tornadoes suggest that emergency protective measures for in-place sheltering may be more cost-beneficial than exterior or structural requirements or enhancements related to mitigating severe wind.

TABLE 3-126 STATE ASSET EXPOSURE PROJECTIONS, 2010 TO 2030

County	State Assets	Asset Valuation	Exposure Rating
Adams	225	\$2,161,277,205	Extreme
Weld	270	\$723,621,025	Extreme
El Paso	252	\$664,445,003	Extreme
Denver	479	\$2,631,589,250	Severe
Arapahoe	231	\$539,093,242	Severe
Summit	54	\$210,520,143	Severe
Lincoln	80	\$115,435,435	Severe
Douglas	139	\$41,437,868	Severe
Elbert	16	\$6,135,197	Severe
Larimer	931	\$2,520,380,927	High
Garfield	227	\$935,656,624	High
La Plata	199	\$459,565,269	High
Montezuma	92	\$26,250,957	High

County	State Assets	Asset Valuation	Exposure Rating
Routt	153	\$19,636,862	High
Yuma	84	\$14,101,083	High
Archuleta	68	\$12,576,015	High
Broomfield	7	\$7,925,505	High
San Miguel	36	\$6,959,484	High
Boulder	288	\$3,184,873,780	Moderate
Jefferson	481	\$1,220,747,270	Moderate
Pueblo	391	\$1,100,717,917	Moderate
Mesa	316	\$571,483,873	Moderate
Alamosa	123	\$361,142,477	Moderate
Logan	174	\$321,168,914	Moderate
Gunnison	146	\$297,472,630	Moderate
Chaffee	196	\$135,641,023	Moderate
Prowers	86	\$73,450,933	Moderate
Morgan	168	\$67,190,695	Moderate
Eagle	148	\$22,080,215	Moderate
Montrose	65	\$19,168,190	Moderate
Park	120	\$17,071,984	Moderate
Grand	69	\$12,702,273	Moderate
Teller	53	\$9,932,426	Moderate
Washington	31	\$4,317,254	Moderate
Hinsdale	19	\$1,605,114	Moderate
Custer	6	\$1,130,092	Moderate
Pitkin	14	\$712,333	Moderate
Fremont	360	\$762,885,780	Slight
Las Animas	118	\$152,450,902	Slight
Clear Creek	75	\$117,846,308	Slight
Bent	173	\$116,882,345	Slight
Crowley	28	\$99,475,999	Slight
Delta	116	\$39,890,610	Slight
Mineral	21	\$30,302,497	Slight
Gilpin	39	\$10,009,237	Slight
Ouray	46	\$8,684,296	Slight
Saguache	49	\$5,188,186	Slight
San Juan	22	\$4,603,609	Slight
Dolores	20	\$4,252,291	Slight
Costilla	28	\$4,179,435	Slight
Kit Carson	27	\$4,146,763	Slight

County	State Assets	Asset Valuation	Exposure Rating
Lake	21	\$2,881,105	Slight
Baca	14	\$1,559,394	Slight
Kiowa	8	\$1,308,651	Slight
Cheyenne	9	\$712,471	Slight
Phillips	5	\$196,988	Slight
Rio Grande	155	\$134,839,206	Negligible
Otero	83	\$79,711,658	Negligible
Rio Blanco	66	\$63,910,055	Negligible
Huerfano	66	\$35,640,305	Negligible
Moffat	90	\$15,349,886	Negligible
Jackson	85	\$13,799,847	Negligible
Conejos	41	\$6,598,803	Negligible
Sedgwick	30	\$1,827,494	Negligible

Source: Colorado State Demography Office, 2017; Office of Risk Management, 2017 and 2013

## 11. RESOURCES

- Colorado Department of Local Affairs (DoLA)
- Colorado Department of Transportation (CDOT) Emergency Operations Plan (EOP)
- Colorado Department of Transportation (CDOT) Threat and Hazard Identification and Risk Assessment (THIRA)
- Federal Emergency Management Agency (FEMA). (2017). Assessing Future Conditions, Colorado.
- Lukas, J., Barsugli, J., Doesken, N., Rangwala, I., and Wolter, K. (2014). Climate Change in Colorado: A Synthesis to Support Water Resources Management and Adaptation.
- National Climatic Data Center (NCDC)
- National Weather Service (NWS)
- Rocky Mountain Insurance Information Association (RMIIA)
- The Tornado Project Online

# WILDFIRE



## 1. DEFINITION

Wildfire is defined as an unplanned wildland fire, including unauthorized human-caused fires, escaped wildland fire use events, and escaped prescribed fire projects.

The data resulting from the 2018 Colorado Wildfire Risk Assessment Portal (CO-WRAP) update is pending at the time of this Plan update. Information from the 2018 CO-WRAP will be incorporated as it becomes available. In absence of the 2018 data, the 2013 CO-WRAP data is used throughout this profile.

Wildfires are divided into four categories:

**Wildland fire** – fuel consists mainly of natural vegetation.

**Interface or intermix fire** – urban/wildland fires that consist of vegetation and human-made fuels.

**Catastrophic Fire** – a very intense event that makes suppression exceedingly difficult and negatively impacts human values.

**Prescribed fire** – any fire ignited by management actions to meet specific objectives. A written, approved prescribed fire plan must exist, and National Environmental Policy Act (NEPA) programmatic agreement requirements (where applicable) must be met, prior to ignition.

Table 3-127 describes the hazard profile summary for wildfires.

TABLE 3-127 HAZARD PROFILE SUMMARY

Consideration	Impact	Description
<b>Location</b>	Statewide	Grassland and forest fires occur throughout the state. Eastern Plains, Front Range foothills, and the Western Slope all have high to moderate wildfire risk. Every county has some area determined at least a moderate risk.
<b>Previous Occurrences</b>	Perennial	Regular occurrences throughout the fire season from March to August, but forest and grass fires are a year-round occurrence. Human-caused or natural in origin. An annual average of 2,440 wildfires occur on federal, state, and private lands.
<b>Probability</b>	Expected	Events producing conditions prone to wildfires are expected to increase as the result of climate change. These conditions are variable based on precipitation, drought, fuel loading, lightning strikes, and other human activities.
<b>Extent</b>	Extensive	Major or long-term property damage that threatens structural stability, isolated deaths (average of one every two years) and injuries, impact to critical lifelines, potential impact to government’s ability to provide service.

Three main factors influence wildfire behavior - topography, fuel, and weather. Other hazards can contribute to the potential for wildfires or can influence wildfire behavior. High winds can down power lines, earthquakes can crack gas lines, and lightning can spark fires. Lightning is a major cause of structural fires and wildfires. In 1997, a lightning-caused warehouse fire in Denver resulted in a \$70 million loss. Drought conditions increase wildfire potential by decreasing fuel moisture. Warm winters, hot and dry summers, severe drought, insect and disease infestations, years of fire suppression, and growth in the Wildland-Urban Interface (WUI) continue to increase wildfire risk and the potential for catastrophic wildland fires in Colorado.

Forest insect epidemics and forest parasites contribute to wildfire potential by increasing fuel loading. Over the past two decades, Colorado has experienced an increase in insect infestations that have left vast areas of forest vulnerable to wildfire. These infestations, coupled with the increasing number of people who live in the WUI, where humans and human-made structures abut vegetation, and the effects of climate change make Colorado increasingly susceptible to large-scale fires that threaten human lives, communities, power lines, roads, domestic water supplies, wildlife habitat, and other important resources.

Protecting the WUI is the nation's fastest-growing firefighting expense. In 2015, the USDA projected that fighting wildfires will account for 67 percent of the annual budget by 2025. Protecting life and property in these areas is costly because fire managers must take an aggressive stand on the ground and from the air.

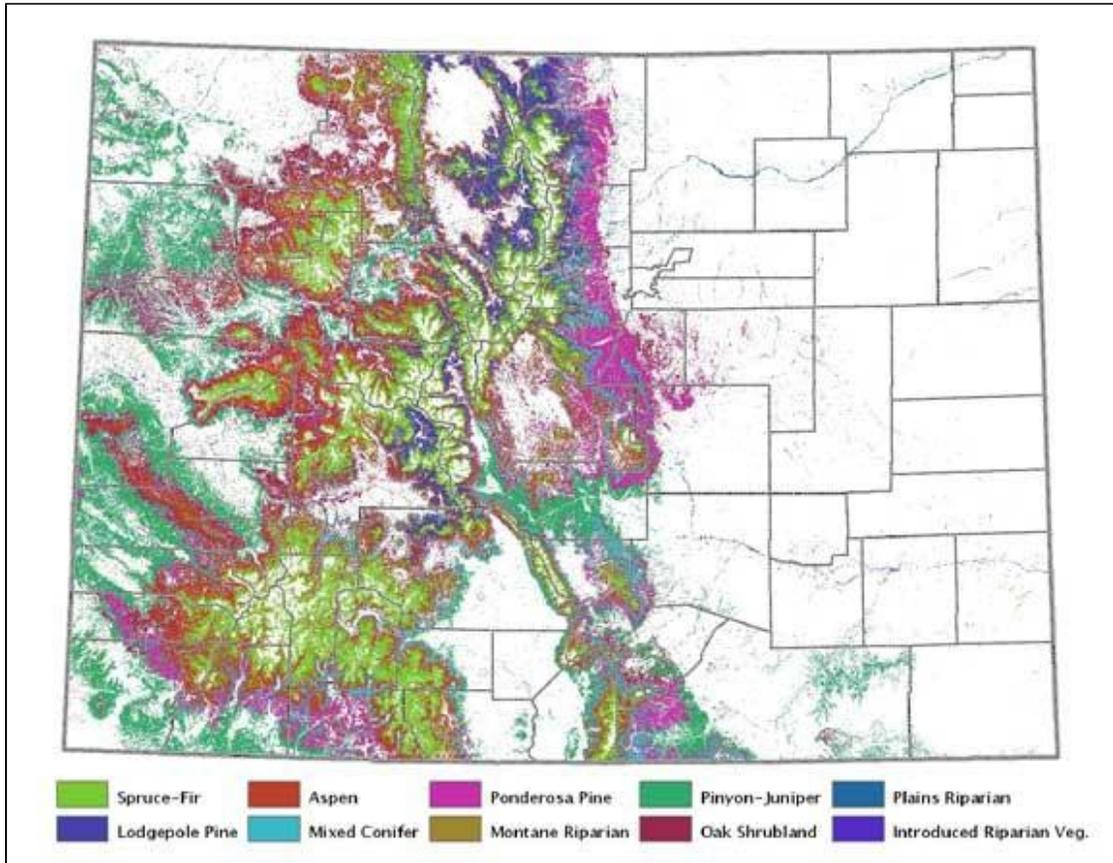
### **WILDLAND-URBAN INTERFACE (WUI)**

*The Wildland-Urban Interface, or WUI, is the area where houses meet or intermingle with undeveloped wildland vegetation. This makes the WUI a focal area for human-environment conflicts, such as the destruction of homes by wildfires (USFS).*

## **2. LOCATION**

The threat of wildfires is statewide in Colorado with the forests, grasslands, and wildland/urban interfaces all at risk. Figure 3-58 illustrates statewide land cover data showing the distribution of forested, shrub/scrub, and grassland areas throughout the state.

FIGURE 3-58 COLORADO LAND COVER BY VEGETATION TYPE



Source: Colorado State Forest Service (CSFS)

## CSFS AND WILDFIRE RISK

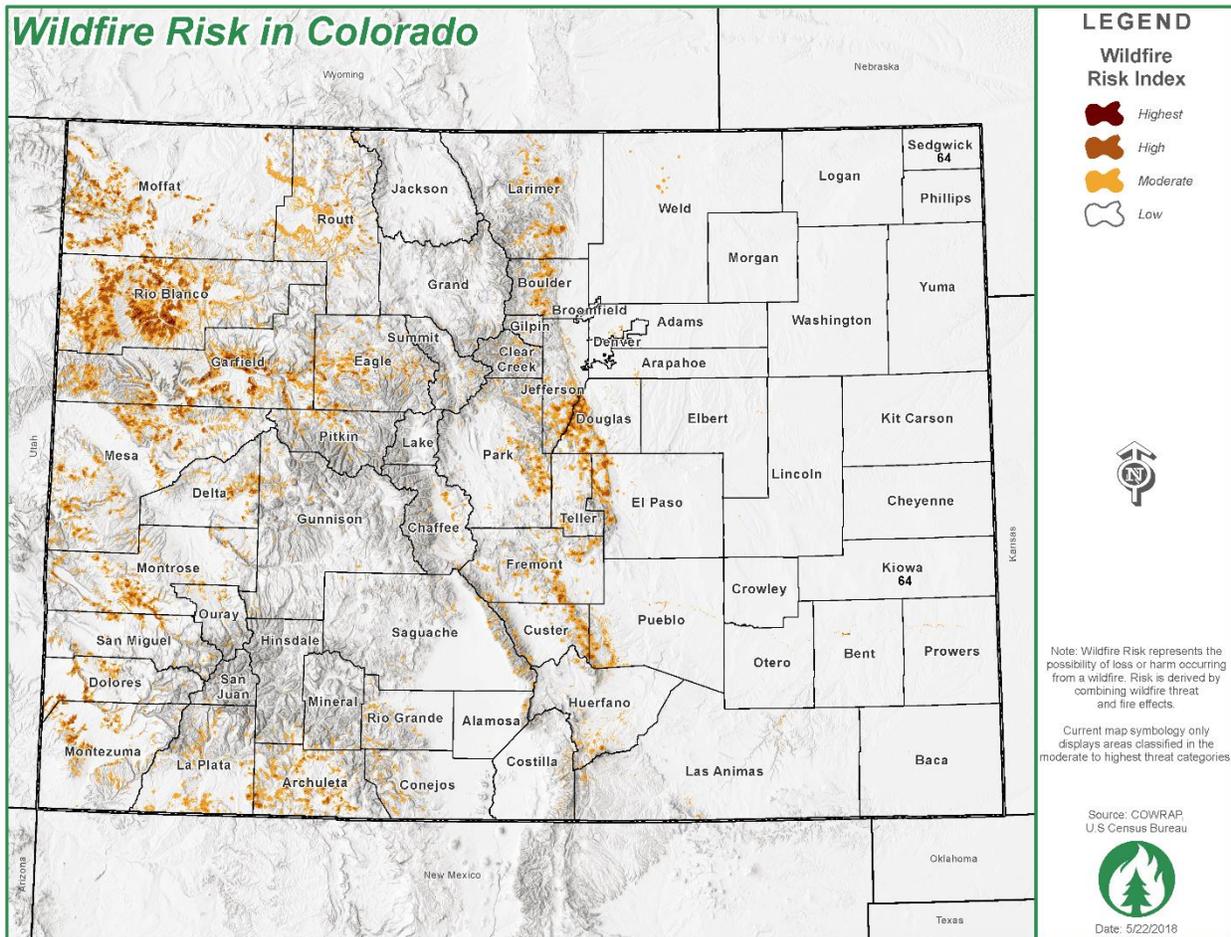
*As the state lead for the Fire Adapted Communities® and Firewise Communities/USA® programs, the CSFS provides a variety of resources to proactively address risks in the WUI. These resources include guidance in developing Community Wildfire Protection Plans, assistance in becoming a Firewise community, and publications offering science-based guidelines on home construction and fuels reduction to help landowners prioritize fire mitigation actions and reduce the risk of losing their homes during a wildfire.*

*To help landowners and communities assess wildfire risk, the CSFS developed the Colorado Wildfire Risk Assessment Portal (CO-WRAP). CO-WRAP is a web-mapping tool that provides access to statewide wildfire risk assessment information. Through CO-WRAP, wildfire mitigation/prevention planners and interested citizens can generate maps and download data and reports highlighting areas that may benefit from focused mitigation efforts.*

*CO-WRAP provides a consistent set of scientific results for wildfire mitigation and prevention planning in Colorado. It also: creates public awareness about wildfire risk; provides state and local planners with information to support mitigation and prevention efforts; identifies areas that may require additional planning related to wildfire mitigation projects; assists in the development of Community Wildfire Protection Plans (CWPPs); complements forest stewardship and forest management plans; and informs decision-making at local and state levels.*

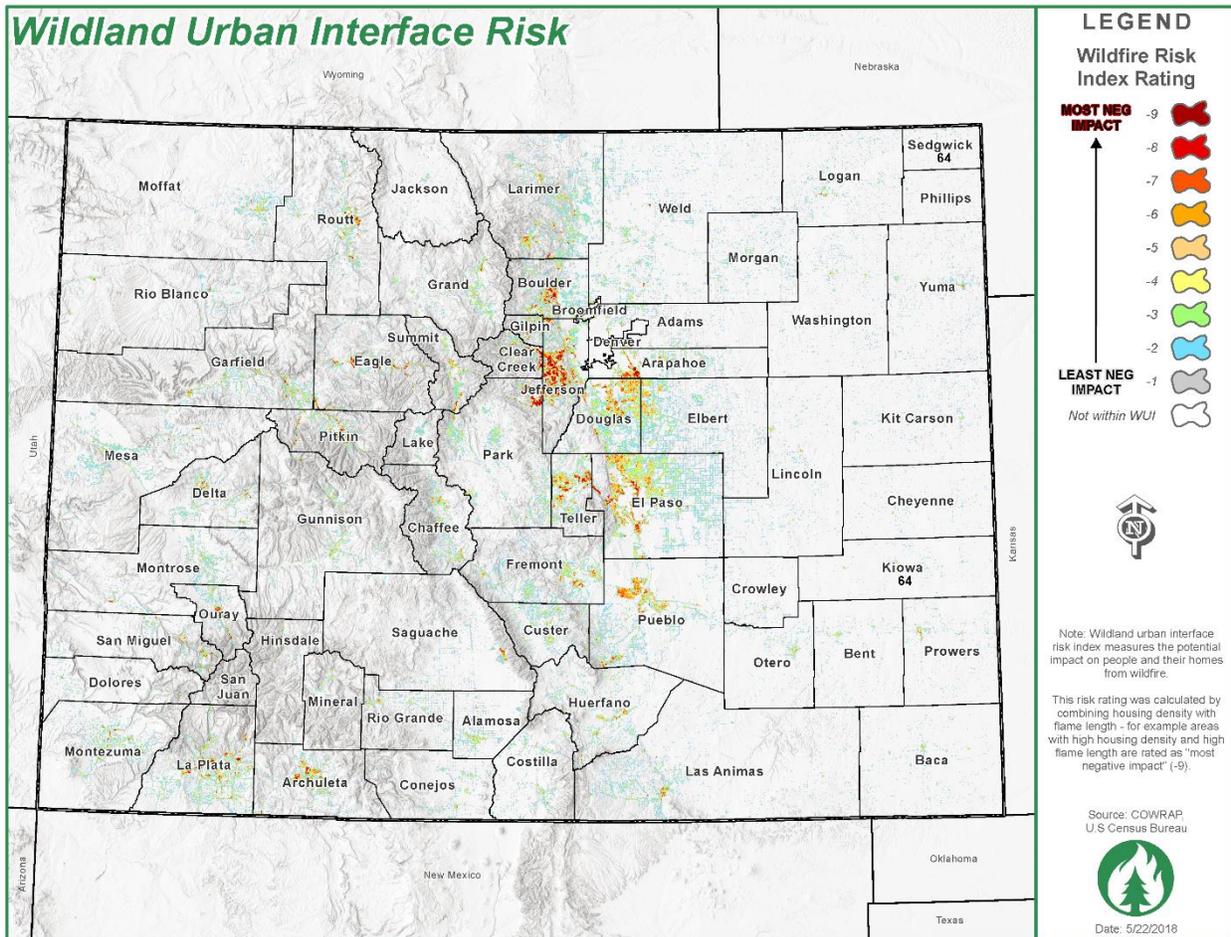
Wildfire risk represents the possibility of loss or harm occurring from a wildfire. Risk is derived by combining wildfire threat and wildfire effects. Figure 3-59 shows the statewide location of the possibility of loss or harm occurring from a wildfire from lowest to highest risk. Although wildfires occur statewide, risk tends to be highest in the foothill and mountain forests due to more development that increases possibility of loss or harm. These areas are in the central and western areas of Colorado.

FIGURE 3-59 WILDFIRE RISK IN COLORADO



Wildland-Urban Interface (WUI) risk index measures the potential impact on people and their homes from wildfire, and is depicted in Figure 3-60. This risk rating was calculated by combining housing density with flame length. For example, areas with high housing density and high flame length are rated as “most negative impact.” Central Colorado, reaching north and south along the Front Range, is most at risk for WUI wildfires.

FIGURE 3-60 WILDLAND URBAN INTERFACE RISK



### 3. EXTENT (MAGNITUDE/STRENGTH)

Wildfire extent is variable and depends on many factors, including vegetation type, forest health and density, and topography, as well as atmospheric conditions such as wind, fuel moisture levels, day and nighttime temperatures, and air moisture. Every year, thousands of small wildfires ignite across the state with several growing to be large and extremely dangerous.

As shown in Table 3-130 in the Previous Occurrences subsection, notable wildfire events can range from 200 acres to nearly 138,000 acres. Some wildfires, such as the Last Chance fire in the Eastern Plains

### FORESTS CONVERTING TO GRASSLANDS

*A study from the University of Colorado suggests that Colorado forests that experience wildfires may not grow back as similar forests in the future, but instead as grasslands. Due to the nature of the fires that we are experiencing today, coupled with our changing climate, seedlings are not able to recover and become established.*

county of Washington, can burn 45,000 acres within a day given the right wind, heat, and drought conditions. Other wildfires, such as the West Fork Complex in Colorado’s high mountains, can burn 110,405 acres over several months in forests with significant dead trees as a result of pest infestation.

Over the last decade, Colorado has experienced an upswing in multiple large and erratic wildfires (Table 3-128). These wildfires are in part a result of prolonged drought that has resulted in extremely dry and volatile fuels. The combination of dry fuels compounded by the ample availability of those fuels has created conditions where wildfires are burning faster and hotter than under more historically natural conditions. According to the Colorado Climate Plan, historically several forest types, such as low-elevation Ponderosa Pine, have maintained a low tree density due to frequent, low intensity wildfire. However, over the past century it has been common forest management practice to suppress all wildfires, creating more dense forests and more fuel to burn. Add to this the continued effects of climate change, and the state should expect to see wildfire events more often and with larger sizes.

**TABLE 3-128 AVERAGE NUMBER OF WILDFIRES BY DECADE**

Decade	Average Number of Fires	Average Number of Acres Burned per Year
<b>1960 – 1969</b>	457	8,179
<b>1970 – 1979</b>	734	6,554
<b>1980 – 1989</b>	1,286	23,308
<b>1990 – 1999</b>	1,806	21,796
<b>2000 - 2009</b>	2,973	96,449

Source: CDOT THIRA

## 4. PROBABILITY

Wildfire is an annual occurrence in Colorado. The CSFS has conducted several assessments that address wildfire hazard and risk. The assessments took place in 1999, 2002, 2008, and most recently with the development of the Colorado Wildfire Risk Assessment Portal (CO-WRAP) in 2012. While slightly different methodologies were used in each assessment, the outcomes show very similar areas are susceptible to wildland fire in terms of risk and hazard.

Table 3-129 reflects 2012 data from the CO-WRAP and shows the percent of area at risk by county. Rio Blanco County has the greatest area at risk with over 720,000 acres in moderate to high hazard areas. With over 2,400 wildfires occurring in Colorado on an annual basis, it is likely that some of these counties will experience wildfires on a regular basis.

TABLE 3-129 COLORADO COUNTIES BY PERCENT OF ACRES AT RISK

County	Moderate to High Hazard Area (acres)	Total Acres in County	Percent Area at Risk
Rio Blanco	721,006.79	2,065,924.00	34.90%
Archuleta	180,387.11	867,207.00	20.80%
Garfield	392,063.30	1,892,209.00	20.72%
Douglas	106,219.28	538,527.30	19.72%
Jefferson	85,940.27	497,076.60	17.29%
Eagle	175,314.74	1,088,545.00	16.11%
Mesa	320,256.67	2,141,740.00	14.95%
Routt	217,625.30	1,511,680.00	14.40%
Custer	67,639.71	473,309.80	14.29%
Boulder	64,266.88	480,686.40	13.37%
Teller	44,704.28	357,724.60	12.50%
Fremont	117,448.16	980,558.00	11.98%
Moffat	352,594.89	3,042,580.00	11.59%
Montrose	159,696.68	1,437,765.00	11.11%
La Plata	115,225.92	1,088,385.00	10.59%
Dolores	71,690.37	689,285.80	10.40%
Montezuma	127,447.19	1,303,012.00	9.78%
Pitkin	54,228.61	621,026.90	8.73%
Park	123,202.69	1,414,525.00	8.71%
Clear Creek	21,644.42	253,372.60	8.54%
Delta	60,676.47	735,609.50	8.25%
San Miguel	60,266.53	826,057.50	7.30%
Larimer	116,941.66	1,684,129.00	6.94%
Ouray	21,384.77	347,072.30	6.16%
El Paso	64,875.45	1,182,788.00	5.48%
Rio Grande	28,768.31	584,600.10	4.92%
Summit	18,214.98	396,124.60	4.60%
Gilpin	4,383.12	96,121.98	4.56%
Conejos	36,599.91	826,095.90	4.43%
Huerfano	44,798.64	1,019,181.00	4.40%
Chaffee	24,250.43	649,452.80	3.73%
Pueblo	55,845.18	1,534,410.00	3.64%
Gunnison	45,780.75	2,084,727.00	2.20%
Mineral	11,057.10	561,889.90	1.97%
Hinsdale	13,241.29	719,278.60	1.84%
Saguache	36,317.08	2,027,853.00	1.79%
Costilla	12,143.83	787,009.30	1.54%
Alamosa	6,247.18	462,496.20	1.35%

County	Moderate to High Hazard Area (acres)	Total Acres in County	Percent Area at Risk
San Juan	3,330.68	248,753.50	1.34%
Denver	1,112.18	99,617.14	1.12%
Grand	11,745.34	1,196,335.00	0.98%
Adams	5,142.65	768,098.50	0.67%
Broomfield	140.88	21,376.00	0.66%
Lake	1,545.46	245,001.80	0.63%
Las Animas	15,253.64	3,053,720.00	0.50%
Jackson	4,999.14	1,036,872.00	0.48%
Arapahoe	2,097.78	514,107.30	0.41%
Bent	3,231.33	986,368.00	0.33%
Otero	2,622.31	812,672.00	0.32%
Prowers	2,583.60	1,052,352.00	0.25%
Weld	6,252.99	2,570,639.00	0.24%
Elbert	1,497.50	1,362,591.00	0.11%
Baca	1,255.33	1,636,544.00	0.08%
Crowley	199.13	512,128.00	0.04%
Lincoln	228.30	1,655,424.00	0.01%
Kiowa	66.30	1,142,912.00	0.01%
Washington	22.33	1,615,424.00	0.00%
Cheyenne	8.13	1,140,096.00	0.00%
Yuma	8.10	1,516,160.00	0.00%
Kit Carson	0.00	1,383,424.00	0.00%
Logan	0.00	1,180,736.00	0.00%
Morgan	0.00	827,968.00	0.00%
Phillips	0.00	440,192.00	0.00%
Sedgwick	0.00	351,680.00	0.00%

Source: Colorado State Forest Service CO-WRAP, 2018

## 5. PREVIOUS OCCURENCES

Across Colorado, nearly 2,500 wildfires occur every year. Ninety-seven percent are contained under 100 acres. Seventeen percent of all wildfires are caused by lightning. Table 3-130 presents a list of the significant wildfire events that have taken place in Colorado between 1937 and 2017. Five of these wildfires, including the Hayman in 2002, Waldo Canyon and High Park in 2012, the Royal Gorge in 2013, and the Black Forest in 2013, received presidential disaster declarations.

TABLE 3-130 NOTABLE FIRE EVENTS IN COLORADO, 1937 TO 2017

Year	Fire Name and Location	Costs/Losses
1937	Roosevelt National Forest	1 death
1976	Battlement Mesa Fire, Garfield County	3 deaths, 880 acres
1985	Columbia Fire	1 death
1986	Montrose Fire, Montrose County	4 deaths
1988	Lefthand Canyon Fire, Boulder County	2,500 acres
1989	Black Tiger Fire, Boulder County	\$10,000,000, 44 structures, 1,778 acres
1989	Panorama Fire, Garfield and Eagle Counties	Unknown
1990	Olde Stage Fire, Boulder County	10 structures, 3,000 acres
1991	Routt National Forest, Routt County	1 death
1992	Glenwood Springs Fire, Garfield County	1 death
1994	Hourglass (Pingree Park) Fire, Larimer County	13 structures, \$2,200,000
1994	Wake Fire, Delta County	\$2,675,000, 3 structures, 4,000 acres
1994	South Canyon Fire, Garfield County	14 deaths, 2,115 acres
1994	Roxborough Fire, Jefferson County	100 acres
1996	Buffalo Creek Fire, Jefferson County	\$3,835,000, 10 structures, 12,000 acres
1999	Battlement Mesa Fire, Garfield County	9 structures
2000	Eldorado Fire, Boulder County	\$2,000,000
2000	Bobcat Fire, Larimer County	18 structures, 10,600 acres
2000	Hi Meadow Fire, Jefferson County	51 structures, 10,800 acres
2000	Pony Fire, Mesa Verde National Park, Montezuma County	4 structures, 5,240 acres
2000	Eldorado Fire, Walker Ranch, Boulder County	1,061 acres
2000	Bircher Fire, Mesa Verde National Park, Montezuma County	19,709 acres
2001	Larkspur Fire, Douglas County	1 death
2001	Armageddon Fire, Carter Lake, Larimer County	1,216 acres
2002	Snaking Fire, Park County	2,590 acres, 2 structures
2002	Cuerno Verde Fire, Custer County	388 acres, 2 structures, 2 deaths
2002	Black Mountain Fire, Jefferson County	200 acres, 1 injury
2002	Schoonover Fire, Douglas County	3,862 acres, 12 structures, 1 bridge, 2 injuries
2002	Iron Mountain Fire, Fremont County	4,440 acres, 200+ structures, 3 injuries
2002	Spring & James John/Fisher (Trinidad Complex), Las Animas County	17,295 acres, 6 injuries
2002	Ute Pass Fire, Teller County	
2002	Coal Seam Fire, Garfield County	12,209 acres, 99 structures & 14 outbuildings

<b>Year</b>	<b>Fire Name and Location</b>	<b>Costs/Losses</b>
<b>2002</b>	Hayman Fire, Douglas, Jefferson, Park, and Teller Counties	137,760 acres, 5 deaths, 16 injuries, 600 structures
<b>2002</b>	Dierich Creek/Long Canyon (Miracle Complex), Mesa County	3,951 acres, 1 injury
<b>2002</b>	Missionary Ridge Fire, La Plata County	70,485 acres, 56 structures, 52 injuries, 1 death
<b>2002</b>	Million Fire, Rio Grande County	9,346 acres, 11 structures
<b>2002</b>	Mt. Zirkel Complex, Routt and Jackson Counties	31,016 acres
<b>2002</b>	Wiley Ridge Fire, Gunnison County	1,084.5 acres
<b>2002</b>	Valley Fire, La Plata County	400 acres, 6 homes
<b>2002</b>	Burn Canyon Fire, San Miguel County	31,300 acres, 9 injuries
<b>2002</b>	Big Elk Fire, Larimer County	4,413 acres, 1 air tanker, 3 deaths
<b>2002</b>	Big Fish Fire, Garfield County	17,056 acres, 1 lodge, 7 cabins
<b>2002</b>	Long Mesa, Mesa Verde National Park, Montezuma County	2,601 acres, 3 homes
<b>2002</b>	Panorama Fire, Garfield County	1,700 acres, 4 homes
<b>2003</b>	Brush Mountain Fire	5,292 acres
<b>2003</b>	Overland Fire, Boulder County	3,439 acres, 12 homes
<b>2003</b>	Cherokee Fire, Douglas County	1,200 acres, 2 homes
<b>2004</b>	Picnic Rock Fire, Larimer County	8,908 acres, 1 home
<b>2005</b>	Mason Fire, Pueblo County	11,357 acres
<b>2006</b>	Mauricio Canyon Fire, Huerfano and Las Animas Counties	3,825 acres
<b>2006</b>	Yuma County	23,000 acres
<b>2006</b>	Thomas Fire	3,347 acres
<b>2006</b>	Mato Vega Fire, Costilla County	13,820 acres
<b>2007</b>	Newcastle Fire, Garfield County	1420 acres
<b>2007</b>	Bear Fire, Moffat County	1526 acres, 1 home, 2 structures
<b>2007</b>	Wolf Park Fire	150 acres
<b>2007</b>	Holms Mesa Fire, Garfield County	180 acres
<b>2008</b>	Ordway Fire, Crowley County	8900 acres, 14 homes, 10 structures, 3 Deaths
<b>2008</b>	Incline Fire, El Paso County	30 acres
<b>2008</b>	Bridger, Las Animas County	45,800 acres
<b>2008</b>	Nash Ranch Fire, Park County	1115 acres, 2 structures
<b>2008</b>	Ferguson Fire, Fremont County	190 acres
<b>2008</b>	Housetop Fire, Mesa County	143 acres
<b>2009</b>	Olde Stage Fire, Boulder County	1300 acres, 3 homes, 2 structures
<b>2009</b>	Newlin Creek Fire, Fremont County	142 acres
<b>2009</b>	Grammar Fire	801 acres

<b>Year</b>	<b>Fire Name and Location</b>	<b>Costs/Losses</b>
<b>2009</b>	Spring Creek Fire, Rio Blanco County	1,340 acres
<b>2010</b>	Parkdale Fire, Fremont County	628 acres, 1 home, 1 structure
<b>2010</b>	Fourmile Canyon Fire, Boulder County	6280 acres, 169 homes, 5+ structures
<b>2010</b>	Reservoir Road Fire, Larimer County	710 acres, 2 homes, 3 structures
<b>2011</b>	Crystal Fire, Larimer County	3,000 acres
<b>2012</b>	Lower North Fork Fire, Jefferson County	4,140 23, homes, 3 deaths
<b>2012</b>	Little Sand Fire, Hinsdale and Archuleta Counties	22,400 acres
<b>2012</b>	Weber Fire, Montezuma County	10,000 acres
<b>2012</b>	Waldo Canyon Fire, El Paso County	15,364 acres, 509 homes, 2 deaths
<b>2012</b>	High Park Fire, Larimer County	87,250 acres, 259 homes, 2 deaths
<b>2012</b>	Springer Fire, Park County	1,100 acres
<b>2012</b>	Last Chance Fire, Washington County	45,000 acres
<b>2013</b>	Fern Lake, Rocky Mountain National Park, Larimer County	3,498 acres
<b>2013</b>	Ward Gulch Fire, Garfield County	485 acres
<b>2013</b>	Black Forest Fire, El Paso County	14,280 acres, 498 homes, 2 deaths
<b>2013</b>	Collins Fire	388 acres
<b>2013</b>	Wild Rose Fire, Rio Blanco County	1,067
<b>2013</b>	Lime Gulch Fire, Jefferson County	511 acres
<b>2013</b>	Brush Creek Fire, Garfield County	403 acres
<b>2013</b>	Royal Gorge Fire, Fremont County	3,218 acres
<b>2013</b>	East Peak Fire, Huerfano County	13,572 acres
<b>2013</b>	Citadel Fire, Moffat County	2,009 acres
<b>2013</b>	East Tschuddi Fire, Rio Blanco County	647 acres
<b>2013</b>	Ox Cart Fire, Saguache County	1,152 acres
<b>2013</b>	Red Canyon Fire, Garfield County	390 acres
<b>2013</b>	Big Meadows Fire, Rocky Mountain National Park, Grand County	617 acres
<b>2013</b>	West Fork Complex, Mineral and Rio Grande Counties	110,405 acres
<b>2016</b>	Cold Springs Fire, Boulder County	528 acres, 8 homes
<b>2016</b>	Junkins Fire, Custer and Pueblo Counties	18,403 acres, 9 homes

Sources: Teie & Weatherford 2000, Wildfire Hazard Mitigation Plan 2007, CSFS 2009 Fire Report, WebEOC

The following Table 3-131 presents recent wildfire losses over the last 10 years as reported by the National Centers for Environmental Information (NCEI) database.

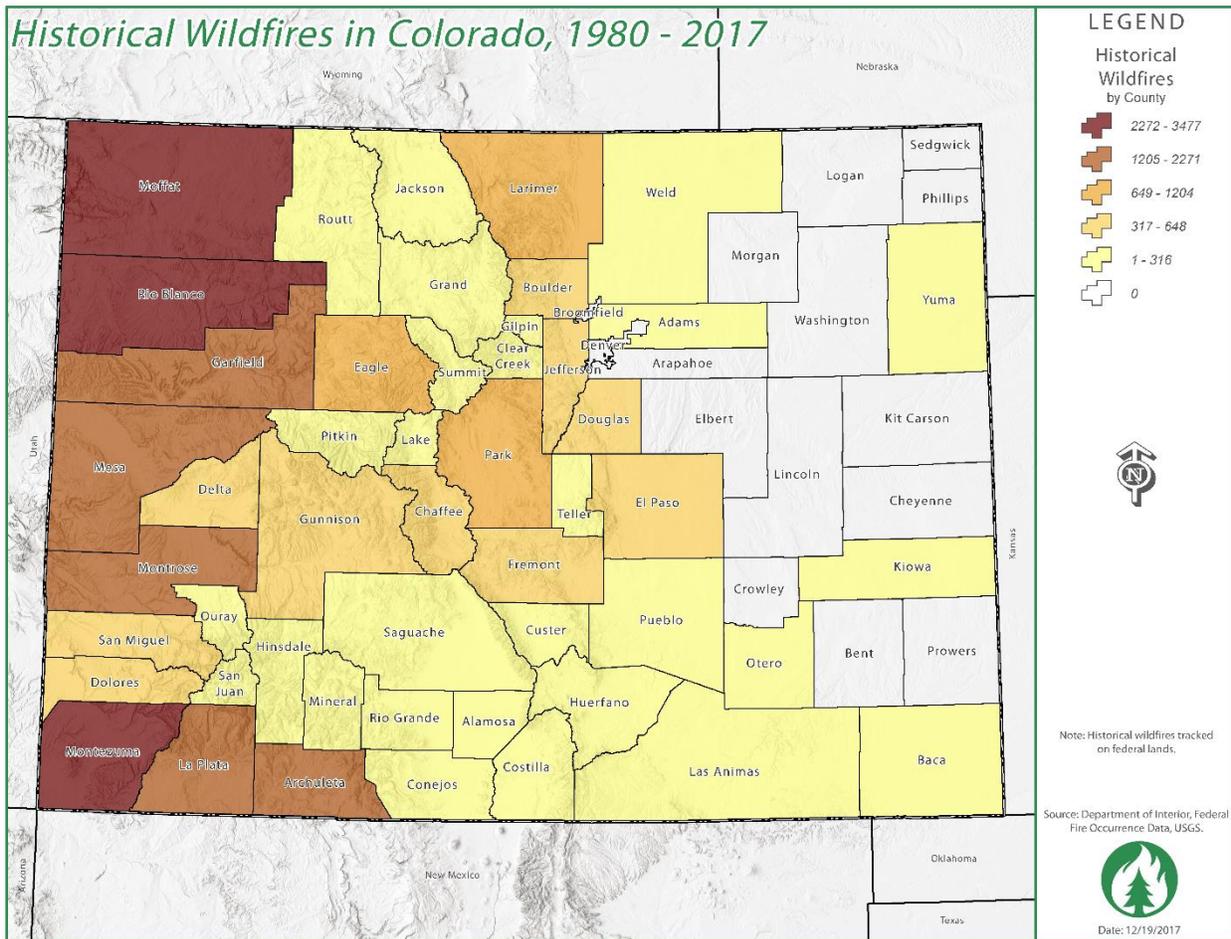
TABLE 3-131 WILDFIRE LOSSES, 2007 TO 2017

Year	Event Count	Deaths	Injuries	Property Damage
2007	9	0	0	\$ 801,000
2008	9	0	1	\$ 6,080,000
2009	3	0	1	\$ 23,000
2010	16	0	0	\$ 218,595,000
2011	27	0	4	\$ -
2012	30	5	3	\$ 824,830,000
2013	13	0	1	\$ 296,000,000
2014	2	0	0	\$ -
2016	10	0	0	\$ -
2017	5	0	1	\$ 1,530,000
<b>Total</b>	<b>124</b>	<b>5</b>	<b>11</b>	<b>\$ 1,347,859,000</b>

Source: NOAA

Figure 3-61 presents all recorded historical wildfires that have occurred on federal lands. The western portion of the state has historically experienced the most wildfires, followed by the Central Mountains and the Front Range. However, the Eastern Plains contain much less federally-owned land than the central and western parts of the state, so the number of wildfires on federal lands in the Eastern Plains is not a robust representation of total historic wildfires in this region.

FIGURE 3-61 WILDFIRES ON FEDERAL LANDS, 1980 TO 2017



## CASE STUDY: THE BLACK FOREST FIRE

*Under Red Flag weather conditions, a lightning strike starts a wildfire in the Wildland-Urban Interface (WUI) on June 11<sup>th</sup>, 2013 and ultimately grows to 15,000 acres.*

*Eventually, this became the single most destructive fire in Colorado history in terms of residential properties lost and caused the second most insured losses from a wildfire event. This was the second time in less than a year that a fire in El Paso County set such a record; the 2012 Waldo Canyon Fire was previously the most destructive in Colorado history and caused the most insured losses from wildfire. Due to both the proximity in geography and time between these fires, residents in El Paso County were once again traumatized.*

*A total of 596 impacted residences of which 498 properties were verified through the FEMA preliminary damage assessment process were destroyed. Not all residents were accounted for, eventually resulting in multiple deaths being discovered as a result of the wildfire. Those residents with home-based businesses experienced loss of income. In addition, families lost cherished pets as the fast-moving fire prevented them from evacuating their animals.*

*The Colorado National Guard (CONG) provided aircraft and personnel to support fire suppression efforts, assist with road closures, and provide security for evacuation areas and check points. Other state assets contributed fire, emergency management, and recovery liaison assistance. The Colorado Division of Local Government (DLG) provided technical assistance to El Paso County in establishing a Disaster Assistance Center (DAC). The Colorado Department of Public Health and Environment (CDPHE) provided air monitoring, published daily smoke-related health advisories, assisted in the coordination of tetanus vaccines for resident re-entry, and coordinated mental health services in the DAC. One-hundred thirty people reached out to local mental health resources, and a Crisis Counseling overview was provided to over 1,200 local residents at a community meeting. Recovery activities included: assisting evacuees with insurance questions and providing housing vouchers.*

*The American Red Cross (ARC) provided food and shelter during the wildfire and provided case management and other emergency assistance. Four shelters would be opened to assist with human sheltering in response to local evacuations; these shelters resulted in 1,000 overnight stays. Additionally, surrounding counties and non-governmental organizations (NGOs) opened 11 large and/or small animal shelters; housing 4,000 animals. These NGOs provided support to multiple large and small animal shelters in three counties. The Salvation Army provided thousands of meals, as well as spiritual and emotional care assistance. Additional NGOs lead the donations collections services and provided survivors with vouchers to collect needed items at various outlets. NGOs also provided assistance in the form of counseling and referrals, food boxes, gas cards, clothing, hygiene products, diapers and formula, furniture, and household goods. United Way 211 provided volunteer coordination and information referral services. Samaritan's Purse and the Southern Baptists assisted residents who lost their homes to sift through ashes.*

*Losses to the utilities and County equaled approximately \$12 million. Utility damage included poles, transformers, and wires, while damaged or destroyed property of El Paso County included roadway guardrail, culverts, road signs, fencing, and storage facilities.*

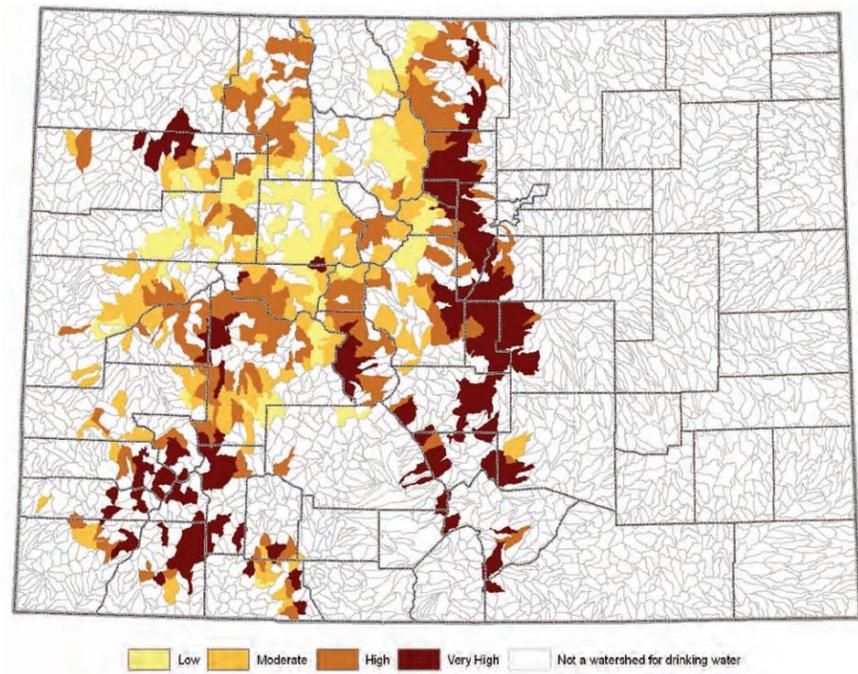
## 6. IMPACT ANALYSIS

Wildfires play a significant role in the development of Colorado's diverse ecosystems. Through time, wildfires have been both beneficial and destructive. That relationship is measured, in part, by the number and frequency of wildfires, how they were ignited, the cost of suppression, the dollar value of what was burned, the negative impact on the environment, the related costs to infrastructure, air, and water quality, and human values/benefits. The immediate danger from wildfires is the destruction of property, timber, wildlife, and injury or loss of life to persons who live in the affected area or who are using recreational facilities in the area (CDOT THIRA, 2017).

Wildfires have post-fire impacts that may contribute to the susceptibility of mudslides, landslides, and floods in areas where fire has burned off vegetation. In recent years, roads, residential structures, and outbuildings have suffered prolonged damaging impacts from flood, mudslides, and siltation of municipal water sources in areas scarred by wildfires. Strontia Springs Reservoir near Denver is one high-profile example of this pattern. Following the 1996 Buffalo Creek Fire and the 2002 Hayman Fire, erodible soils poured into the reservoir, choking the water supply with sediment. Denver Water partnered with the U.S. Forest Service to drain the reservoir and improve water quality, which cost \$33 million (Colorado Climate Plan, 2015).

Large fire incidents, such as the High Park Fire, can leave critical watersheds in need of emergency and long-term rehabilitation. Wildfire can cause water repellency and consume plant canopy, surface plants and litter, and structure-enhancing organics within soil. Changes in soil moisture, structure, and infiltration can accelerate surface runoff, erosion, sediment transport, and deposition. Intense rainfall and some soil and terrain conditions can contribute to overland runoff and in-channel debris torrents. Mineralization of organic matter, interruption of root uptake, and loss of shade can further impact water quality by increasing stream temperatures and nutrient concentrations. Where wildfires are unnaturally large and severe, watershed effects are likely to be negatively skewed. Figure 3-62 shows the risk of post-fire erosion in watersheds that are important sources of drinking water (Colorado Water Plan, 2015).

**FIGURE 3-62 COLORADO STATE FOREST SERVICE RISK OF POST-FIRE EROSION IN WATERSHEDS THAT ARE IMPORTANT SOURCES OF DRINKING WATER**



Source: Colorado Water Plan, 2015

Fire effects are the physical, chemical, and biological impacts of fire on ecosystem resources and the environment. The abiotic effects of fire include its role in changing air quality, water quality, soil properties, and nutrient cycling. Biotic effects include altering vegetation and related impacts on wildlife. Fire effects are the result of an interaction between the heat regime created by fire and ecosystem properties. The particular effect of fire on any one of these components (i.e., the fire severity) is not fixed, but will vary according to site characteristics and fire behavior. For example, the effects of a fire burning under the same conditions may be very different on soils of different textures. Likewise, the effects of fires burning under different fuel and weather conditions can be very different on similar soils.

Pollutants emitted from fires can be harmful to human health and welfare. As a result of these risks, increasingly effective smoke management policies and air quality standards are being implemented.

## WILDFIRES AND PM2.5

*Wildfires seem to have a number of unexpected secondary effects, one of which is that smoke inhalation is being shown to cause premature deaths. Fine Particulate Matter, also known as PM2.5, is produced as a result of wildfires, and has been linked to several thousand premature deaths each year. This same level of particulate matter is also present in coal power plants, which have gotten cleaner over the years, while wildfires have become more widespread, leading them to be one of the more predominant sources of PM2.5.*

Fire can affect water quality both directly, by increasing temperature and nutrients, or indirectly, by increasing sedimentation and turbidity, and altering channel morphology. Fires affect physical, chemical, and biological soil properties directly by transferring heat into soil, and indirectly, by changing vegetation and the dynamics of nutrients and organic matter. Fires affect plants directly by injury and mortality, and indirectly, by changing resource availability. These effects translate into vegetation changes at the plant, population, and community level. Fire can affect wildlife directly through injury and mortality; however, the most profound effects of fire are caused indirectly by altering wildlife habitat.

The CDOT Emergency Operations Plan (EOP) states that wildfire can cause minor damage on the highways, but their biggest destructive force can be upon bridges. Wildfire smoke can also cause visibility issues along highways.

Additionally, according to the Colorado Energy Assurance Emergency Plan, the potential energy sector impacts to wildfire are severe, stating the following potential impacts:

“Wildfire may damage or destroy transmission and distribution lines, substations, and other vulnerable facilities and infrastructure. Wildfire may occasionally present as a secondary impact of energy infrastructure damage due to other hazards. For example, windstorms, lightning, and other natural hazards can down transmission and distribution lines, leading to wildfire ignition. Lax vegetation management can result in contact with transmission lines, resulting in wildfire ignition as well as infrastructure damage. High intensity arc flashes can also melt conductors, destroy insulation, and start fires. Wildfire may impact accessibility to energy assets for emergency response and recovery operations.”

Table 3-132 describes the impact summary of wildfires.

TABLE 3-132 WILDFIRE EMAP IMPACT SUMMARY

Consideration	Description
<b>General Public</b>	Deaths and injury have occurred in past events. Staff, recreationists, campers, property owners in remote areas or the wildland urban interface areas, and persons with breathing difficulties may all be impacted. Secondary impacts may negatively affect water quality and downstream water users.
<b>First Responders</b>	Exposure exists to response personnel performing routine duties when event occurs; fire event-related duties may cause significant danger to response personnel including evacuation, suppression, law enforcement, and damage assessment. The tragic event on Storm King Mountain near Glenwood Springs took the lives of 14 firefighters.
<b>Property</b>	Buildings, vehicles, signage, and/or any unsecured property may be affected during an event. Property may be destroyed, have significant structural damage, or be affected by smoke. State historical, recreational, natural, and wildlife properties/facilities are at risk.
<b>Facilities and Infrastructure</b>	Buildings, equipment, vehicles, and communications and utility infrastructure are exposed and lost to wildfires every year in Colorado. The number of state assets in high or moderate fire risk areas total 588. State asset value located in high or moderate fire risk areas is \$246.7 million.
<b>Economic</b>	Potential loss of facilities or infrastructure function or accessibility and uninsured damages. Potential impact to tourism and land development activities depending on severity of the fire season and location of fire events. Depending on the nature of the area where fire occurs, many home-based businesses will be impacted due to evacuation, lack of utility service, or through destruction of property.
<b>Environment</b>	Significant impact related to loss of forest or grasslands, impacts to water quality, erosion, and sedimentation may affect critical infrastructure and natural waterways. Loss of ground vegetation may encourage landslides, mudslides, or other geologic movement of land. Dead or damaged trees are at risk of falling. An annual average of 160 square miles of state and private land is burned.
<b>Continuity of Government and Services</b>	Potential loss of facilities or infrastructure function or accessibility, or ability to provide services. Power interruption is likely if not adequately equipped with backup generation. Potential decrease in property tax collection by local government and special districts due to loss of structure or land value may impact service provision.
<b>Confidence in Government</b>	Public holds high expectations of government capabilities for warning, public information, and response and recovery activities related to wildfires. Recent and past events indicated a high expectation from evacuees for the provision of real-time property-level damage assessments (e.g., what properties are confirmed destroyed, damaged, or unaffected).
<b>Critical Assets</b>	Potential impact to water treatment facilities, government buildings, public safety facilities and equipment, and healthcare services. Scour on bridge pilings may result in bridge and road closures.

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

Wildfires will negatively affect Colorado with a variety of impacts. Forested lands and any surrounding Wildland-Urban Interface (WUI) areas are most at risk to wildfires. Potential risks include destruction of land, property, and structures as well as injuries and loss of life. Typically rare, but occurring over the last several years, death and injury may occur at the beginning stages of wildfires when sudden flare-ups occur from high wind conditions or during response activities. In many situations, however, people have the opportunity to evacuate the area and avoid bodily harm.

According to the CDOT Threat and Hazard Identification and Risk Assessment (THIRA), Colorado's landscape has changed substantially over the last several decades due to wildland development, and so the potential danger from wildfires has become more severe. Increased development in and around rural areas has increased the potential for loss of life and property from wildfires. There has been more than a 60 percent increase in the number of rural homes since the 1980s. Recent studies have determined that one in every four homes in Colorado is in the red zone, or interface areas of high wildfire risk. Not only does wildfire destroy structures, but it places significant strains on local and regional economics which are often dependent on tourism to support businesses and the local tax base. Table 3-133 presents loss information at the county and National Weather Service (NWS) reporting zone levels since 1950. Previously, NCEI reported historical event information at the county level.

TABLE 3-133 WILDFIRE LOSSES BY COUNTY AND NWS REPORTING ZONE

County/Zone	# of Events	# of Deaths	# of Injuries	Property Damage	Crop Damage
Alamosa	1	0	0	\$ -	\$ -
Archuleta	5	0	0	\$ -	\$ -
Bent	4	0	1	\$ 60,000	\$ -
Custer	2	0	0	\$ 200,000	\$ -
Dolores	1	0	0	\$ -	\$ -
Eagle	1	0	0	\$ -	\$ -
El Paso	5	0	0	\$ 4,000	\$ -
Fremont	2	0	0	\$ 5,000,000	\$ -
Garfield	15	0	0	\$ 6,700,000	\$ -
Gunnison	5	0	0	\$ -	\$ -
Jefferson	2	0	0	\$ 14,200,000	\$ -

County/Zone	# of Events	# of Deaths	# of Injuries	Property Damage	Crop Damage
Kiowa	1	0	0	\$ -	\$ -
La Plata	10	0	0	\$ 10,500,000	\$ -
Larimer	1	0	0	\$ 3,000,000	\$ -
Las Animas	1	0	0	\$ 50,000	\$ -
Mesa	10	0	0	\$ 2,000	\$ -
Moffat	24	0	0	\$ -	\$ -
Montezuma	17	0	0	\$ 420,000	\$ -
Montrose	3	0	0	\$ -	\$ -
Prowers	2	0	0	\$ -	\$ -
Rio Blanco	30	0	0	\$ -	\$ -
Rio Grande	2	0	0	\$ 22,000,000	\$ -
Routt	21	0	0	\$ -	\$ -
San Miguel	6	0	0	\$ -	\$ -
Teller	3	0	4	\$ 12,040,000	\$ -
Yuma	2	0	3	\$ 250,000	\$ -
Alamosa Vicinity / Central San Luis Valley Below 8500 Ft (Zone)	3	0	0	\$ 1,000	\$ -
Animas River Basin (Zone)	7	0	0	\$ 200,000	\$ -
Canon City Vicinity / Eastern Fremont County (Zone)	5	0	0	\$ -	\$ -
Central Colorado River Basin (Zone)	2	0	0	\$ 500,000	\$ -
Central Gunnison And Uncompahgre River Basin (Zone)	2	0	2	\$ -	\$ 5,000
Central Yampa River Basin (Zone)	10	0	2	\$ -	\$ -
Colorado Springs Vicinity / Southern El Paso County / Rampart Range Below 7500 Ft (Zone)	4	0	0	\$ 550,000	\$ -
Crowley County (Zone)	3	0	0	\$ 5,000,000	\$ -
De Beque to Silt Corridor (Zone)	5	0	0	\$ 300,000	\$ -
Eastern Lake County / Western Mosquito Range	1	0	0	\$ -	\$ -

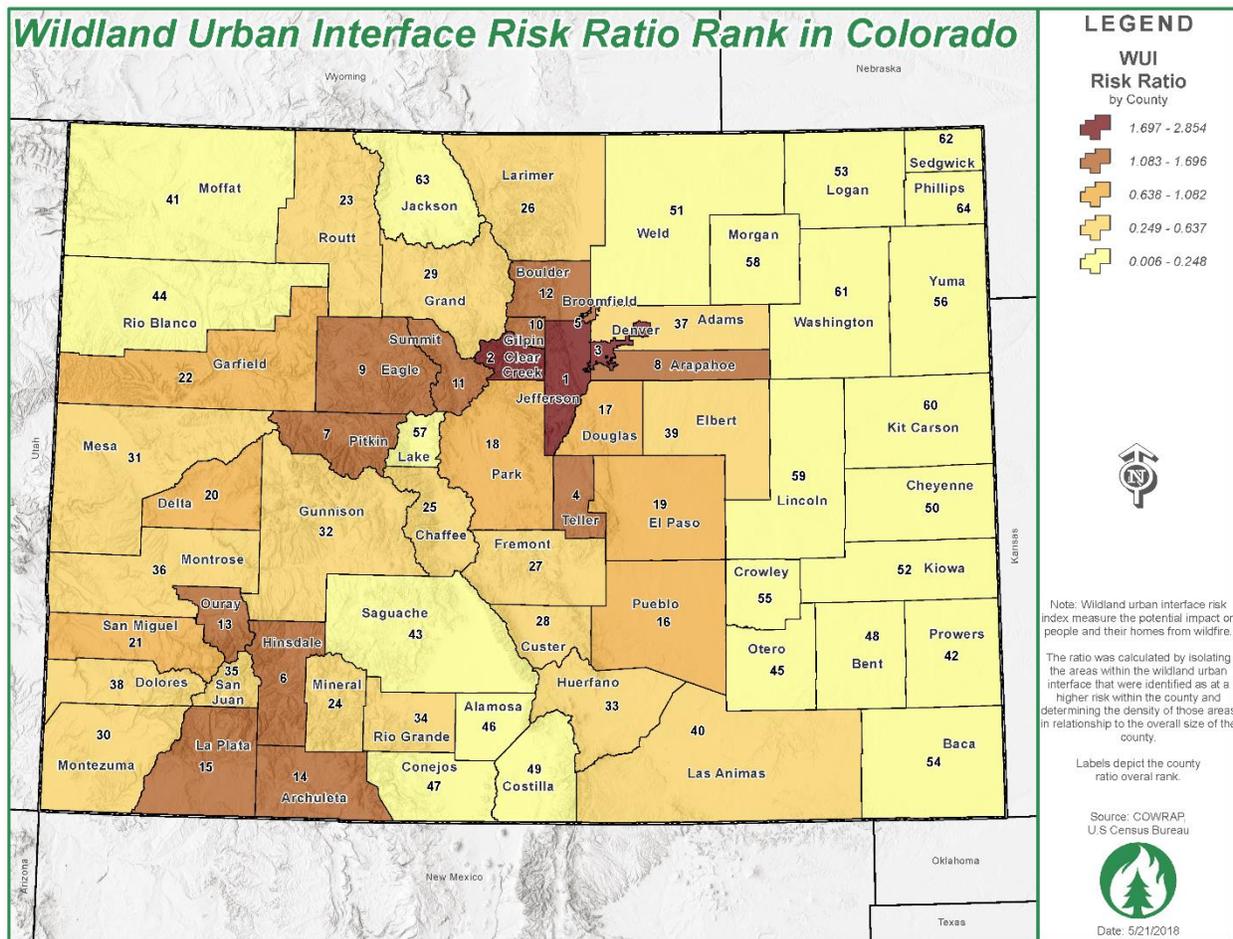
<b>County/Zone</b>	<b># of Events</b>	<b># of Deaths</b>	<b># of Injuries</b>	<b>Property Damage</b>	<b>Crop Damage</b>
<b>Above 11000 Ft (Zone)</b>					
<b>Eastern Las Animas County (Zone)</b>	7	0	0	\$ -	\$ -
<b>Eastern San Juan Mountains Above 10000 Ft (Zone)</b>	2	0	0	\$ -	\$ -
<b>Four Corners/ Upper Dolores River Basin (Zone)</b>	2	0	0	\$ 50,000	\$ -
<b>Grand and Battlement Mesas (Zone)</b>	5	0	0	\$ 500,000	\$ -
<b>Grand Valley (Zone)</b>	3	0	1	\$ 223,000	\$ -
<b>Jefferson &amp; W Douglas Counties Above 6000 Ft / Gilpin / Clear Creek / NE Park Counties Below 9000 Ft (Zone)</b>	2	3	0	\$ 22,000,000	\$ -
<b>La Junta Vicinity / Otero County (Zone)</b>	7	0	0	\$ 30,000	\$ -
<b>Lamar Vicinity / Prowers County (Zone)</b>	1	0	0	\$ 15,000	\$ -
<b>Larimer &amp; Boulder Counties Between 6000 &amp; 9000 Ft (Zone)</b>	1	0	0	\$ 217,000,000	\$ -
<b>Larimer County Below 6000 Ft / NW Weld County (Zone)</b>	1	0	0	\$ 1,500,000	\$ -
<b>Logan County (Zone)</b>	1	0	0	\$ 1,000,000	\$ -
<b>Lower Yampa River Basin (Zone)</b>	2	0	0	\$ -	\$ -
<b>Northern El Paso County / Monument Ridge / Rampart Range Below 7500 Ft (Zone)</b>	3	2	0	\$ 1,093,000,000	\$ -
<b>Northern Sangre De Cristo Mountains Above 11000 Ft (Zone)</b>	3	0	0	\$ -	\$ -
<b>Northern Sangre De Cristo Mountains Between 8500 &amp; 11000 Ft (Zone)</b>	6	0	0	\$ -	\$ -
<b>Northwestern San Juan Mountains (Zone)</b>	3	0	0	\$ -	\$ -
<b>Paradox Valley / Lower Dolores River Basin (Zone)</b>	11	0	0	\$ 150,000	\$ -
<b>Phillips County (Zone)</b>	1	0	0	\$ 300,000	\$ -
<b>Pueblo Vicinity / Pueblo County Below 6300 Ft (Zone)</b>	6	0	0	\$ 600,000	\$ -
<b>Roan and Tavaputs Plateaus (Zone)</b>	5	0	0	\$ -	\$ -
<b>Saguache County East of Continental Divide Below 10000 Ft (Zone)</b>	1	0	0	\$ -	\$ -

County/Zone	# of Events	# of Deaths	# of Injuries	Property Damage	Crop Damage
San Juan River Basin (Zone)	2	0	0	\$ -	\$ -
Southern Sangre De Cristo Mountains Above 11000 Ft (Zone)	2	0	0	\$ -	\$ -
Southern Sangre De Cristo Mountains Between 7500 & 11000 Ft (Zone)	5	0	1	\$ 3,030,000	\$ -
Southwestern San Juan Mountains (Zone)	10	0	0	\$ 30,000	\$ -
Springfield Vicinity / Baca County (Zone)	6	0	0	\$ -	\$ -
Teller County / Rampart Range Above 7500 Ft / Pikes Peak Between 7500 & 11000 Ft (Zone)	3	0	0	\$ -	\$ -
Trinidad Vicinity / Lower Huerfano River Basin & Western Las Animas County Below 7500 Ft (Zone)	5	0	3	\$ 1,000,000	\$ -
Uncompahgre Plateau and Dallas Divide (Zone)	3	0	0	\$ 25,000	\$ 20,000
Upper Gunnison River Valley (Zone)	1	0	0	\$ -	\$ -
Upper Rio Grande Valley / Eastern San Juan Mountains Below 10000 Ft (Zone)	2	0	0	\$ -	\$ -
Walsenburg Vicinity / Upper Huerfano River Basin Below 7500 Ft (Zone)	3	0	0	\$ -	\$ -
West / Central Fremont County Below 8500 Ft (Zone)	3	0	0	\$ -	\$ -
West Elk and Sawatch Mountains (Zone)	1	0	0	\$ -	\$ -
Westcliffe Vicinity / Wet Mountain Valley Below 8500 Ft (Zone)	2	0	0	\$ -	\$ -
Wet Mountains Between 8500 And 10000 Ft (Zone)	8	0	0	\$ 7,310,000	\$ -

Source: NOAA

Figure 3-63 depicts a WUI risk index to measure the potential impact on people and their homes from wildfire. This ratio was calculated by isolating the areas within the WUI that were identified as at a higher risk within each county, and determining the density of those areas in relationship to the overall size of the county. Labels depict the county ratio overall rank.

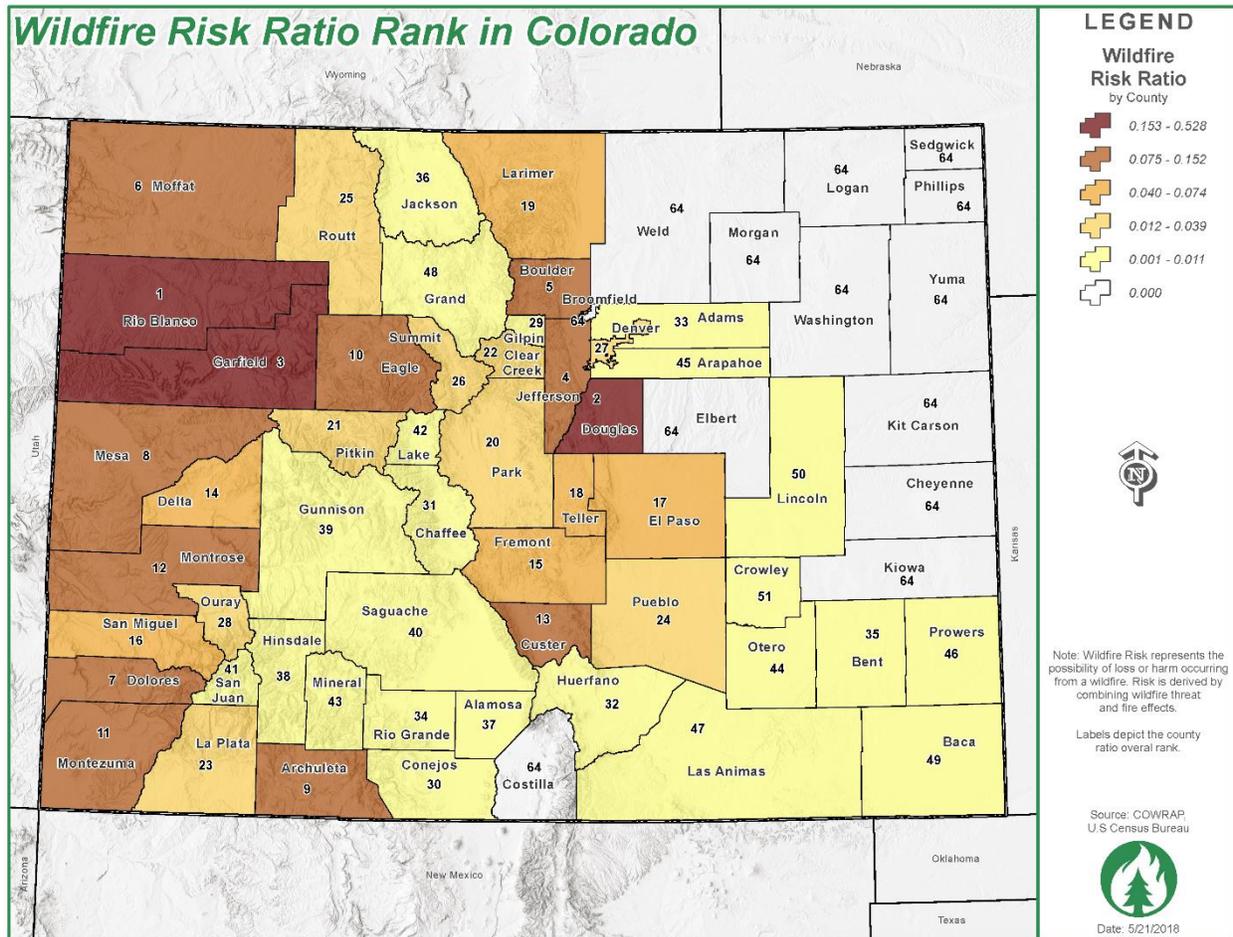
FIGURE 3-63 WILDLAND URBAN INTERFACE RISK RATIO RANK BY COUNTY



Jefferson and Clear Creek Counties have the highest WUI Risk Ratio in Colorado. Denver also ranks high, but this may be a statistical anomaly that requires further analysis. Other counties with higher WUI Risk Ratios include Arapahoe, Boulder, Eagle, Summit, Pitkin, Ouray, Hinsdale, La Plata, and Archuleta.

General wildfire risk represents the possibility of loss or harm occurring from a wildfire as shown in Figure 3-64. Risk is derived by combining wildfire threat and fire effects. The wildfire risk ratio calculates the percentage of high wildfire risk areas within each county relative to the overall size of the county. Labels in Figure 3-64 depict the county ratio overall rank.

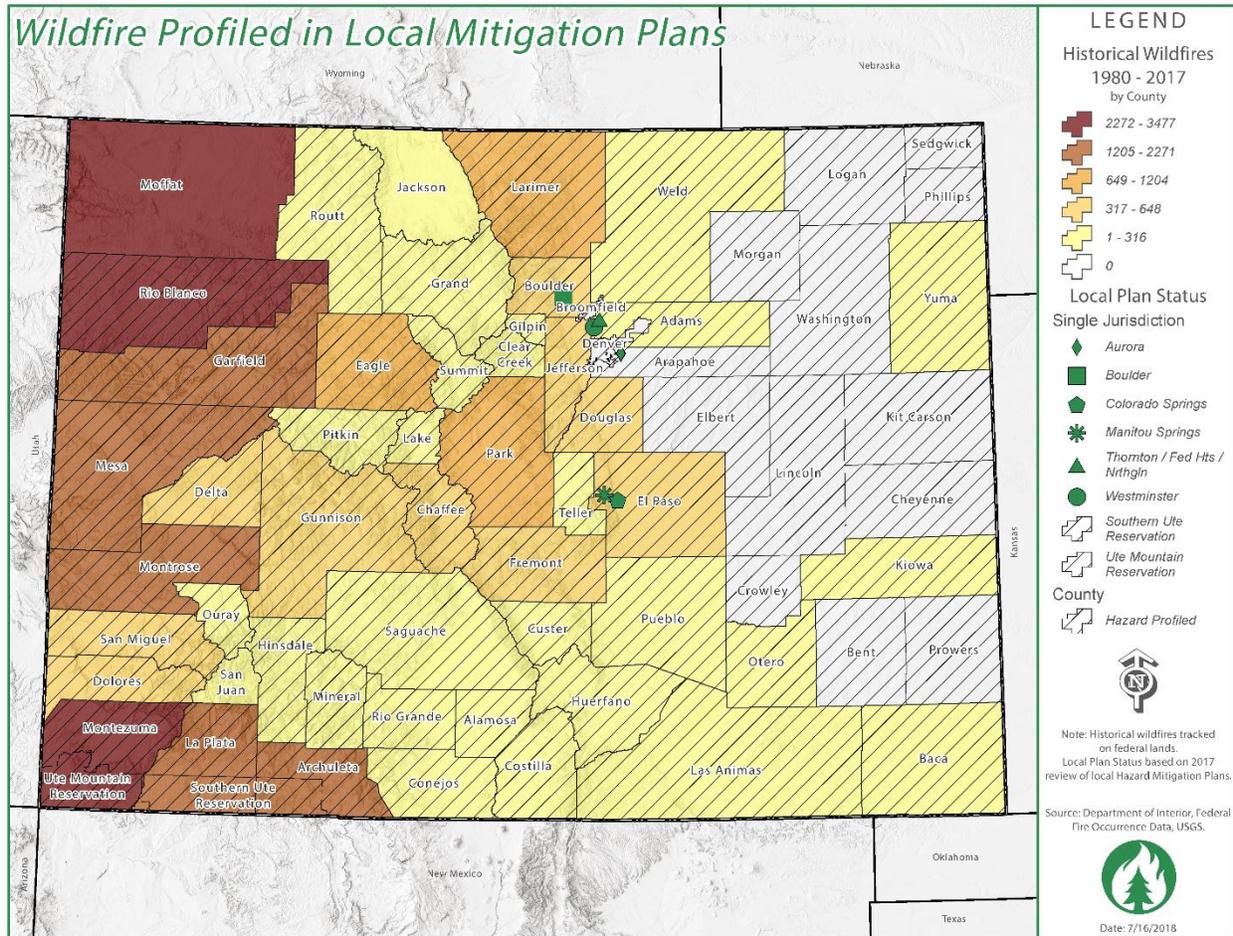
FIGURE 3-64 WILDLAND RISK RATIO RANK BY COUNTY



Douglas, Rio Blanco, and Garfield Counties show the highest Wildfire Risk Ratio of any Colorado county. These counties are followed by Larimer, Boulder, Jefferson, and El Paso Counties along the Front Range, and Moffat, Eagle, Mesa, Montrose, Dolores, and Montezuma on the Western Slope, in addition to Teller, Fremont, Custer and Archuleta Counties.

Based upon a recent (2017) review of local mitigation plans, Figure 3-65 illustrates the counties that have assessed the risk of wildfire and which have included actions in the plan to mitigate the hazard. Nearly all counties and several major single jurisdictions have profiled wildfire risk in their hazard mitigation plans. Moffat County does not have a hazard mitigation plan, yet experiences a high number of wildfires. Generally, for those counties with plans, the counties addressing wildfire tend to have the most risk. Counties addressing mitigation through development of actions is also generally related to risk.

FIGURE 3-65 WILDFIRE HAZARD PROFILED IN LOCAL MITIGATION PLANS



Based on review of local hazard mitigation plans, 54 jurisdictions profiled wildfire as one of their top four hazards, with 21 of the jurisdictions profiling wildfire as their top hazard. Within those 54 jurisdictions, a total of 580,815 structures or parcels are identified in wildfire hazard areas, and 4,716 critical facilities are identified in wildfire hazard areas. Table 3-134 describes this information in further detail, as well as the total loss estimates.

TABLE 3-134 LOCAL HAZARD MITIGATION PLANS

Jurisdiction	# of Structures/Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate	Loss Estimate Methodology
Alamosa County		18			
Arapahoe County		136	WUI		
Archuleta County	6,387	45		\$2,233,393,273	

Jurisdiction	# of Structures/ Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate	Loss Estimate Methodology
City of Boulder	3,907	4		\$1,530,604,000	GIS Mapping and CWPP
Chaffee County	6,579	57		\$1,944,720,000	
Cheyenne County		36			
Clear Creek County	2,059	101	GIS Mapping	\$395,000,000	GIS Mapping
City of Colorado Springs	28,351 (parcels)		CWPP		
University of Colorado Boulder					
Conejos County	5,653	37			
Costilla County	723	33			
Custer County	4,179	53		\$1,591,430,000	CO-WRAP & CWPP
Delta County	2,792	64	MIFMU GIS	\$424,003,316	
Dolores County	1,104	36		\$703,609,000	GIS Mapping
Douglas County	21,134	528		\$15,600,000,000	GIS Mapping of High Fire Risk
Eagle County	15,367			\$17,690,470,000	
El Paso County (Unincorporated)	131,708	725		\$63,735,721,000	50% damage
Elbert County	900 (just in 2 high risk areas)	66			
Fremont County	15,288	221		\$5,744,537,170	10% damage
Gilpin County	3,326	40	GIS Mapping	\$1,602,888,000	GIS Mapping
Grand County	23,279	123		\$7,689,125,055	GIS Mapping
Gunnison County	6,678	10		\$3,168,259,529	GIS Mapping
Hinsdale County		25			
Huerfano County	6,772	268		\$601,229,414	Total exposure
Jefferson County	27,574	345	CWPP, CO-WRAP	\$14,569,972,026	GIS Mapping
Kit Carson County		155		\$5,600,000	Crop Insurance Losses

Jurisdiction	# of Structures/ Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate	Loss Estimate Methodology
La Plata County	20,457		GIS Mapping	\$3,201,830,000	GIS Mapping
Lake County	4,796	30	WUI	\$1,155	avg annual losses
Larimer County	159,154	25			
Las Animas County	4,870	264		\$1,560,025,000	GIS Mapping
Lincoln County		111	GIS Mapping		Crop Insurance Losses
Logan County		216			
City of Manitou Springs	1,359			\$264,075,512	GIS Mapping and CO-WRAP
Mesa County					
Mineral County	0.4% land in hazard zone				
Montezuma County	5,426	124		\$2,220,531,000	GIS Mapping
Montrose County (Unincorporated)				\$2,342,787,330	
Morgan County		211			
Ouray County	2,617	35		\$930,044,845	GIS Mapping
Park County		137		\$1,124,755,018	50% damage
Phillips County		35			
Pitkin County	10,913			\$14,585,000,000	Value of structures
Pueblo County	11,338				
Rio Blanco County					
Rio Grande County					
Saguache County					
San Miguel County	6,891	15			
Sedgwick County		63			
Southern Ute Indian Tribe	1,969			\$341,580,671	WUI
Summit County	19,662	36		\$10,642,912,909	
Teller County	14,809	101	GIS Mapping	\$2,582,852,293	50% damage
Ute Mountain Ute Tribe	471	1		\$46,414,000	
Washington County		81			

Jurisdiction	# of Structures/ Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate	Loss Estimate Methodology
<b>Weld County</b>	2,323	5		\$472,916,287	
<b>Yuma County</b>		100			
<b>Total</b>	<b>580,815</b>	<b>4,716</b>		<b>\$179,540,687,803</b>	

## 8. FUTURE DEVELOPMENT

Colorado State University (CSU) researchers estimate that by the year 2030, the size of Colorado’s WUI will have increased to 720,000 homes (from an estimated 313,000 in 2010). Based on projections, the areas at greatest risk of wildfires is correlated with continuing population growth over the next 25 years.

Local jurisdictions, with the support and active participation by state and federal partners, address wildfire vulnerability through emergency response and mitigation. Mechanisms for emergency response are well established but increasingly stretched and expensive as more homes are built in the WUI and need to be protected. Mitigation programs and resources are existing, but often are not appropriately resourced, yet remain a focus of discussion in many communities as they look for ways to diminish the danger and cost of wildfire.

Development and population growth can contribute to increased exposure of people and property to hazards. Understanding changes in hazard exposure over time is an important element of comprehensive hazard mitigation planning. In the context of wildfire, increased population growth and development along the WUI has increased human exposure to wildfire in a number of Colorado communities. According to the Headwaters Institute, 84 percent of private lands in a high-risk WUI zone are currently undeveloped, meaning there is high potential for future development in these high-risk areas. By identifying areas with significant potential for population growth and/or future development in high-risk areas, communities can identify areas of mitigation interest and reduce hazard risks associated with increased exposure.

Table 3-136 provides county-scale wildfire exposure projections by comparing wildfire risk ratios and population growth forecasts between 2010 and 2030. Wildfire risk represents the possibility of loss or harm occurring from a wildfire. It was derived by combining wildfire threat with fire effects data collected by the Colorado State Forest Service Colorado Wildfire Risk Assessment Portal. The Wildfire Risk Ratio calculates the percentage of moderate to high wildfire risk areas within each county relative to the overall size of the county. Below is the methodology used to determine the exposure projections for each county.

TABLE 3-135 WILDFIRE EXPOSURE PROJECTIONS

Future Wildfire Exposure Projections					
		County Population Percent Change Projections, 2010 to 2030			
	Wildfire Risk Ratio	-13% to 2%	3% to 17%	18% to 34%	35% to 89%
High ↑ Moderate	0.153 – 0.528	Moderate	High	Severe	Extreme
	0.039 – 0.152	Slight	Moderate	High	Severe
	0.000 – 0.038	Negligible	Slight	Moderate	High

Exposure to wildfire is expected to increase across the State of Colorado between 2010 and 2030 as development and population growth continue. The darker colors in Table 3-135 and Table 3-136 illustrate relative rates of increase in exposure between counties. Douglas and Garfield Counties rank in the most extreme risk category. Many high density Front Range counties located along the foothills, including Larimer, Jefferson, El Paso, and Boulder, rank in the severe or high exposure category. These counties are continuing to experience population growth and have a higher risk to wildfire.

TABLE 3-136 WILDFIRE EXPOSURE PROJECTIONS, 2010 TO 2030

County	Wildfire Risk Ratio	Population Change	Exposure Projection
Douglas	0.291	43%	Extreme
Garfield	0.259	37%	Extreme
Archuleta	0.113	40%	Severe
Montezuma	0.094	37%	Severe
San Miguel	0.054	58%	Severe
El Paso	0.053	36%	Severe
Larimer	0.042	41%	Severe
Jefferson	0.152	20%	High
Boulder	0.132	27%	High
Mesa	0.115	23%	High
Eagle	0.094	33%	High
Montrose	0.090	29%	High
Custer	0.089	19%	High
Teller	0.042	24%	High
Park	0.039	34%	High
La Plata	0.026	42%	High

County	Wildfire Risk Ratio	Population Change	Exposure Projection
Routt	0.022	40%	High
Summit	0.021	40%	High
Denver	0.019	42%	High
Adams	0.006	48%	High
Arapahoe	0.001	35%	High
Broomfield	0.000	71%	High
Elbert	0.000	88%	High
Weld	0.000	80%	High
Rio Blanco	0.528	1%	Moderate
Dolores	0.120	5%	Moderate
Delta	0.074	8%	Moderate
Fremont	0.061	5%	Moderate
Pitkin	0.033	17%	Moderate
Pueblo	0.023	19%	Moderate
Chaffee	0.007	29%	Moderate
Alamosa	0.003	22%	Moderate
Hinsdale	0.002	29%	Moderate
Gunnison	0.002	25%	Moderate
Grand	0.001	31%	Moderate
Lincoln	0.000	21%	Moderate
Moffat	0.125	-3%	Slight
Clear Creek	0.031	13%	Slight
Ouray	0.018	16%	Slight
Gilpin	0.011	13%	Slight
Saguache	0.002	9%	Slight
San Juan	0.002	4%	Slight
Lake	0.002	17%	Slight
Mineral	0.001	16%	Slight
Crowley	0.000	4%	Slight
Costilla	0.000	6%	Slight
Logan	0.000	14%	Slight
Morgan	0.000	15%	Slight
Washington	0.000	5%	Slight
Yuma	0.000	6%	Slight
Conejos	0.008	0%	Negligible
Huerfano	0.007	-1%	Negligible

County	Wildfire Risk Ratio	Population Change	Exposure Projection
Rio Grande	0.004	-4%	Negligible
Bent	0.004	-4%	Negligible
Jackson	0.004	-7%	Negligible
Otero	0.001	-6%	Negligible
Prowers	0.001	-5%	Negligible
Las Animas	0.001	-9%	Negligible
Baca	0.000	-13%	Negligible
Cheyenne	0.000	2%	Negligible
Kiowa	0.000	-7%	Negligible
Kit Carson	0.000	-1%	Negligible
Phillips	0.000	-2%	Negligible
Sedgwick	0.000	-2%	Negligible

Source: CO Department of Local Affairs; CO-WRAP, 2013

Continuing outreach for education and adoption of building codes that are strong in the use of ignition resistant materials and defensible space are necessary to keep up with increasing wildfire risk.

In review of local hazard mitigation plans, the following information was provided regarding wildfires and future development:

- Archuleta County - While overall development has slowed down, some of the development has occurred in hazard areas such as the WUI and floodplains.
- Clear Creek County - Clear Creek County is a historic mining district that has only seen modest land development since that period. However, there is extensive large- lot development in the eastern- most areas of the county adjoining Jefferson County. Most all of the commercial development is located within the towns and cities along Interstate 70 bordering Clear Creek.
- City of Colorado Springs - Building standards can offer only limited protection from fire damage. Increasing population growth and development increases vulnerability to fires, specifically along the foothills.
- Ouray County - 187 new properties developed in WUI between 2008 and 2013; greatest growth in Log Hill Village/Fairway Pines and North Log Hill Mesa.

## 9. CLIMATE CHANGE

Table 1.11 describes the projected impacts of climate change on wildfire in Colorado. However, ongoing efforts to reduce Colorado's greenhouse gas emissions and adapt to a changing

climate, such as the Colorado Climate Plan and the Climate Change in Colorado Report, will help to reduce the impacts of climate change on wildfire.

**TABLE 3-137 IMPACTS OF CLIMATE CHANGE ON WILDFIRE IN COLORADO**

Impact	Projected Change
<b>Location</b>	The area at risk to wildfires is not projected to change.
<b>Extent/Intensity</b>	Wildfire intensity is projected to increase due to additional dry vegetation that can fuel wildfires. Extent is projected to increase. Total area burned per year is projected to increase substantially into the 21st century in the Rocky Mountain West and Colorado.
<b>Frequency</b>	Droughts are projected to occur more frequently, increasing the frequency of wildfires.
<b>Duration</b>	The length of the fire season in Colorado is projected to increase by several weeks.

Source: FEMA 2017 and Lukas et al. 2014

## 10. RISK TO STATE ASSETS

Figure 3-66 shows state assets in relation to areas of the state with high wildfire potential. State assets in areas with highest threat of wildfire total 37 with a value of around \$5.3 million. This number expands ten-fold when considering High and Moderate wildfire threat areas with 588 state assets and \$246.7 million in value. Table 3-138 summarizes these results.

FIGURE 3-66 STATE ASSETS BY WILDFIRE THREAT LEVEL

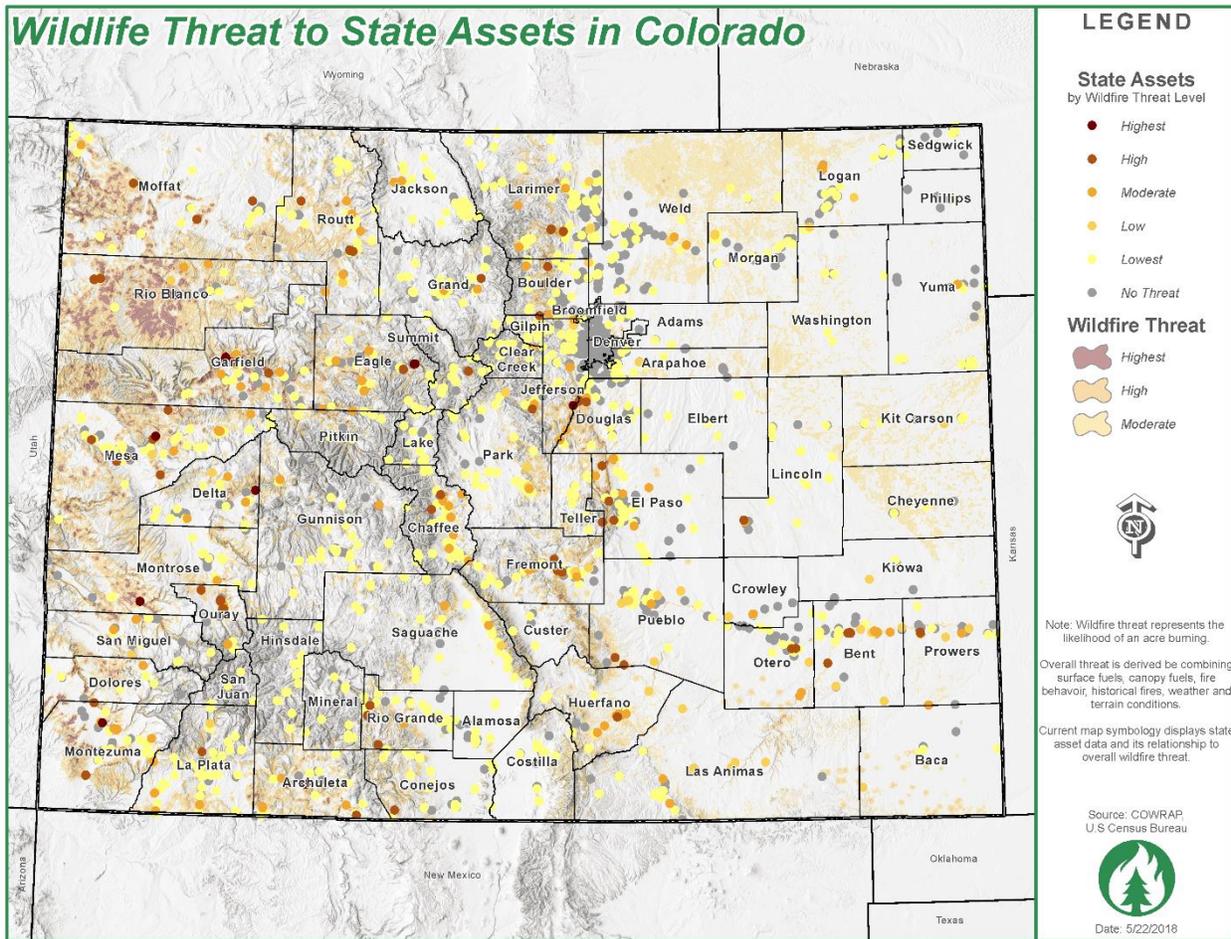


TABLE 3-138 STATE ASSETS BY WILDFIRE THREAT LEVEL

Threat Level	Count	Value
<b>Highest</b>	37	\$5,302,995
<b>High</b>	142	\$144,807,359
<b>Moderate</b>	409	\$96,603,293
<b>Low</b>	95	\$23,504,373
<b>Lowest</b>	2,720	\$2,607,963,492
<b>No Threat</b>	4,829	\$17,360,169,124
<b>Total</b>	<b>8,232</b>	<b>\$20,238,350,636</b>

Rio Blanco and Garfield Counties stand out as possessing the greatest number and value of state assets in the highest wildfire hazard areas as shown in Table 3-139. These two counties contain a total of \$4.46 million in the highest wildfire threat. Overall, Rio Blanco County contains the highest value of state assets in the highest, high, or moderate wildfire threat areas, with a

value of \$53.7 million. This is approximately 85 percent of Rio Blanco County’s total state asset value, which is \$63.91 million.

The relationship between the highest concentrations of state assets and related value is nearly inverse to wildfire threat, as the threat of wildfire is significantly reduced east of the foothills in the urbanized Front Range where most of the state property is located. In the Front Range, it is not state assets that are the most vulnerable, but rather structures on private property that are within the WUI and not properly mitigated with defensible space or fire-resistant materials.

Since 2008, there have been 11 property losses reported on state assets due to wildfire, resulting in \$954,197 in losses. Reported property damage includes damage to property signs, fences, irrigation wells, and wood posts. The largest reported expense was \$577,660 due to a lightning strike caused wildfire that damaged Colorado Parks and Wildlife property in Yuma County. It is important to note that state asset loss data is only available for state assets included in the 2017 Office of Risk Management (ORM) database. These numbers exclude many Higher Education assets, and therefore may under-represent actual losses.

One of the most notable loss events resulted from the 1996 Buffalo Creek and 2002 Hayman Fires, which costed Denver Water \$20 million in wildfire-related dredging and maintenance at the Strontia Springs Reservoir, without complete resolution of the problem.

**TABLE 3-139 WILDFIRE THREAT TO STATE ASSETS BY COUNTY**

Highest Wildfire Threat			High Wildfire Threat			Moderate Wildfire Threat		
County	Count	Total Value	County	Count	Total Value	County	Count	Total Value
Rio Blanco	13	\$2,338,418	Rio Blanco	13	\$40,630,484	Montezuma	22	\$16,906,434
Garfield	13	\$2,122,722	Prowers	5	\$35,591,913	Garfield	73	\$15,979,404
Eagle	5	\$507,095	Bent	15	\$31,667,556	Rio Blanco	7	\$10,735,520
Archuleta	1	\$270,101	Garfield	22	\$12,051,087	Larimer	77	\$9,617,344
Delta	1	\$33,383	Fremont	7	\$11,165,812	El Paso	9	\$8,998,319
Jefferson	1	\$9,563	Mesa	13	\$3,834,480	Eagle	25	\$4,720,067
Mesa	1	\$7,238	Douglas	3	\$1,864,657	Yuma	11	\$4,717,847
Montezuma	1	\$7,238	Ouray	11	\$1,474,750	Crowley	2	\$3,712,800
Montrose	1	\$7,238	Huerfano	9	\$1,217,752	Bent	13	\$2,851,887
<b>Total</b>	<b>37</b>	<b>\$5,302,995</b>	Moffat	4	\$931,410	Mesa	25	\$2,620,329
			Larimer	4	\$728,649	Logan	11	\$2,336,887
			El Paso	3	\$727,707	Ouray	13	\$2,299,275
			Montezuma	5	\$711,243	Fremont	14	\$1,767,880
			Chaffee	3	\$637,654	Archuleta	8	\$1,662,050
			Routt	5	\$533,394	Prowers	3	\$1,289,431
			Otero	3	\$467,349	Rio Grande	5	\$881,782
			Pueblo	2	\$381,926	Clear Creek	1	\$741,967

Highest Wildfire Threat			High Wildfire Threat			Moderate Wildfire Threat		
County	Count	Total Value	County	Count	Total Value	County	Count	Total Value
			La Plata	1	\$80,000	Huerfano	14	\$689,053
			Rio Grande	3	\$30,407	Dolores	5	\$664,429
			Boulder	2	\$21,211	Lincoln	6	\$614,563
			Archuleta	1	\$10,136	Douglas	8	\$544,801
			Gilpin	1	\$10,136	Chaffee	12	\$442,610
			Grand	1	\$10,136	Las Animas	2	\$400,332
			Lincoln	1	\$10,136	Park	2	\$284,638
			Park	1	\$10,136	Jefferson	2	\$268,768
			Summit	1	\$7,238	San Miguel	8	\$216,000
			Conejos	1	\$1	Weld	2	\$170,238
			Eagle	1	\$1	Routt	4	\$138,436
			Teller	1	\$1	Moffat	3	\$122,257
			<b>Total</b>	<b>142</b>	<b>\$144,807,359</b>	La Plata	4	\$37,645
						Delta	3	\$30,181
						Jackson	2	\$25,626
						Boulder	2	\$20,271
						Otero	2	\$20,271
						Saguache	2	\$20,271
						Gunnison	2	\$17,374
						Montrose	1	\$10,136
						Pitkin	1	\$10,136
						Grand	2	\$8,798
						Pueblo	1	\$7,238
						<b>Total</b>	<b>409</b>	<b>\$96,603,293</b>
<b>Grand Totals</b>							<b>588</b>	<b>\$246,713,647</b>

Source: Colorado Office of Risk Management, COWRAP

## 11. RESOURCES

- Colorado Climate Plan
- Colorado Department of Transportation (CDOT) Emergency Operations Plan (EOP)
- Colorado Department of Transportation (CDOT) Threat and Hazard Identification and Risk Assessment (THIRA)
- Colorado Division of Homeland Security and Emergency Management (DHSEM) Threat and Hazard Identification and Risk Assessment (THIRA)
- Colorado Energy Assurance Emergency Plan
- Colorado State Forest Service (CSFS)

- Colorado Water Plan
- Colorado Wildfire Risk Assessment Portal (CO-WRAP)
- The Denver Post
- Federal Emergency Management Agency (FEMA). (2017). Assessing Future Conditions, Colorado.
- Lukas, J., Barsugli, J., Doesken, N., Rangwala, I., and Wolter, K. (2014). Climate Change in Colorado: A Synthesis to Support Water Resources Management and Adaptation.
- U.S. Fish and Wildlife Service
- U.S. Forest Service (USFS)

# AVALANCHE



## 1. DEFINITION

An avalanche is a mass of snow, ice, and debris flowing and sliding rapidly down a steep slope. Avalanches are also referred to as snow slides. Snow avalanches are defined in Colorado state statutes as a geologic hazard. There are four factors that contribute to an avalanche: a steep slope, a snow cover, a weak layer in the snow cover, and a trigger. Table 3-140 describes the hazard profile summary for avalanche.

TABLE 3-140 HAZARD PROFILE SUMMARY

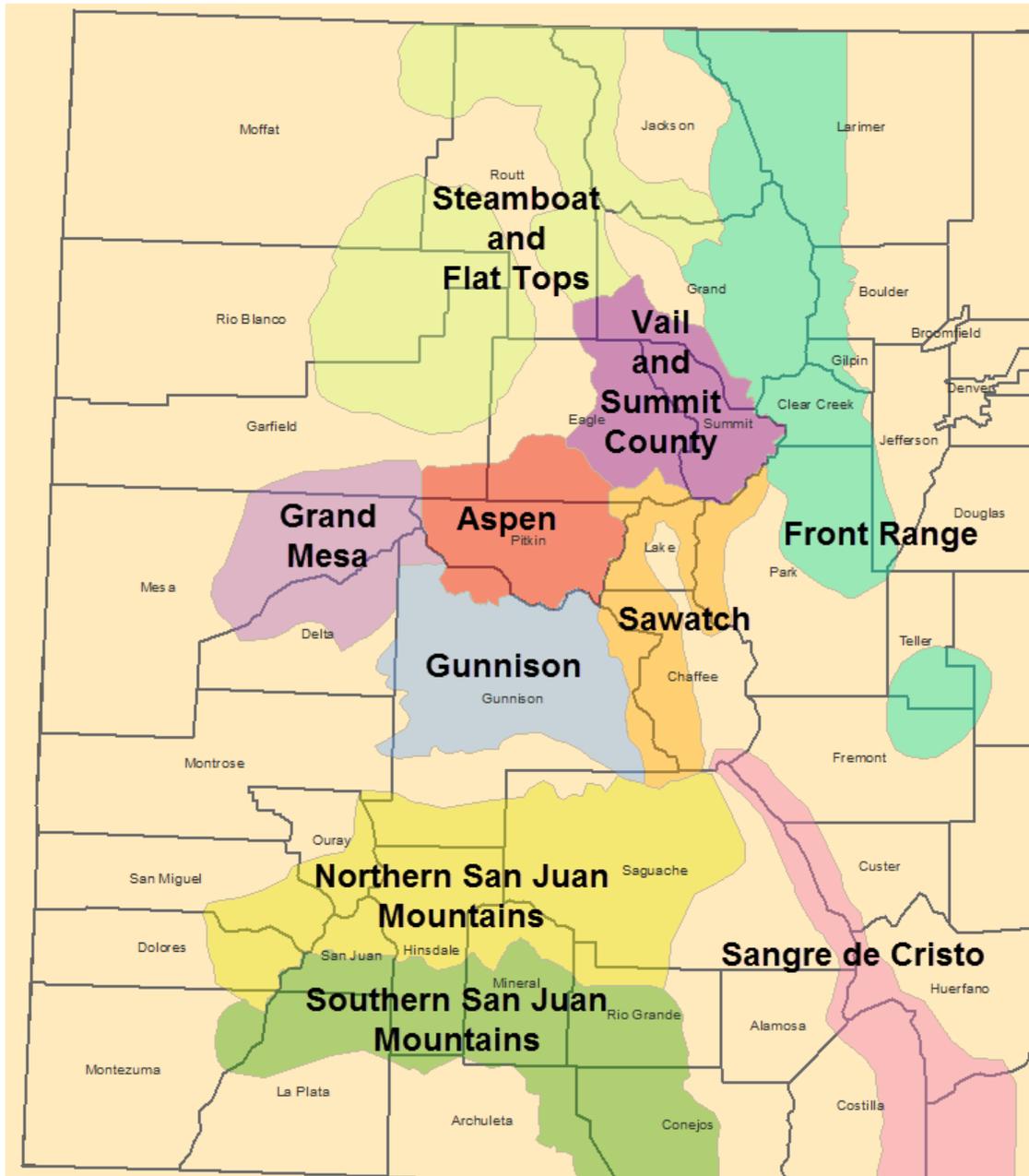
Consideration	Impact	Description
<b>Location</b>	Regional	Concentrated west of Interstate 25 in the higher elevations of the mountains.
<b>Previous Occurrence</b>	Seasonal	Occur every year - commonly from November through April. Not all avalanche paths run every year. Many run only once every 5 to 15 years, and others even less frequently.
<b>Probability</b>	Expected	Atmospheric conditions resulting in appropriate snow conditions for avalanche are expected to occur in the future as in the past. Known avalanche areas will typically continue to produce events.
<b>Extent</b>	Extensive	Limited property damage that does not typically threaten structural integrity; annual deaths (5 - 6 per year) and multiple injuries; little or no impact on critical services or facilities.

## 2. LOCATION

Avalanche hazards occur predominantly in the mountainous regions of Colorado above 8,000 feet. About 90 percent of all avalanches start on slopes of 30-45 degrees; about 98 percent of all avalanches occur on slopes of 25-50 degrees. Avalanches release most often on slopes above timberline that face away from prevailing winds (leeward slopes collect snow blowing from the windward sides of ridges). Nevertheless, avalanches can 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. The Colorado Geological Survey (CGS) and the Colorado Avalanche Information Center (CAIC) have mapped some areas of the state susceptible to avalanche activity. The CAIC forecasts backcountry avalanche and mountain weather conditions for 10 zones in the mountains of Colorado as shown in Figure 3-67. This figure depicts the zone forecast areas for avalanche risk, but is not intended to show

current risk as it constantly changes throughout the winter season. Rather, the intent of this figure is to show forecast zone boundaries as an indication of where avalanches tend to occur across the state.

**FIGURE 3-67 AVALANCHE FORECAST ZONES IN COLORADO**



Source: CAIC

### 3. EXTENT (MAGNITUDE/STRENGTH)

Avalanches occur regularly in the backcountry and are not a problem until human activities and land uses are affected adversely by the avalanches. Possible conflicting land uses between humans and avalanches include recreation, residential, transportation, and mining. Examples of this conflict include property damage, injury, deaths, and excessive maintenance costs (e.g., removal of debris from transportation corridors impacted by avalanches). Some power line corridors in southwest Colorado have also been known to be affected by avalanches, resulting in power outages.

Avalanches are extremely destructive due to the great impact forces of the rapidly moving snow and debris and the burial of areas in the runout zone. Structures not specifically designed to withstand the impacts are generally totally destroyed. Where avalanches cross highways, passing vehicles can be swept away and demolished, and their occupants killed. Snow avalanches also imperil cross-country skiers, downhill skiers, snowboarders, and snowmobilers. Several backcountry visitors perish each winter. Residences planned or erected in avalanche run out zones may not qualify for financing or insurance.

The maximum measured impact pressure of an avalanche is 20,000 lb/ft<sup>2</sup> while 2,000 lb/ft<sup>2</sup> is more common. Impact pressure typically averages between 1,000 lb to 10,000 lb/ft<sup>2</sup>. Air blasts from powder avalanches commonly exert a pressure of 100 lb/ft<sup>2</sup> of force. Pressures of only 20-50 lb/ft<sup>2</sup> are capable of knocking out most windows and doors. Additional damages associated with impact pressure are shown below.

TABLE 3-141 IMPACT PRESSURE DAMAGE

Impact Pressure (lbs/ft <sup>2</sup> )	Potential Damage
40-80	Break windows
60-100	Push in doors, damage walls, roofs
200	Severely damage wood frame structures
400-600	Destroy wood-frame structures, break trees
1000-2000	Destroy mature forests
>6000	Move large boulders

Source: FEMA, Colorado Geological Survey

Roads, highways, and railroads are blocked for hours, or sometimes days, every year due to avalanches. Many skiers, other winter sports enthusiasts, and travelers have been injured or killed by avalanche activity.

### 4. PROBABILITY

Avalanche-prone areas may pass many winters or even decades without a serious avalanche with many running only once every five to 15 years, and others even less frequently. When

avalanches do occur, they are most common between November and April. The most avalanche-prone months are, in order, February, March, and January. Not all avalanche paths run every year, and when they do they may not run the full length of their paths. Avalanches may stop in the starting zone, track, or run-out zone, depending on the amount and condition of the snow in the path.

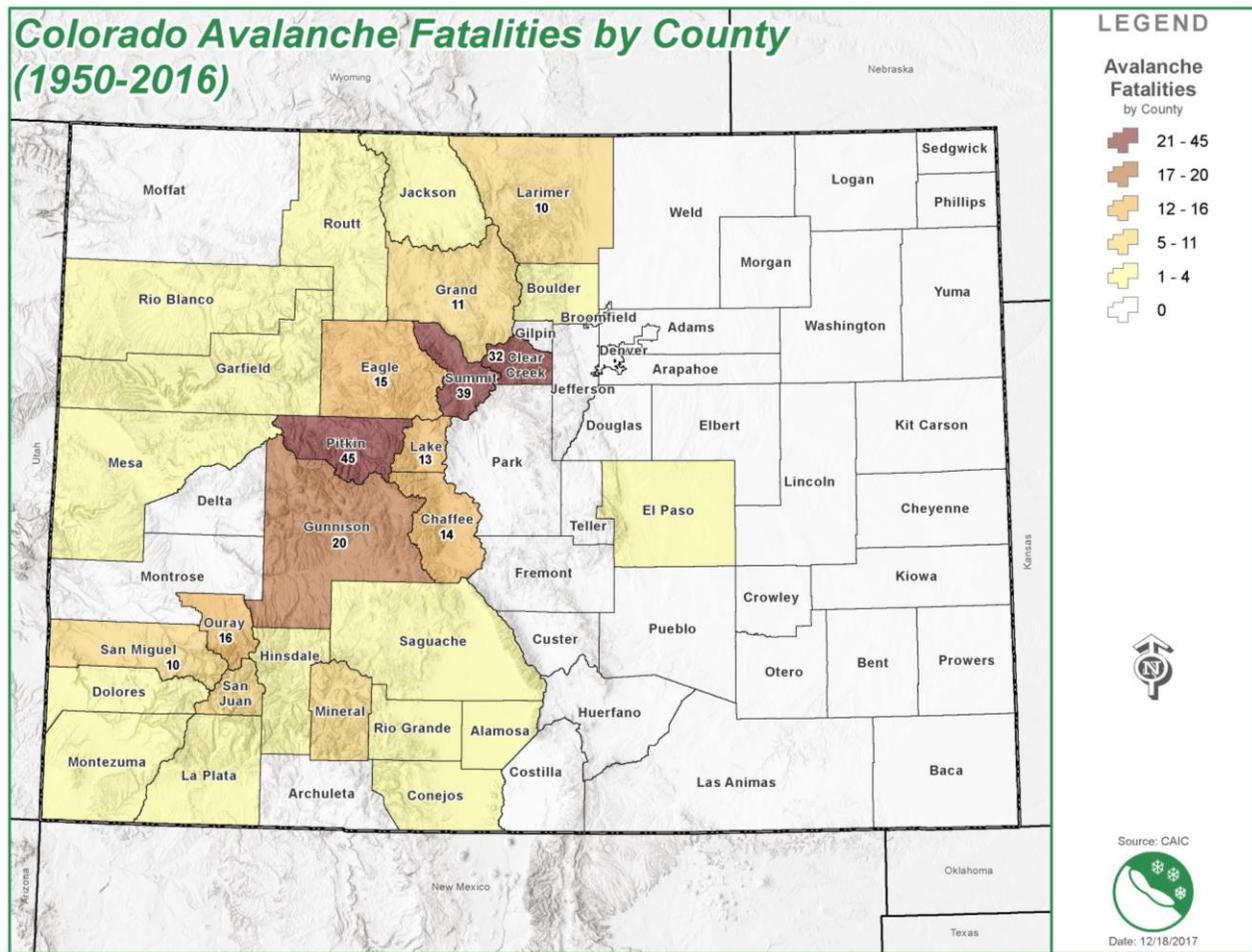
Because it is difficult to accurately capture the number of avalanches occurring in any given year, looking at the number of fatalities by county may provide an idea of where to focus mitigation activities. The American Institute for Avalanche Research and Education (AIARE) reports that 90 percent of avalanche victims die in slides triggered by themselves or a member of their group. Obtaining a better understanding of outdoor recreation in avalanche-prone areas may lend a better understanding of future probability for this hazard.

## 5. PREVIOUS OCCURRENCES

Hundreds of snow avalanches happen each winter, most of them in remote places. The central and west central mountains have the most reported occurrences. Figure 3-68 shows that between 1950 and 2016, Pitkin County experienced the greatest number of avalanche-related deaths in the state at 45 fatalities, followed closely by Summit County with 39 fatalities. Clear Creek County had the third highest number of deaths during this time period with 32. Other counties with 10 or more avalanche deaths since 1950 include Gunnison, Ouray, Eagle, Chaffee, Lake, Grand, and San Miguel.

**Loveland Pass, Clear Creek County – April 20, 2013:** The deadliest recorded avalanche in the past 50 years in Colorado occurred on April 20, 2013. Six experienced backcountry skiers and snowboarders triggered the slide in the Sheep Creek drainage of Loveland Pass in Clear Creek County. All six group members were buried, and only one survived. The slope where the avalanche occurred was not extremely steep, but heavy, wet snows and high winds created unstable conditions. The 2012-2013 winter was one of the highest risk avalanche seasons seen by forecasters in several decades (Tom McGhee, The Denver Post, April 21, 2013, <http://www.denverpost.com/2013/04/21/loveland-avalanche-victims-identified-from-colorados-deadliest-slide-in-50-years/>).

FIGURE 3-68 COLORADO AVALANCHE FATALITIES BY COUNTY



Historic significant avalanche events and others resulting in loss of life or injury since 2007 are listed and described in Table 3-142 below. As indicated by the year column in the table, events with loss of life or injury are typically an annual occurrence. Table 3-143 lists the number of incidents and fatalities by decade since 1990.

TABLE 3-142 FATAL AVALANCHES BY LOCATION, 2007-2018

Year	Description	Deaths
2007	Cameron Pass. Snowmobiler.	1
2008	Little Box Canyon. Snowmobiler.	1
2008	East Vail backcountry. Snowboarder.	1
2008	Gravel Mountain, north of Granby. Snowmobilers.	2
2008	Northwest of Crested Butte. Snowmobiler.	1
2008	Near Aspen Ski Area. Skier.	1

<b>Year</b>	<b>Description</b>	<b>Deaths</b>
2009	Bartlett Mountain near Fremont Pass. Skier.	1
2009	Apache Peak, Indian Peaks. Skier.	1
2010	Steep Gully #1, west of Arapahoe Basin Ski Area. Snowboarder.	1
2010	Battle Mountain, Vail side country. Snowboarder.	1
2010	Southwest of Creede. Other.	2
2010	Near the Ridgway Hut, San Juan Mountains. Skier.	1
2010	Lindley Backcountry Hut south of Aspen. Skier.	1
2010	Near Antora Peak south of Buena Vista. Snowmobiler.	1
2010	Near Baldy Peak, east of Ridgway. Climber.	1
2010	Wolf Creek Pass Ski Area, Glory Hole point. Ski patroller.	1
2010	Dry Gulch – east of Eisenhower Tunnel. Skier.	1
2011	High Trails Cliff, northeast of Berthoud Pass. Snowboarder.	1
2011	Sand Peak – Flat Tops. Snowmobiler.	1
2011	East Snowmass Creek Valley, Sand's Chute. Skier.	1
2011	Highlands Ridge, Desolation Row, Aspen Zone. Skier.	1
2011	Torreys Peak. Snowboarder.	1
2012	Burnt Mountain near Snowmass Village. Skier.	1
2012	Chedsey Creek, North Park. On foot.	1
2012	Prima Cornice, Vail. Skier.	1
2012	Trestle Trees, Winter Park. Skier.	1
2012	Contention Fingers, Bear Creek, Telluride. Snowboarder.	1
2012	Gibbs Creek, near Wolf Creek Pass. Skier.	1
2012	Ophir, Paradise -Basin. Skier.	1
2012	Ships Prow Glades, Snowmass Ski Area. Ski patroller.	1
2013	Raspberry Creek, near Marble. Skier.	1
2013	Clothesline Path, Cement Creek, near Silverton. Skier.	1
2013	Nokhu Crags, Never Summer Mountains. Skier.	1

Year	Description	Deaths
2013	Ypsilon Mountain, Rocky Mountain National Park. Climber.	1
2013	Ptarmigan Hill, near Vail Pass. Snowboarder.	1
2013	Sheep Creek, north Loveland Pass. Backcountry tourer.	5
2013	Parkview Mountain, west of Willow Creek Pass. Backcountry traveler.	1
2014	East Vail, backcountry southeast of Vail Ski Area. Rider.	1
2014	North Fork Swan River, south of Keystone Ski Area. Skier.	1
2014	Near Kebler Pass, west of Crested Butte. Snowmobiler.	1
2014	Star Mountain, near Twin Lakes. Skier.	2
2014	Diablo Ridge, Pt. 12,505, approx. 1 mile W of Coneios Peak. Skier.	1
2014	Sharkstooth Peak, La Plata Mountains. Snowmobiler.	1
2014	Kelso Mountain. Climber/snowshoer.	1
2015	Rabbit Ears path, Kendall Mountain. Skier.	1
2015	Peter Barker path, near Aspen Mountain. Skier.	1
2016	St. Mary's Lake. Climber.	1
2016	Ruby Peak, Ruby Range, west of Crested Butte. Snowmobiler.	1
2016	Lost Mine Creek, east of Wolf Creek Pass. Snowmobiler.	1
2016	Cottonwood Pass, west of Buena Vista. Snow bike rider.	1
2016	Red Mountain, Clear Creek County. Snowboarder.	1
2017	Near West Lost Lake, Flat Tops Wilderness Area. Snow bike rider.	1
2018	South of Red Mountain Pass. Skier.	1
<b>TOTAL</b>		<b>60</b>

Source: National Climatic Data Center, Colorado Avalanche Information Center

TABLE 3-143 SIGNIFICANT AVALANCHES BY DECADE

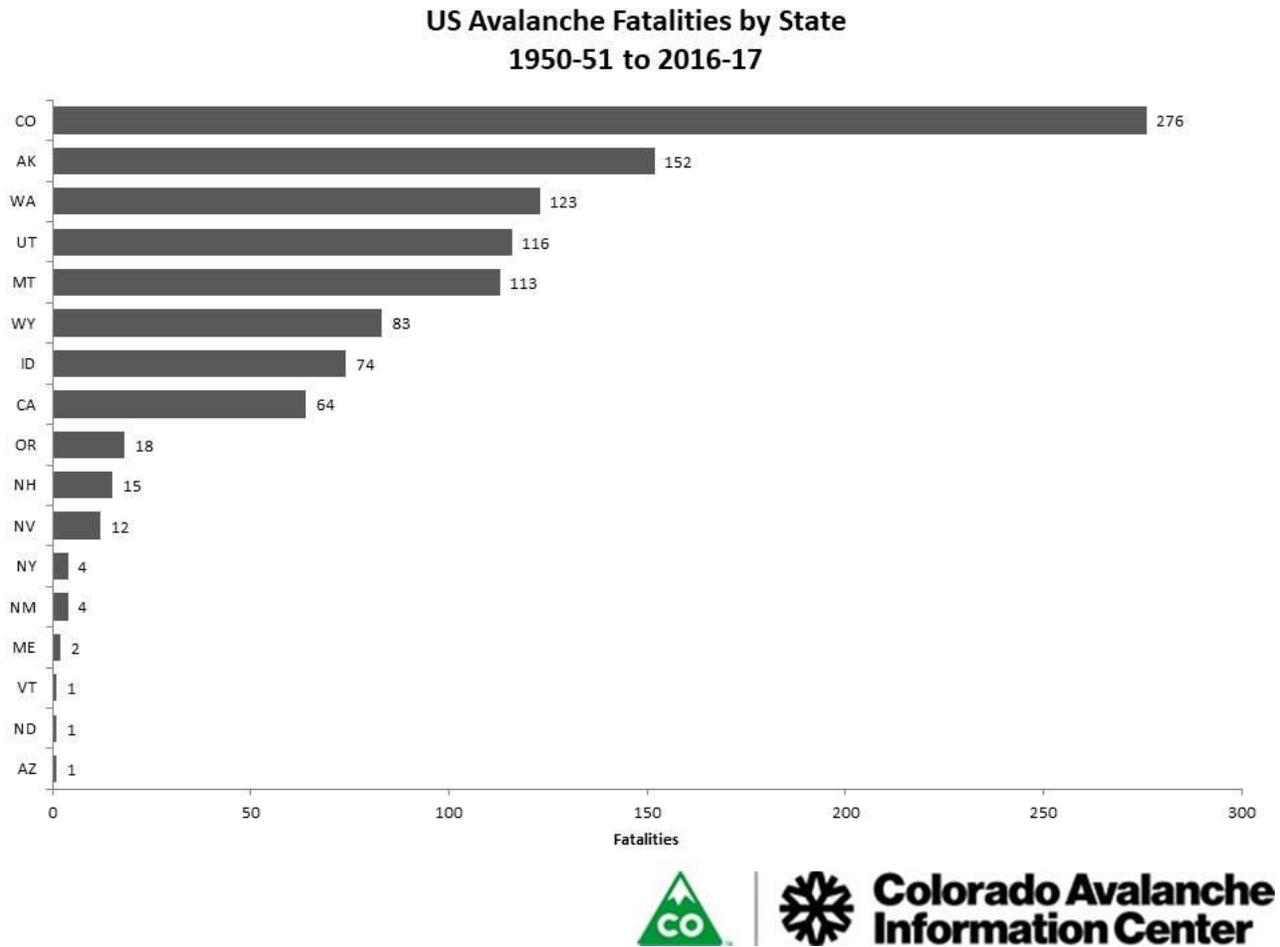
Year	Count	Deaths
1990-1999	13	12
2000-2009	40	41
2010-2017	44	50
<b>TOTAL</b>	<b>97</b>	<b>103</b>

## 6. IMPACT ANALYSIS

Over the last 10 winters in the United States an average of 27 people died in avalanches every year. Every fatal accident is investigated and reported, so those numbers can be reported with some certainty. Most avalanche related deaths occur from winter sports and recreation activities. Some deaths result from highway maintenance and avalanche response activities. Although it is difficult to determine the exact number of persons at risk from avalanche, Colorado historically averages between five to six deaths per year. There have been avalanche fatalities and accidents in Colorado every month of the year. There is no way to determine the number of people who are caught or buried in avalanches but survive each year, because non-fatal avalanche incidents are increasingly under reported per CAIC ([http://avalanche.state.co.us/caic/acc/acc\\_stats.php](http://avalanche.state.co.us/caic/acc/acc_stats.php)).

Figure 3-69 depicts the number of avalanche fatalities in the United States by state for winter seasons 1950/1951 to 2016/2017 (as of December 10, 2017). Colorado leads the country with 276 deaths attributed to avalanches during this time period, 100 more deaths than the next highest ranked state.

FIGURE 3-69 AVALANCHE FATALITIES BY STATE, WINTER 1950/1951 TO WINTER 2016/2017



Source: CAIC

Lack of recognition of avalanche run out potential (the farthest reach of debris) has resulted in some residential building construction within run out zones in Colorado. When the infrequent but large avalanche event occurs, these structures will be damaged unless measures are taken to protect existing structures and prohibit new development in run out zones.

Property damage can occur throughout the entire avalanche path. Impact (air or snow) damage ranges from minor to major structural damage to any structure within the path. Vehicles and equipment can be moved great distances and damaged. When deposited, the debris associated with the avalanche might cause damage and be expensive to remove.

Roads, highways, and railroads may become blocked and damaged by avalanche snow and debris. In addition to delaying highway and rail travel, it is costly to clear the transportation routes. In a few cases, where avalanches threaten access roads to mountaintop radio and microwave communication sites, emergency repairs and maintenance are delayed. In areas

where efforts are underway to control avalanches, the maintenance of avalanche control structures and /or explosive control is costly.

Even though avalanches are a seasonal hazard, their impacts can have major consequences on a variety of critical infrastructure/key resource sectors. A brief sampling of these impacts is shown in Table 3-144.

**TABLE 3-144 AVALANCHE EMAP IMPACT SUMMARY**

Consideration	Description
<b>General Public</b>	There are six to seven annual deaths along with multiple injuries with most deaths and injuries impacting winter sport and backcountry recreationists such as skiers and snowboarders, hikers, and snowmobilers. Highway maintenance crews and motorists are also at risk of avalanche near or on roadways.
<b>First Responders</b>	Some exposure exists to personnel performing routine duties on roadways and other areas that may be prone to events. Some responders may face risk of avalanches during response if entering avalanche prone areas, however most avalanche-related duties are post-event where risk of occurrence has subsided.
<b>Property</b>	Instances of personal property losses are infrequent yet occur on occasion. Known avalanche runs are typically void of development due to local land use regulations. Some events will impact private vehicles.
<b>Facilities and Infrastructure</b>	Buildings and equipment are typically not located within avalanche runs due to their known locations and local land use regulations. Roadways are blocked by avalanches but typically do not sustain significant damage. Communication and power infrastructure occasionally experiences short-term or minor impacts.
<b>Economic</b>	Possible short-term blockage of roadways that prevent travel and access to local businesses by residents, recreationists, and tourists. Due to limited exposure of property to this hazard, economic losses resulting from damage to buildings and personal property or associated downtime are anticipated to be limited.
<b>Environment</b>	Localized impact related to tree damage may be found in or around avalanche chutes. Removal or displacement of trees and rocks may cause secondary impacts such as landslides or rock falls as slope stability is impacted. There is potential for the short-term damming and sudden release of water if event intersects a waterway.
<b>Continuity of Government and Services</b>	Loss of facilities or infrastructure for the provision of government services is expected to be non-existent or negligible. Possible short-term accessibility issues for first responders performing routine duties or personnel reporting to work locations.
<b>Confidence in Government</b>	Characteristics of avalanches result in limited response and recovery functions for government beyond first responders. Monitoring programs typically mitigate potential large-scale events and road crews are typically swift in restoring service to blocked roadways.

Consideration	Description
<b>Critical Assets</b>	Risk to any critical assets is limited due to few state or local facilities located within avalanche runs.

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

The avalanche hazard is localized to counties in mountain regions in Colorado. Avalanche-prone areas are well known; avalanche chutes identify where they will likely occur again. Where communities have built or developments have encroached into steep mountainous terrain, the vulnerability increases. Most of the exposure to the population is in winter recreation areas. The complex interaction of weather and terrain factors contributes to the location, size, and timing of avalanches. In the absence of detailed scientific observation, any accumulation of snow on a slope steeper than 20 degrees should be considered a potential avalanche hazard. Usually when one slope is hazardous, many of the nearby slopes are also hazardous.

Data on property damages is limited. In previous versions of this plan SHELDUS data was analyzed on a county by county basis. Related property damage in Colorado between 1960-2008 was relatively low with a total of \$313,500, as shown in Table 3-145. An update to this data was not available for the 2018 E-SHMP since SHELDUS data is no longer publicly available and requires a user fee. The National Centers for Environmental Information (NCEI) property damage summary of avalanche events did not include information on damages.

TABLE 3-145 AVALANCHE DAMAGE IN COLORADO BY COUNTY: 1960 TO 2008

County	Number of Events	Property Damage
<b>Alamosa</b>	1	\$0
<b>Archuleta</b>	2	\$22,422
<b>Boulder</b>	5	\$8,333
<b>Broomfield</b>	1	\$8,333
<b>Chaffee</b>	3	\$0
<b>Clear Creek</b>	4	\$0
<b>Costilla</b>	1	\$0
<b>Custer</b>	1	\$0
<b>Delta</b>	6	\$2,500
<b>Dolores</b>	2	\$22,422
<b>Eagle</b>	6	\$367
<b>Fremont</b>	1	\$0
<b>Garfield</b>	7	\$367
<b>Gilpin</b>	3	\$0

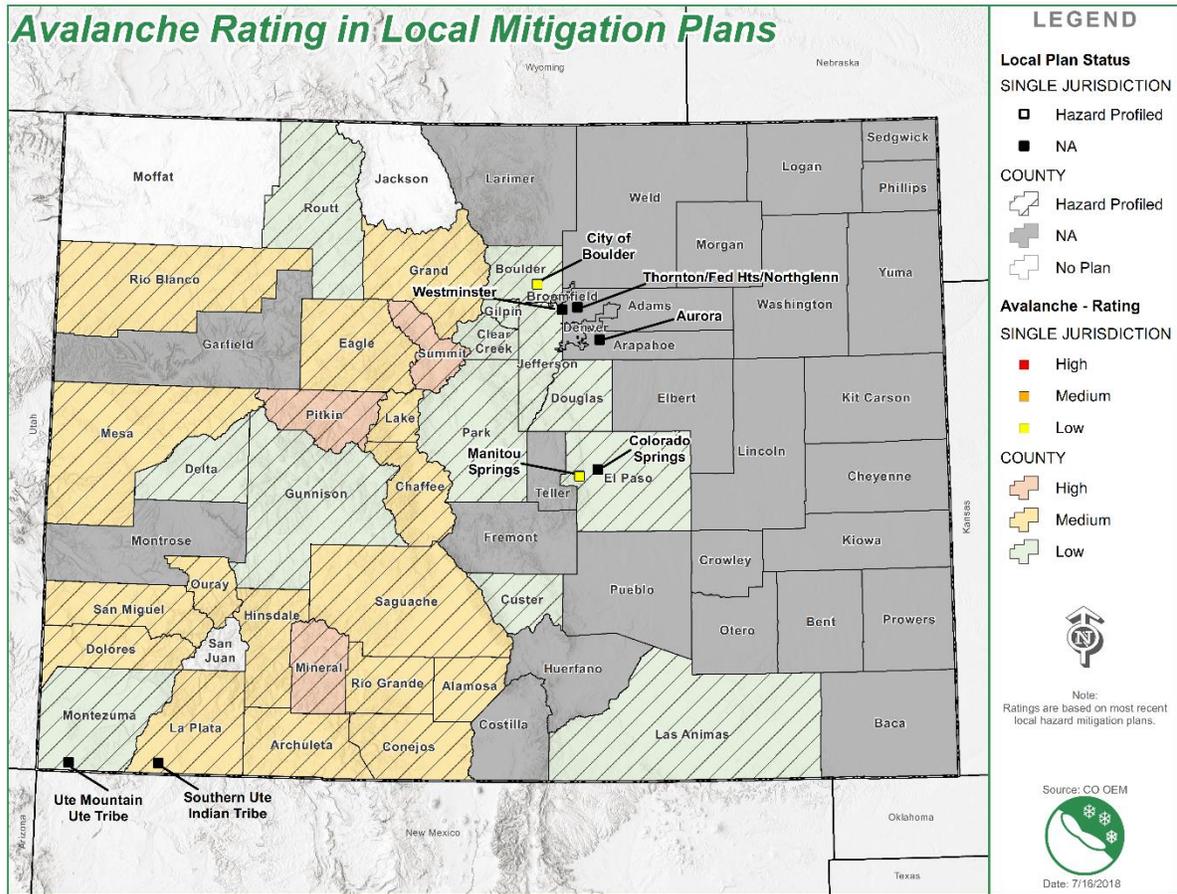
County	Number of Events	Property Damage
Grand	6	\$0
Gunnison	9	\$22,222
Hinsdale	4	\$22,422
Huerfano	1	\$0
Jackson	1	\$0
Jefferson	4	\$8,333
La Plata	2	\$22,422
Larimer	2	\$0
Mesa	4	\$2,500
Moffat	1	\$0
Montezuma	4	\$27,922
Montrose	5	\$0
Ouray	3	\$22,222
Park	3	\$0
Pitkin	13	\$367
Rio Blanco	1	\$0
Routt	3	\$0
Saguache	1	\$0
San Juan	6	\$97,922
San Miguel	8	\$22,422
Summit	7	\$0
<b>TOTAL</b>	<b>131</b>	<b>\$313,500</b>

Source: SHELDUS

Three jurisdictions identify avalanche as a high priority hazard in their local hazard mitigation plans: Mineral County, Pitkin County, and Summit County. Of those three, Mineral County and Summit County list avalanche as one of their top four hazards overall. Neither county specifically identified any structures or critical facilities in avalanche hazard areas due to a lack of comprehensive information or mapping of avalanche hazard areas. Neither jurisdiction provided loss estimates for avalanches. Summit County does not have any mitigation actions specific to avalanche. Mineral County's mitigation actions included raising public awareness to avalanche hazards.

Figure 3-70 represents avalanche hazard rank by county, based on a review of local hazard mitigation plans.

FIGURE 3-70 AVALANCHE HAZARD RANK IN LOCAL MITIGATION PLANS



## 8. FUTURE DEVELOPMENT

Population projections in Colorado indicate that the most avalanche prone areas will not experience the most significant population growth. However, overall population growth in the state is generally equating to more people recreating in the backcountry, increasing exposure to potential avalanche accidents. Advances in snowmobile technology, and the variety of snow machines (e.g., motorized and non-motorized snow bikes) allow easier access to backcountry terrain. Newcomers to the state may not be cognizant of the typically weak and risky backcountry snowpack. Population growth also means more traffic in the mountains, furthering the need for avalanche mitigation along popular transportation corridors.

Population growth and development contribute to increased exposure of people and property to avalanches and their related impacts. Understanding changes in hazard exposure over time is an important element of comprehensive hazard mitigation planning. Among other things, increased population growth elevates exposure levels of people to the impacts of avalanches.

Colorado continues to experience some of the largest population growth in the country and future projections seem to indicate a similar trend should be expected. Table 3-146 presents the projected percent change in housing on a county scale from 2010-2030. Counties with high projected percent increases in housing and a history of avalanche fatalities face the most risk in the future.

Pitkin County has the highest number of past avalanche fatalities, as well as an expected percent change in housing of 34 percent. Summit County is also at risk, with 39 previous avalanche fatalities and a projected housing percent change of 49 percent. Eagle, San Miguel, and Larimer Counties all have had between 10 and 15 past avalanche fatalities and are projected to experience housing percent change of 46 percent or greater.

**TABLE 3-146 HOUSING PROJECTIONS (2010 TO 2030) AND HISTORICAL AVALANCHE FATALITIES (1950 TO 2016)**

County	Historical Avalanche Fatalities	Housing Percent Change	Growth Rating
Elbert	0	120%	Highest
Weld	0	93%	Highest
Broomfield	0	78%	Highest
Douglas	0	67%	Highest
Park	0	65%	Highest
San Miguel	10	64%	Highest
Archuleta	0	61%	Highest
Montrose	0	61%	Highest
Adams	0	60%	Highest
Eagle	15	56%	Highest
Arapahoe	0	52%	Highest
Garfield	2	51%	Highest
La Plata	2	50%	Highest
Summit	39	49%	Highest
Larimer	10	47%	Highest
Routt	4	46%	Highest
Grand	11	44%	High
Custer	0	41%	High
El Paso	1	40%	High
Chaffee	14	38%	High
Mesa	2	38%	High
Boulder	4	37%	High
Denver	0	37%	High
Montezuma	1	37%	High
Delta	0	35%	High
Pitkin	45	34%	High
Jefferson	0	30%	High
Fremont	0	28%	High

County	Historical Avalanche Fatalities	Housing Percent Change	Growth Rating
Gunnison	20	28%	High
Crowley	0	26%	High
Lincoln	0	26%	High
Morgan	0	26%	High
Pueblo	0	26%	High
Alamosa	1	25%	High
Las Animas	0	23%	Moderate
Teller	0	23%	Moderate
Lake	13	21%	Moderate
Logan	0	21%	Moderate
Clear Creek	32	20%	Moderate
Kit Carson	0	20%	Moderate
Hinsdale	1	19%	Moderate
Saguache	0	17%	Moderate
Yuma	0	17%	Moderate
Conejos	2	14%	Moderate
Huerfano	0	13%	Moderate
Ouray	16	13%	Moderate
Gilpin	0	12%	Moderate
Kiowa	0	12%	Moderate
Cheyenne	0	11%	Low
Costilla	0	10%	Low
Mineral	8	10%	Low
Rio Blanco	1	10%	Low
San Juan	8	10%	Low
Jackson	4	9%	Low
Washington	0	8%	Low
Bent	0	7%	Low
Moffat	0	7%	Low
Rio Grande	2	7%	Low
Otero	0	6%	Low
Dolores	1	4%	Low
Prowers	0	3%	Low
Phillips	0	1%	Low
Sedgwick	0	1%	Low
Baca	0	-6%	Low

Source: Colorado State Demography Office, 2017

The following section provides county-scale avalanche exposure projections by comparing avalanche risk based on total incidents and total fatalities with projected population percent change. Through this analysis, Summit County shows the highest risk with respect to future growth. The combination of a growing population and high avalanche threat results in increasing

exposure over that of today. The counties of Garfield, Gunnison, Larimer, Pitkin, and San Miguel are projected to experience the next highest exposure to avalanches through 2030.

**TABLE 3-147 AVALANCHE EXPOSURE PROJECTIONS**

Future Avalanche Exposure Projections					
		County Population Percent Change Projections, 2010 to 2030			
Combined Risk (Avalanche)		-13% to 2%	3% to 17%	18% to 34%	35% to 89%
<p style="text-align: center;">High ↑ Moderate</p>	5-6	Moderate	High	Severe	Extreme
	3-4	Slight	Moderate	High	Severe
	1-2	Negligible	Slight	Moderate	High
	0	Negligible	Negligible	Negligible	Negligible

The Combined Risk calculations in Table 3-123 are based on the methodology outlined in Table 3-124. Values (between 0 and 3) have been assigned to total deaths and total number of avalanche events per county. The Jenks Natural Breaks algorithm was used to classify these historical data sets. The sum of these values then arrives at the Combined Risk value for each county. Counties that have no historical avalanche events and no fatalities were all assigned a rating of negligible. These counties are mostly located on the eastern plains where avalanches do not occur due to the topography.

**TABLE 3-148 COMBINED RISK METHODOLOGY**

Deaths (1950 – 2017)	Value	# of Avalanche Events (1950-2017)	Value
21 – 45	3	9 – 13	3
10 – 20	2	5 – 8	2
1 – 9	1	1 – 4	1
0	0	0	0

Exposure to avalanches is expected to intensify across the State of Colorado between 2010 and 2030 as population increases. The darker, more red colors in Table 3-123 illustrate relative rates of increase in exposure between counties. This same information is also shown on the following Table 3-125 by county. As Colorado’s population increases, infrastructure and businesses will follow these population centers. This further adds to the potential future

exposure that counties face from avalanches. Colorado's population and related business and infrastructure are concentrated in, and will continue to intensify, in areas of high avalanche activity. Figure 3-71 presents this same information on a statewide map.

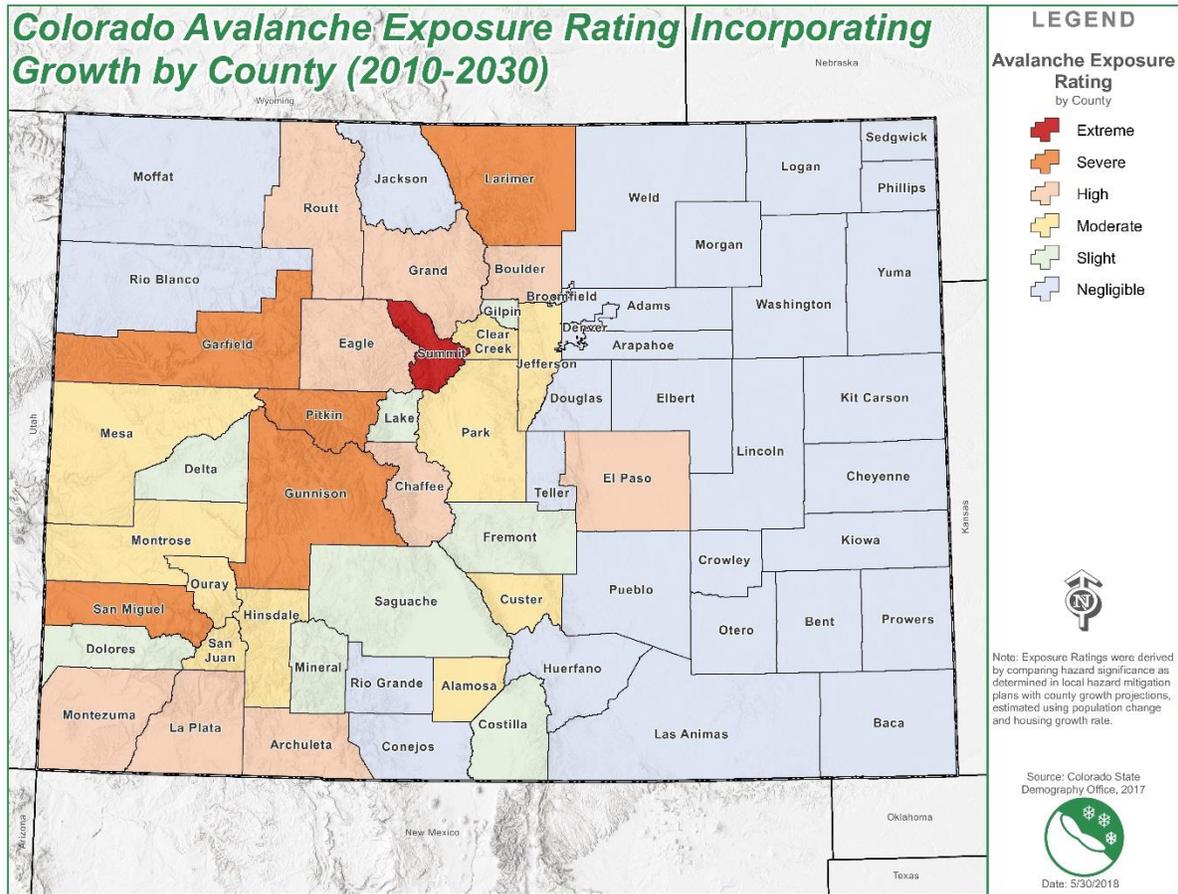
TABLE 3-149 AVALANCHE EXPOSURE PROJECTIONS, 2010 TO 2030

County	Combined Risk	Population Change	Exposure Rating
Summit	5	41%	Extreme
Garfield	3	38%	Severe
Gunnison	5	26%	Severe
Larimer	3	42%	Severe
Pitkin	6	18%	Severe
San Miguel	4	59%	Severe
Archuleta	1	40%	High
Boulder	3	28%	High
Chaffee	3	29%	High
Eagle	4	34%	High
El Paso	1	36%	High
Grand	4	32%	High
Montezuma	2	37%	High
Routt	2	40%	High
La Plata	2	42%	High
Alamosa	2	22%	Moderate
Clear Creek	4	14%	Moderate
Custer	1	20%	Moderate
Hinsdale	2	29%	Moderate
Jefferson	1	21%	Moderate
Mesa	2	24%	Moderate
Montrose	2	30%	Moderate
Ouray	3	17%	Moderate
Park	1	34%	Moderate
San Juan	3	5%	Moderate
Costilla	1	7%	Slight
Lake	2	17%	Slight
Delta	2	8%	Slight
Dolores	2	5%	Slight
Fremont	1	5%	Slight
Gilpin	1	13%	Slight
Mineral	1	16%	Slight
Saguache	1	9%	Slight
Adams	0	48%	Negligible
Arapahoe	0	36%	Negligible
Baca	0	-13%	Negligible

County	Combined Risk	Population Change	Exposure Rating
Bent	0	-5%	Negligible
Broomfield	0	71%	Negligible
Cheyenne	0	2%	Negligible
Conejos	1	1%	Negligible
Crowley	0	5%	Negligible
Denver	0	42%	Negligible
Douglas	0	44%	Negligible
Elbert	0	89%	Negligible
Huerfano	1	-1%	Negligible
Jackson	2	-7%	Negligible
Kiowa	0	-8%	Negligible
Kit Carson	0	-1%	Negligible
Las Animas	0	-9%	Negligible
Lincoln	0	21%	Negligible
Logan	0	14%	Negligible
Moffat	1	-3%	Negligible
Morgan	0	16%	Negligible
Otero	0	-7%	Negligible
Phillips	0	-3%	Negligible
Prowers	0	-5%	Negligible
Pueblo	0	20%	Negligible
Rio Blanco	2	2%	Negligible
Rio Grande	1	-5%	Negligible
Sedgwick	0	-3%	Negligible
Teller	0	25%	Negligible
Washington	0	5%	Negligible
Weld	0	81%	Negligible
Yuma	0	7%	Negligible

Source: Colorado State Demography Office, 2017

FIGURE 3-71 AVALANCHE EXPOSURE RATING INCORPORATING GROWTH



## 9. CLIMATE CHANGE

According to the best data available at the time of this plan update, the future impacts of climate change are expected to influence future avalanche events. The following Table 3-150 presents a breakdown of these projected changes in terms of hazard: location, extent/intensity, frequency, and duration.

TABLE 3-150 CLIMATE CHANGE IMPACTS

<b>Location</b>	Avalanches are only a hazard in mountainous regions of the state. The area affected by avalanches is projected to shrink as warmer temperatures cause more precipitation to fall as rain.
<b>Extent / Intensity</b>	In areas affected by avalanches, it is unknown if or how the intensity of avalanches will change. Extent is not projected to change.

<b>Frequency</b>	Additional research is needed to determine the effects of climate change on avalanche frequency.
<b>Duration</b>	Additional research is needed to determine the effects of climate change on avalanche duration. However, some research suggests that there will be earlier wet snow avalanches, by as much as six weeks by the end of the century under a higher emissions scenario (SWCARR, 450).

Avalanche officials in several western states have noticed a pattern associated with increased avalanche risk (Freedman, 2012). Snow occurs early in the winter and is then followed by a long period without snow. This creates a thin snowpack that becomes structurally weaker as winter goes on. New layers of snow may not bond well to the weak base layer, creating prime conditions for avalanches. As Colorado experiences winters with higher average temperatures and lower average precipitation, these conditions that increase avalanche risk become more common.

## 10. RISK TO STATE ASSETS

State assets exposed to avalanches are few in number but are high in value. GIS data of best available avalanche path data was provided by the CAIC. There are four assets identified that intersect with the available avalanche path mapping. These state assets are shown in Table 3-151 and valued at over \$48 million. These assets are located in Lake, Ouray, and Summit Counties.

TABLE 3-151 - STATE ASSETS AT RISK TO AVALANCHE

County	Name	Avalanche Path	Total Value
Lake	Twin Lakes Tunnel	Gate – Highway Path	\$7,238
Ouray	Monument Weather Station	Slippery Jim – Highway Path	\$18,000
Ouray	Mt. Abrams Weather Station	East Riverside – Highway Path	\$18,000
Summit	Eisenhower Tunnel West Vent Building	West Portal – Highway Path	\$48,029,650

Although avalanches typically pose a greater risk to the life and safety of outdoor enthusiasts than structures in Colorado, the CAIC and CDOT work cooperatively throughout the snow season to minimize impact to the state’s vulnerable mountain roads. There are 21 avalanche corridors currently identified on the state highways system as shown in Table 3-152. The approximate number of slide paths that CDOT and CAIC crews monitor and/or control per

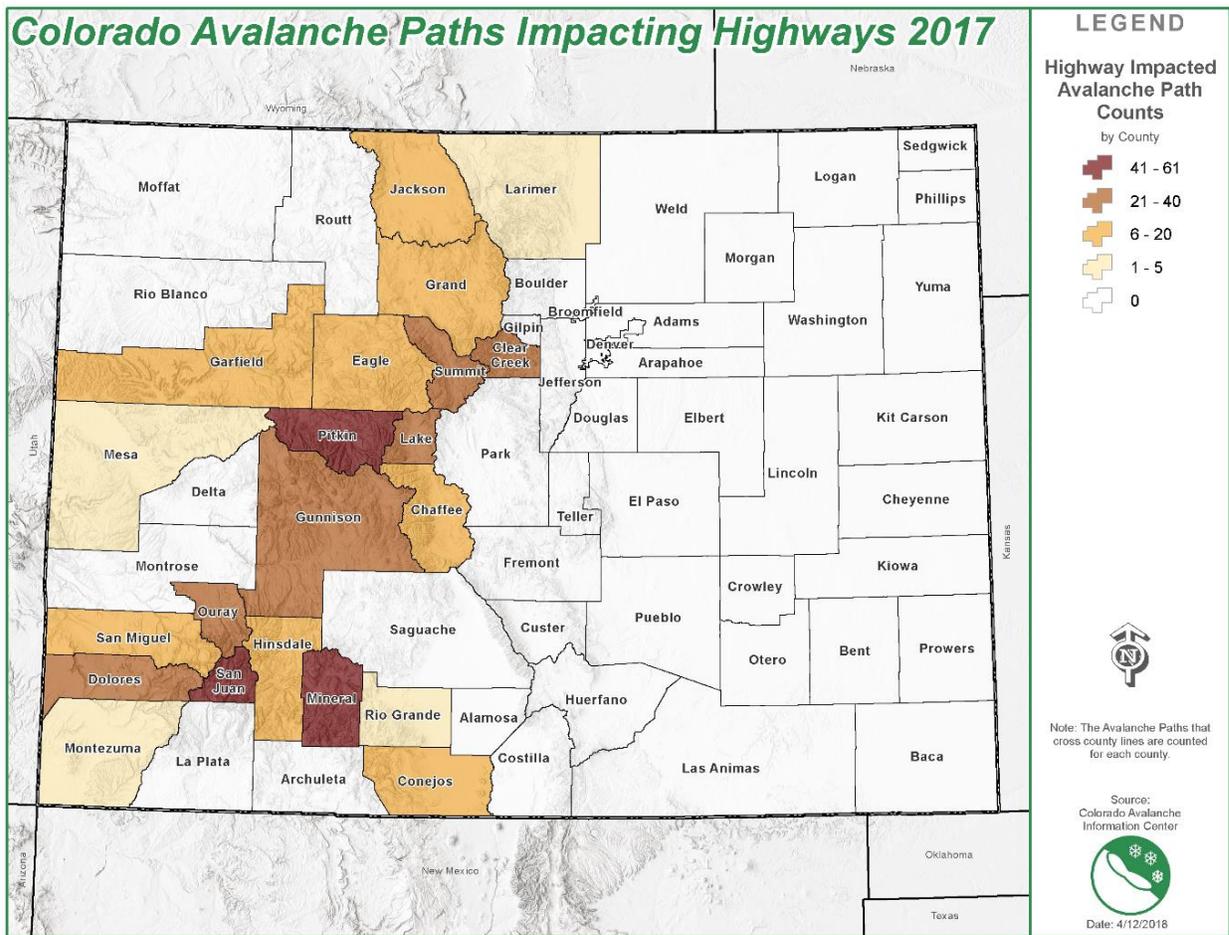
avalanche corridor range is shown in the following table. A count of the number of slide paths crossing state highways by County is shown in Figure 3-72 based on the GIS mapping provided by the CAIC.

**TABLE 3-152 STATE HIGHWAY SYSTEM AVALANCHE CORRIDORS AND MONITORED SLIDE PATHS**

<b>Avalanche Corridor</b>	<b>Slide Paths</b>	<b>Avalanche Corridor</b>	<b>Slide Paths</b>	<b>Avalanche Corridor</b>	<b>Slide Paths</b>
<b>US 6 Loveland Pass</b>	24	<b>SH 82 Independence Pass</b>	60	<b>US 50 Monarch Pass</b>	19
<b>US 40 Berthoud Pass</b>	25	<b>SH 133 Crystal River and McClure Pass</b>	22	<b>SH 145 Lizard Head Pass</b>	48
<b>I-70 Georgetown to Frisco</b>	28	<b>SH 139 Douglas Pass</b>	8	<b>US 160 Wolf Creek Pass</b>	61
<b>I-70 Ten Mile Canyon</b>	25	<b>US 24 Battle Mountain</b>	11	<b>US 285 Poncha Pass</b>	2
<b>I-70 Vail Pass</b>	2	<b>SH 91: Fremont Pass</b>	13	<b>US 550 Coal Bank Pass</b>	20
<b>SH 65 Grand Mesa</b>	3	<b>SH 14 Cameron Pass</b>	10	<b>US 550 Molas Pass</b>	50
<b>I-70 Vail Pass</b>	2	<b>SH 17 Cumbres &amp; La Manga Passes</b>	15	<b>US 550 Red Mountain Pass</b>	137

Source: CDOT

FIGURE 3-72 AVALANCHE PATHS IMPACTING HIGHWAYS BY COUNTY



Every winter, CDOT regularly monitors and/or controls over 278 of the more than 522 total known avalanche slide paths in Colorado to help prevent avalanches from impacting Colorado highways. During the 2013-2014 winter season, CDOT triggered 283 avalanches with explosives and handled 158 natural occurrences, all of which impacted Colorado highways. CDOT experienced 616 hours of road closures due to avalanche control, resulting in a total of 29,866 feet of snow covering the centerline of the roadway. Although protecting highway infrastructure is one benefit from implementing avalanche control mitigation activities, CAIC and CDOT programs are equally, if not more focused, on reducing the economic and human impacts of avalanches on recreation, tourism, commerce, industry, citizens, and visitors.

There are also a number of buildings, primarily storage facilities, that lie in avalanche areas. While state park and preservation lands could potentially be impacted by avalanche, they have previously occurred in state-owned undeveloped areas and there is little potential for losses associated with state facilities.

## 11. RESOURCES

- American Institute for Avalanche Research and Education (AIARE)
- Colorado Avalanche Information Center (CAIC)
- Colorado Department of Transportation (CDOT)
- CDOT Emergency Operations Plan (EOP)
- CDOT Threat and Hazard Identification and Risk Assessment (THIRA)
- Colorado Geological Survey (CGS)
- Federal Emergency Management Agency (FEMA)
- Freedman, Andrew. "Avalanches Taking Toll; Foreshadowing the Future?" February 24, 2012. <http://www.climatecentral.org/news/thin-snowpack-in-the-west-raises-avalanche-risks>
- National Centers for Environmental Information (NCEI)
- Spatial Hazard Events and Losses Database for the United States (SHELDUS)

# EARTHQUAKE



## 1. DEFINITION

Earthquakes are the vibrations or shaking created when large plates of Earth’s crust move with respect to one another. The break between these blocks is a fault. Virtually all earthquakes in the Earth’s crust occur from movement on faults, or less frequently through volcanic or magmatic activity. Table 3-153 describes the unique hazard profile of earthquakes and the associated consequences and impacts for the State of Colorado.

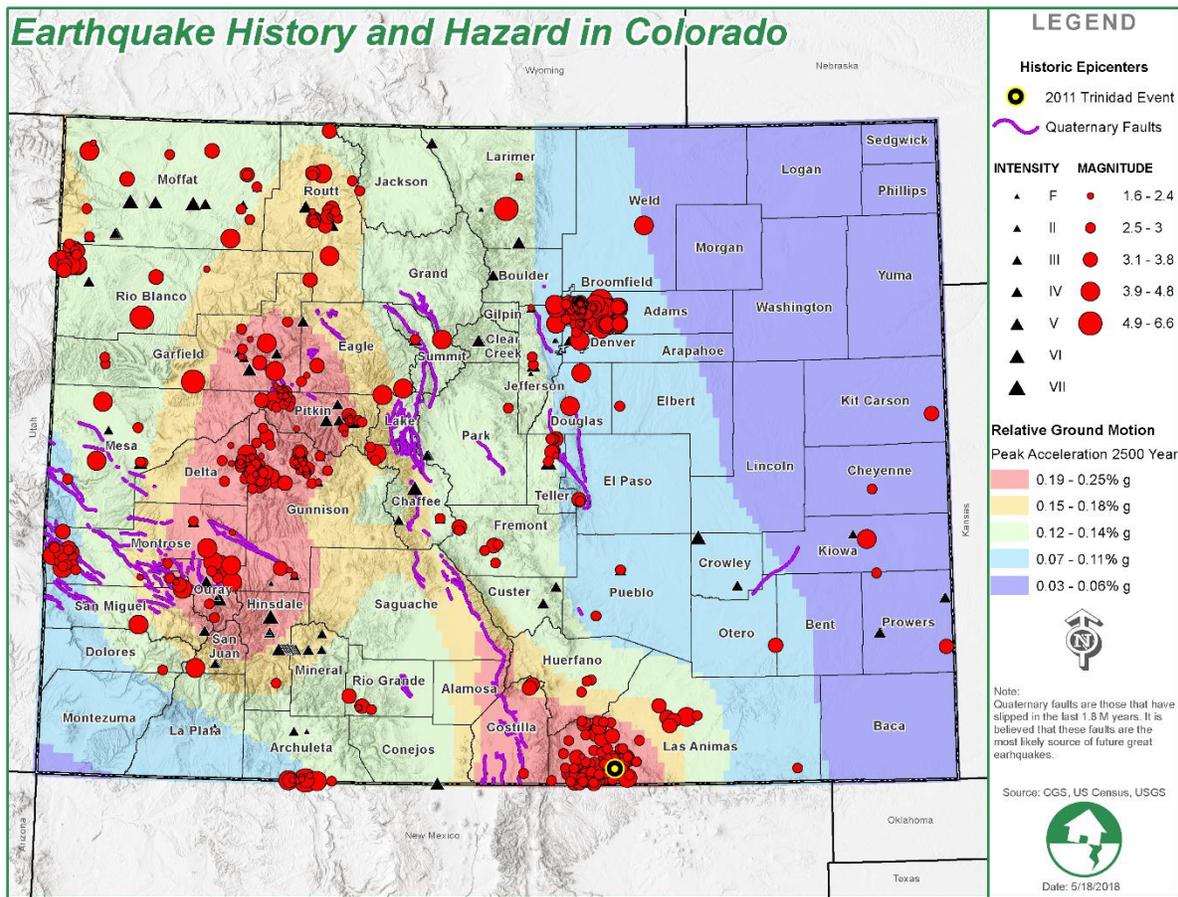
TABLE 3-153 HAZARD PROFILE SUMMARY

Consideration	Impact	Description
<b>Location</b>	Regional	Recorded earthquakes are located over a large area of the state. However, faults with capacity for larger magnitude events are in central and western Colorado.
<b>Previous Occurrence</b>	Sporadic	More than 500 earthquake tremors of magnitude 2½ or higher have been recorded in Colorado since 1867. Higher magnitude earthquakes have only occurred a few times in the last 150 years.
<b>Probability</b>	Occasional	Although on average, several earthquakes are expected to occur in the state, they are likely to be of smaller magnitude. A 5+ magnitude is expected once or twice per decade based on historic trend.
<b>Extent</b>	Catastrophic	Destroyed or damaged property that threatens structural stability, mass fatalities and/or casualties, impact to critical lifelines, impact to government’s ability to provide service. Likely to overwhelm state and local recourses and require Federal assistance for full recovery.

## 2. LOCATION

Although many of Colorado’s earthquakes occurred in mountainous regions of the state, some have been located in the western valleys and plateau region or east of the mountains. Thousands of faults have been mapped in Colorado, but scientists think only about 90 of these were active in the past 1.6 million years. Figure 3-73 shows Colorado’s earthquake history and quaternary faults. These quaternary faults are generally located along the Continental Divide and the southwest. There are several faults along the Front Range and one in the Eastern Plain, although eastern Colorado is generally void of faults.

FIGURE 3-73 EARTHQUAKE HISTORY AND HAZARD IN COLORADO



The Sangre de Cristo Fault, which lies at the base of the Sangre de Cristo Mountains along the eastern edge of the San Luis Valley, and the Sawatch Fault, which runs along the eastern margin of the Sawatch Range, are two of the most prominent potentially active faults in Colorado. Not all of Colorado's potentially active faults are in the mountains and some cannot be seen at the earth's surface. For example, the Cheraw Fault, which is in the Great Plains in southeast Colorado, appears to have had movement during the recent geologic past. The Derby Fault near Commerce City lays thousands of feet below the earth's surface but has not been recognized at ground level.

### 3. EXTENT (MAGNITUDE/STRENGTH)

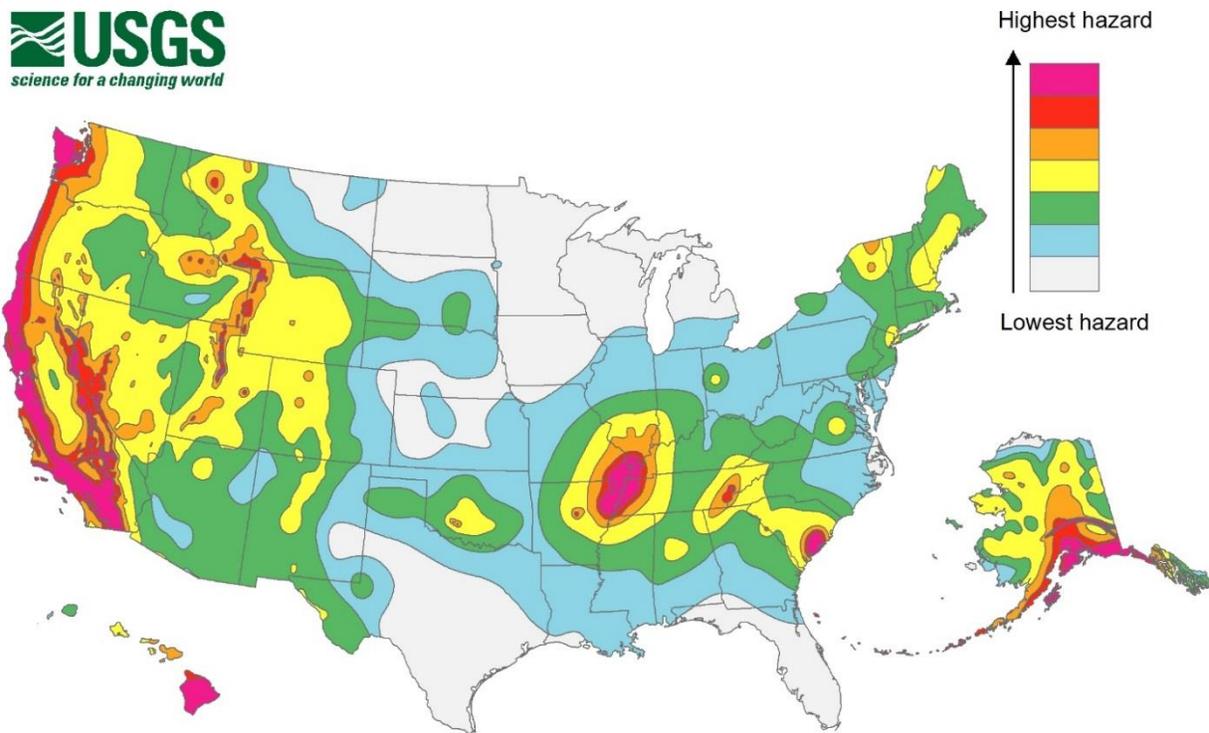
Many earthquakes in Colorado occur naturally, but most are caused by human actions. Humans may trigger earthquakes through different types of activities including oil and gas extraction, reservoir impoundment, fluid injection, or mining.

The most intense shaking experienced during earthquakes generally occurs near the rupturing fault, and decreases with distance away from the fault. In a single earthquake, however, the

shaking at one site can easily be 10 times stronger than at another site, even when their distance from the ruptured fault is the same. Seismic events may lead to landslides, uneven ground settling, flooding, and damage to homes, dams, levees, buildings, power and telephone lines, roads, tunnels, and railways. Broken natural gas lines may cause fires.

The National Seismic Hazard Map (Figure 3-74) shows levels of horizontal shaking that have a 2-in-100 chance of being exceeded in a 50-year period. The areas of magenta indicate a higher risk of shaking from an earthquake while white indicates the lowest. Colorado falls in the lower to middle range of this indicator.

**FIGURE 3-74 NATIONAL SEISMIC HAZARD MAP**



Source: USGS. Last updated in 2014.

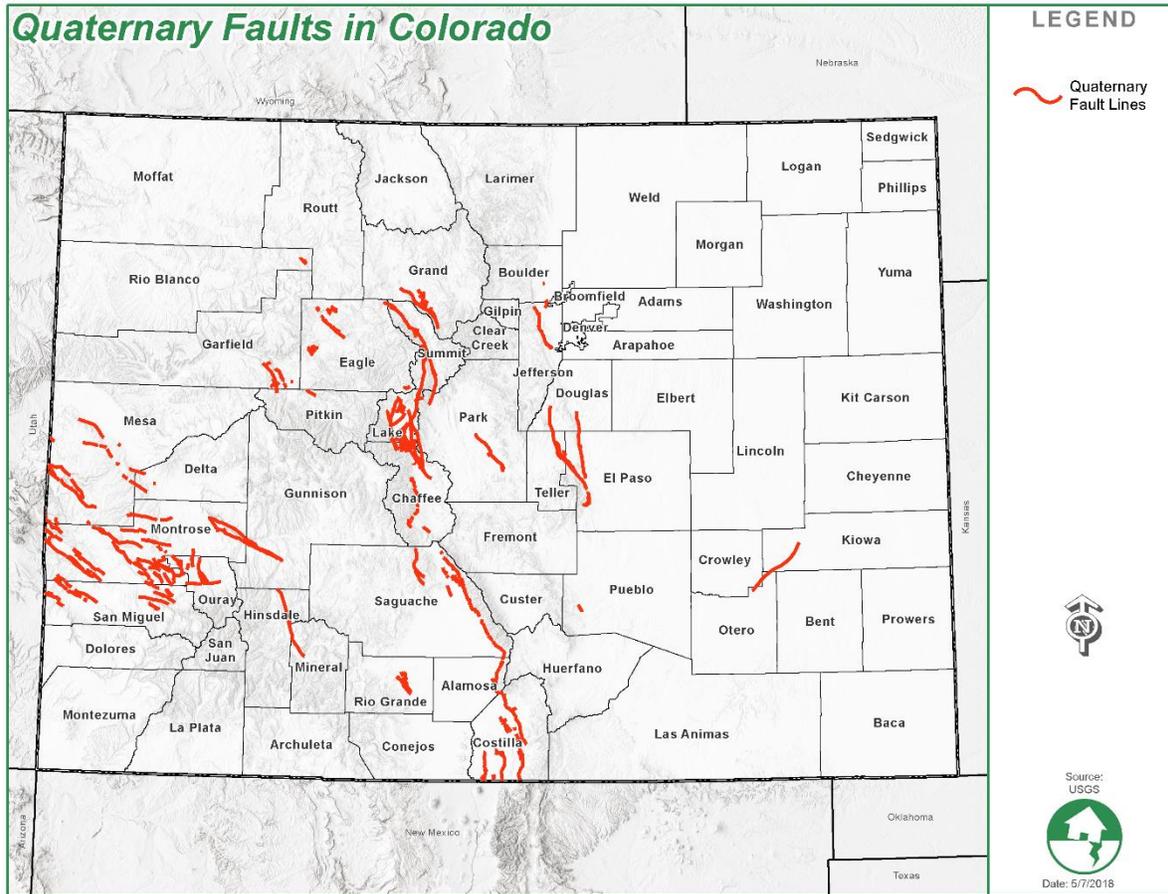
Magnitude and intensity are used to describe seismic activity. Magnitude (M) is a measure of the total energy released. Each earthquake has one magnitude. Intensity (I) is used to describe the effects of the earthquake at a particular place. Intensity differs throughout the area. A scale commonly used to measure magnitude is the Richter Scale whereas the Modified Mercalli Scale (MMI) is used for intensity.

## 4. PROBABILITY

Because the occurrence of earthquakes is relatively infrequent in Colorado and the historical earthquake record is short (only about 140 years), it is challenging if not impossible to accurately estimate the timing or location of future dangerous earthquakes in Colorado. Although limited, available seismic hazard information can provide a basis for a reasoned and prudent approach to seismic safety. Scientists are constantly studying faults in Colorado to determine future earthquake potential. Based on the historical earthquake record and geologic studies in Colorado, an event of magnitude 6.5 to 7.5 could occur somewhere in the state. One study suggests an earthquake of magnitude 6.3 or larger has a one percent probability of occurring each year somewhere in Colorado (Charlie, Doehring, Oaks Colorado Earthquake Hazard Reduction Program Open File Report 93-01, 1993).

Figure 3-75 shows the locations of Colorado's quaternary faults. The quaternary faults are those that have slipped in the last 1.8 million years. It is believed that these faults are the most likely source of future earthquakes. Portions of the state show clustering such as near the Denver metro region, central mountains, and the southwestern and northwestern part of the state. Northeast Colorado is largely void of seismic activity.

FIGURE 3-75 QUATERNARY FAULTS IN COLORADO



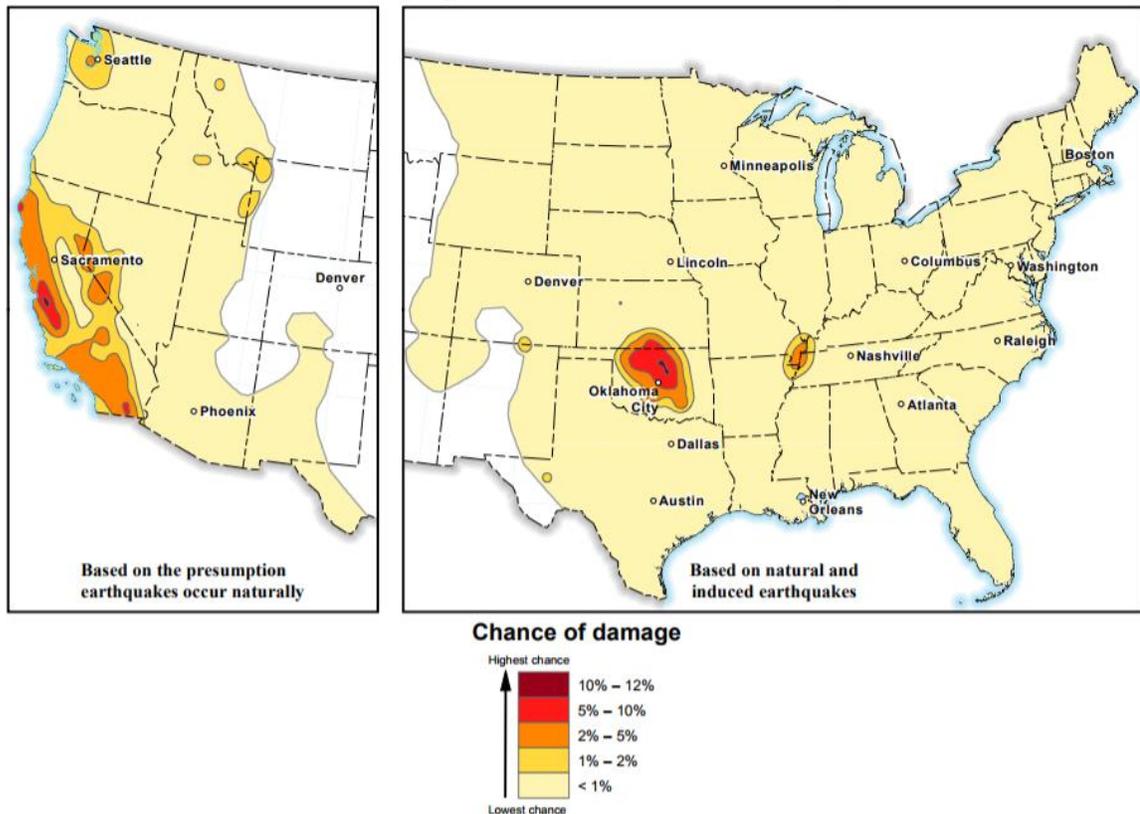
#### 4.1 INDUCED SEISMICITY

In recent years, induced seismicity has become an increasingly pertinent issue. Induced seismicity refers to seismic events instigated by human activities. Triggered quakes have a predominantly natural origin, whereas induced quakes are a result of anthropogenic activity and would not have occurred otherwise. There is a range of unique causes of induced seismicity, including impounding surface water reservoirs, removing mass by quarrying, extraction of resources (groundwater, coal, geothermal fluids), injection activities (waste fluid disposal, fracking, research experiments, gas storage, enhanced oil recovery, carbon dioxide sequestration), and nuclear testing.

In more recent years there has been an increase in documented seismic activity potentially induced by waste fluid disposal. In March 2016, the USGS released its first induced earthquake hazard model, forecasting the strength and frequency of potential ground shaking from future induced and natural earthquakes for a one-year period, based primarily on earthquake data from the previous year. In Colorado, the Raton Basin was identified as one of the areas of higher potential for induced-earthquake hazard. As part of recent initiatives to assess induced

earthquake hazards, the USGS has produced two figures to highlight spatial patterns and susceptible areas. Figure 3-76 displays forecasted damage related to induced earthquakes, and Figure 3-77 presents ground shaking potential related to induced earthquakes. Most of Colorado has a less than one percent chance of damage from induced quakes in 2017, with expected Intensities of IV or less. However, there are concentrations of higher shaking potential (Intensity VI) in the Raton Valley area (Colorado/New Mexico border).

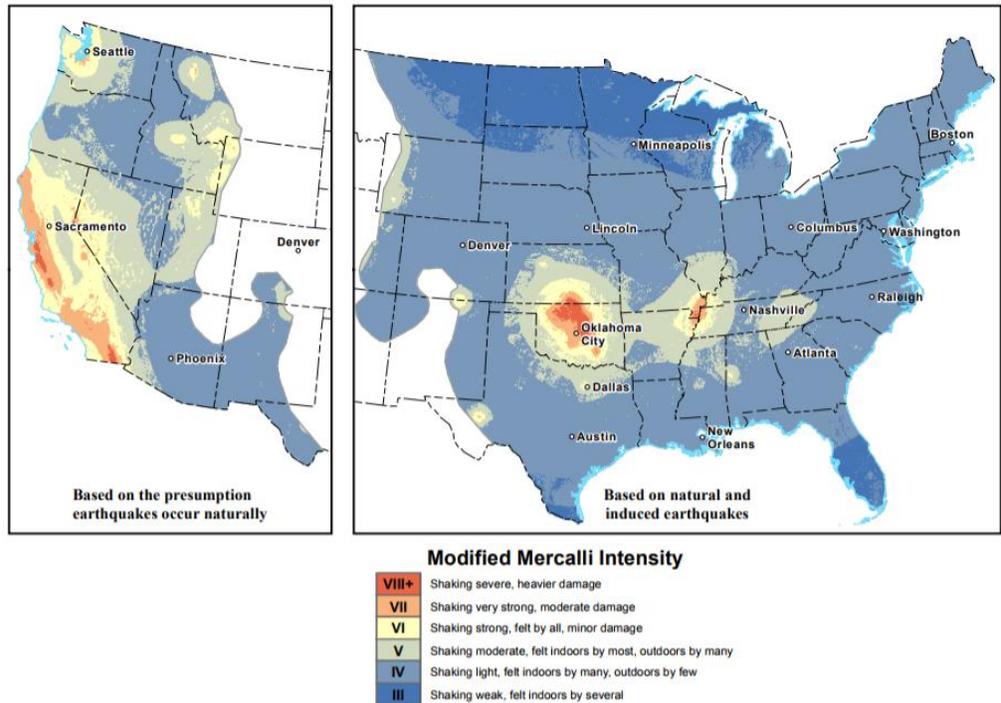
**FIGURE 3-76 FORECAST FOR DAMAGE FROM NATURAL AND INDUCED EARTHQUAKES IN 2017**



USGS map displaying potential to experience damage from natural or human-induced earthquakes in 2017. Chances range from less than 1 percent to 12 percent.

Source: USGS, 2017

**FIGURE 3-77 FORECAST FOR GROUND SHAKING INTENSITY FROM NATURAL AND INDUCED EARTHQUAKES 2017**



USGS map displaying intensity of potential ground shaking from natural and human-induced earthquakes. There is a small chance (one percent) that ground shaking intensity will occur at this level or higher. There is a greater chance (99 percent) that ground shaking will be lower than what is displayed in these maps.

Source: USGS, 2017

## 5. PREVIOUS OCCURRENCES

More than 500 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 table below provides a list of Colorado's larger earthquakes. The largest known earthquake in Colorado occurred on November 7, 1882 and had an estimated magnitude of 6.5. The location of this earthquake, which has been the subject of much debate and controversy over the years, appears to be in the northern Front Range west of Fort Collins. The Colorado Geologic Survey does not list any significant earthquakes after 2011. See Table 3-154 for a summary of previous earthquake events.

TABLE 3-154 NOTABLE EARTHQUAKE EVENTS IN COLORADO: 1870 - 2017

Date	Location	Magnitude	Intensity
1870	Pueblo/Ft. Reynolds		
1871	Lily Park, Moffat County		
1880	Aspen		VI
1882	North central Colorado	6.6*	VII
1891	Axial Basin (Maybell)		VI
1901	Buena Vista		VI
1913	Ridgway Area		VI
1944	Montrose/Basalt		VI
1955	Lake City		VI
1960	Montrose/Ridgway	5.5	V
1966	NE of Denver	5.0	V
1966	CO-NM border, near Dulce, NM	5.5	VII
1967	NE Denver	5.3	VII
1967	NE Denver	5.2	VI
2011	Southwest of Trinidad	5.3	VIII

\*Estimated, based on historical felt reports.

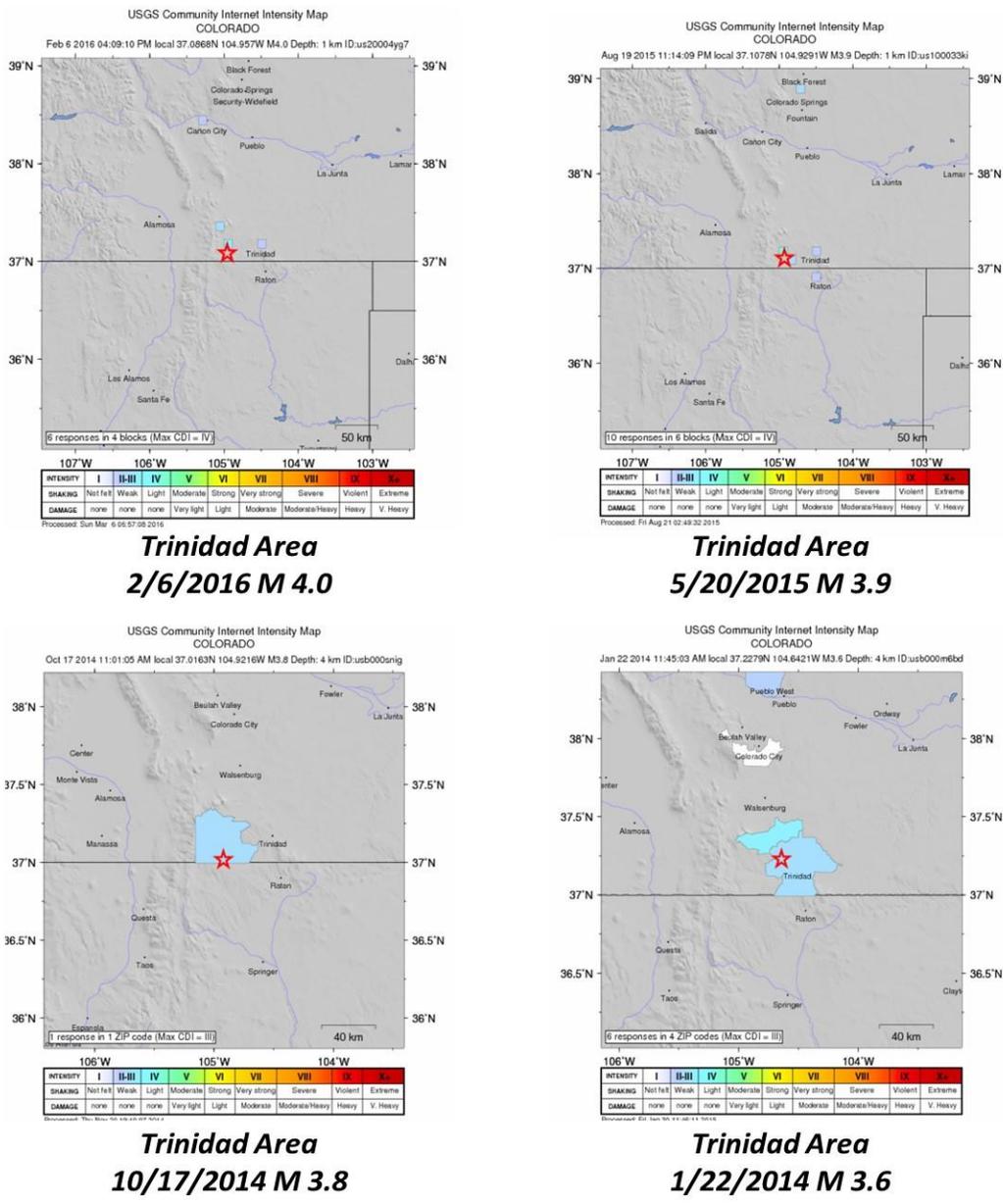
Source: Colorado Geological Survey

On August 22, 2011, a magnitude 5.3 earthquake was recorded at about 11:46 p.m. nine miles west-southwest of Trinidad and 180 miles south of Denver, according to the National Earthquake Information Center in Golden and the USGS. The quake followed two smaller ones that hit the area earlier in the day. The epicenter of the earthquake was very shallow at a depth of 2.5 miles.

The USGS had received calls from more than 70 people in Trinidad and several dozen people in New Mexico who felt the shaking. More than 30 people in Colorado Springs, about 130 miles north of Trinidad, also reported feeling the quake.

Figure 3-78 represents Colorado citizens reporting earthquakes through the USGS “Did You Feel It?” program. Earthquakes represented occurred since the previous plan update. Most quakes were located around Trinidad, the Paradox Valley, Ridgway, and Glenwood Springs, areas known as centers of historic activity. There were 59 earthquakes reported between June 2013 and 2017, of which the greatest magnitude was 4.0, near Trinidad on February 2, 2016.

**FIGURE 3-78 USGS COMMUNITY INTERNET INTENSITY MAPS FOR COLORADO, JUNE 2013 – NOVEMBER 2017**



The Human Induced Earthquake Database (HiQuake) is the largest database of earthquake events induced or triggered by human activity. The database reports six human induced

earthquakes occurring in Colorado. Of these incidents, four quakes were catalyzed by waste fluid disposal, one was a result of water reservoir impoundment, and one linked to research. Table 3-155 provides more details on these events.

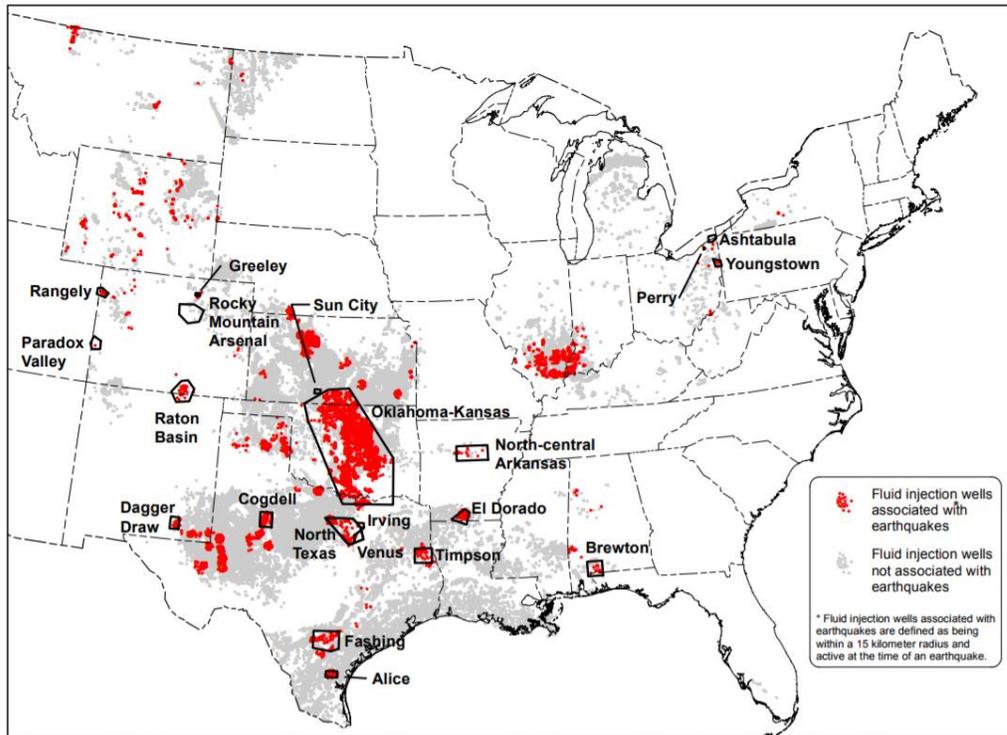
**TABLE 3-155 COLORADO INDUCED EARTHQUAKE INCIDENTS**

<b>Year</b>	<b>Location</b>	<b>Magnitude</b>	<b>Earthquake Cause and Sub-Cause</b>
<b>1967</b>	Rocky Mountain Arsenal	5.5	Waste Fluid Disposal
<b>1968</b>	Town of Cabin Creek (near Byers), Arapahoe County	2	Water Reservoir Impoundment
<b>1970</b>	Town of Rangely, Rio Blanco County	3.1	Research and Secondary Recovery (Water Injection)
<b>2000</b>	Paradox Valley, Montrose County	4.3	Waste Fluid Disposal Brine Injection
<b>2011</b>	Raton Valley, Las Animas County	5.3	Waste Fluid Disposal Waste Water Injection
<b>2014</b>	Greeley, Weld County	3.2	Waste Fluid Disposal Waste Water

Source: HiQuake

Figure 3-79 displays the USGS map of areas impacted by induced earthquakes. The figure identifies 21 locations affected by fluid injection wells, some of which are associated with earthquakes. As evident, the induced seismic events described in Table 3-155 are distinguished.

FIGURE 3-79 INDUCED EARTHQUAKE AREAS



USGS map displaying 21 areas impacted by induced earthquakes as well as the location of fluid injection wells that have and have not been associated with earthquakes.

Source: USGS, 2017

## 6. IMPACT ANALYSIS

The most economically damaging earthquake in Colorado's history occurred on August 9, 1967 in the Denver metropolitan area. This magnitude 5.3 earthquake caused more than a million dollars of damage in Denver and the northern suburbs. In 1967, a series of quakes associated with the Rocky Mountain Arsenal disposal site spurred initial discussion of the implications of high pressure fluid injection. Fluid injections outside of Denver began in 1962, leading to unusual seismic activity. Almost 150 million gallons of contaminated waste had been injected into the Arsenal well by the end of September 1965 (The Mountain Geologist, 1966). Most of these earthquakes had epicenters within a five-mile radius of the Arsenal well. The volume of fluid and pressure of the injection is thought to be directly related to the frequency of earthquakes. Various studies suggest that rock movement was due to the increase in fluid pressure within the fractured reservoir. The August 1967 earthquake was followed by an earthquake of magnitude 5.2 three months later in November 1967.

Although these earthquake events cannot be classified as major earthquakes, they should not be discounted as insignificant. They occurred within Colorado's Front Range Urban Corridor, an area where nearly 75 percent of Colorado residents and many critical facilities are located. Even though the seismic hazard in Colorado is low to moderate, it is likely that future damaging

earthquakes will occur. It is prudent to expect future earthquakes as large as magnitude 6.5, the largest event of record. Calculations based on the historical earthquake record and geological evidence of recent fault activity suggest that an earthquake of magnitude 6 or greater may be expected somewhere in Colorado every several centuries.

Colorado's earthquake hazard and risk has historically been rated lower than most knowledgeable scientists in the state consider justified. As a result, local emergency managers are generally unaware of the size and consequences of an earthquake that could occur in the state.

**TABLE 3-156 EARTHQUAKE EMAP IMPACT SUMMARY**

<b>Consideration</b>	<b>Description</b>
<b>General Public</b>	In a significant event (6-7 magnitude), there is high expectation of a mass casualties and/or fatalities. Anyone caught in a vulnerable structure during an event is at risk. There is limited earthquake preparedness activity in Colorado.
<b>First Responders</b>	Exposure exists to personnel performing routine duties when event occurs, although event related duties are primarily post-event. Unsafe structural or environmental conditions may persist during the response period putting search and rescue personnel and other responders at risk. Scale of event will likely overwhelm local resources and require mutual aid assistance from outside the area of impact.
<b>Property</b>	Buildings, vehicles, signage, and/or any unsecured property may be damaged or destroyed during a significant event. Hazus loss estimation scenario results returned billions of dollars in loss related to faults capable of 6-7 magnitude quakes. Lesser magnitude events in the 5 range may cost millions in damage depending on impacted area.
<b>Facilities and Infrastructure</b>	Buildings, equipment, and utility infrastructure are typically not constructed in Colorado to withstand a 6-7 magnitude quake. There is potential for high impact of destruction or usability. Communications would be negatively impacted.
<b>Economic</b>	Potential loss of facilities or infrastructure function or accessibility and uninsured damages. Hazus loss estimation scenario results for a 6.5 magnitude event on the Golden fault resulted in a loss of \$22 billion. Lesser magnitude earthquakes in the Denver region have caused millions of dollars in damages.
<b>Environment</b>	Difficult to assess environmental damage due to variability in location and magnitude. Possible cascading water quality issues from damaged water treatment facilities or impacts to ground and air quality from hazardous material leaks.

Consideration	Description
<b>Continuity of Government and Services</b>	Loss of facilities or infrastructure function or accessibility or ability to provide services. Power interruption is likely if not adequately equipped with backup generation. Large scale of event will typically overwhelm emergency response and coordination services and may require mutual aid assistance from outside the impacted area.
<b>Confidence in Government</b>	Public holds high expectations of government capabilities for public information and response and recovery activities related to large scale disaster events such as earthquake. High expectations for rapid restoration of critical lifelines.
<b>Critical Assets</b>	Expected damage to water treatment facilities, government buildings, public safety facilities, power generation and distribution, and healthcare facilities.

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

The Colorado Geological Survey has utilized Hazus to model deterministic impacts on specific faults or re-creations of historic earthquake events. The map in Figure 3-80 shows the location of modeled epicenters with losses related to casualties and economic impacts. Earthquakes along the Front Range are anticipated to be most costly due to the concentration of population and business centers. Epicenters around Summit, Lake, and Custer Counties, although not showing the magnitude of loss, may be more devastating than Front Range earthquakes due to potentially higher per capita losses. The scenarios have not been updated since 2013 but are still considered representative models of potential earthquake losses.

FIGURE 3-80 QUATERNARY FAULTS AND EARTHQUAKE SCENARIOS IN COLORADO

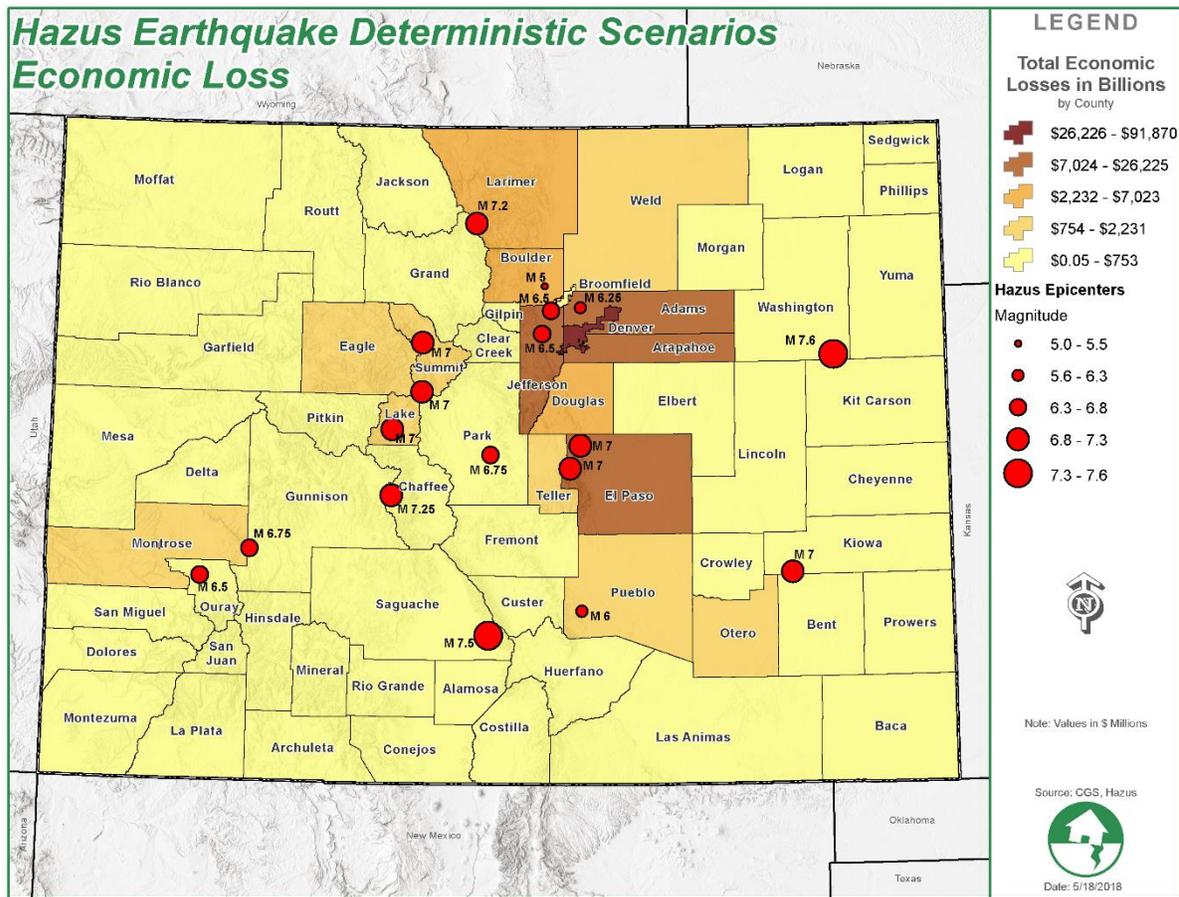


Table 3-157 below summarizes the total losses and number of earthquake-related casualties estimated for each county, based on the various deterministic scenarios. The estimates are based on the results of the Hazus loss estimation methodology and represent an aggregate of multiple fault scenarios at the county scale. By aggregating all loss estimates within each county, there is potential for double-counting in areas where two fault scenarios are expected to damage the same assets. In counties where total loss estimates are over \$1 Billion, or casualties are over 100, the associated cells have been highlighted red.

TABLE 3-157 EARTHQUAKE LOSS AND CASUALTIES BY COUNTY

County	Total Losses (Millions of US Dollars)	Number of Casualties
Adams	\$ 21,994.42	2,172
Alamosa	\$ 249.31	12
Arapahoe	\$ 21,144.31	2,584

County	Total Losses (Millions of US Dollars)	Number of Casualties
Archuleta	\$ 5.60	0
Baca	\$ 7.79	0
Bent	\$ 26.94	0
Boulder	\$ 5,050.75	368
Broomfield	\$ 4.75	440
Chaffee	\$ 387.92	14
Cheyenne	\$ 4.23	0
Clear Creek	\$ 81.61	1
Conejos	\$ 19.12	0
Costilla	\$ 45.26	3
Crowley	\$ 130.58	21
Custer	\$ 58.80	2
Delta	\$ 120.06	2
Denver	\$ 91,869.66	10,556
Dolores	\$ 0.59	0
Douglas	\$ 7,023.30	685
Eagle	\$ 1,215.46	105
El Paso	\$ 26,225.31	3,057
Elbert	\$ 225.38	14
Fremont	\$ 148.69	7
Garfield	\$ 160.63	5
Gilpin	\$ 84.31	3
Grand	\$ 457.47	18
Gunnison	\$ 245.32	14
Hinsdale	\$ 2.98	0
Huerfano	\$ 24.43	0
Jackson	\$ 33.40	2
Jefferson	\$ 15,526.96	1,459
Kiowa	\$ 21.31	0
Kit Carson	\$ 43.74	2
La Plata	\$ 81.20	0
Lake	\$ 1,430.40	84

County	Total Losses (Millions of US Dollars)	Number of Casualties
Larimer	\$ 5,972.30	935
Las Animas	\$ 5.27	0
Lincoln	\$ 65.05	2
Logan	\$ 16.41	0
Mesa	\$ 154.83	2
Mineral	\$ 1.46	0
Moffat	\$ 14.28	0
Montezuma	\$ 7.70	0
Montrose	\$ 1,668.06	189
Morgan	\$ 25.21	0
Otero	\$ 975.18	92
Ouray	\$ 122.67	3
Park	\$ 752.60	23
Phillips	\$ 0.22	0
Pitkin	\$ 649.67	24
Prowers	\$ 108.85	8
Pueblo	\$ 1,249.93	50
Rio Blanco	\$ 86.02	3
Rio Grande	\$ 1.36	0
Routt	\$ 122.59	6
Saguache	\$ 49.73	2
San Juan	\$ 40.30	0
San Miguel	\$ 30.20	0
Sedgwick	\$ 0.05	0
Summit	\$ 2,230.70	127
Teller	\$ 1,764.00	106
Washington	\$ 1.66	0
Weld	\$ 2,046.12	177
Yuma	\$ 23.71	0

Source: Colorado Geological Survey Hazus Analysis

An annualized loss scenario that enabled an “apples to apples” comparison of earthquake risk for each county was synthesized from a FEMA nationwide annualized loss study (FEMA 366

Hazus Estimated Annualized Earthquake Losses for the United States April 2017). The results of the FEMA annualized loss scenario are shown in Table 3-158 and Figure 3-81. The map in Figure 3-81 shows direct economic losses to buildings annualized over eight earthquake return periods (100, 250, 500, 750, 1,000, 1,500, 2,000, and 2,500 years). Hazus defines annualized loss as the expected value of loss in any one year. The software develops annualized loss estimates by aggregating the losses and their exceedance probabilities from the eight return periods. Annualized loss is the maximum potential annual dollar loss resulting from various return periods averaged on a 'per year' basis. It is the summation of all Hazus-supplied return periods multiplied by the return period probability (as a weighted calculation). This is the scenario that FEMA uses to compare relative risk from earthquakes and other hazards at the county level nationwide. The trend shows dollar losses to be most significant in the Front Range and central and northern mountain counties.

**TABLE 3-158 ANNUALIZED EARTHQUAKE LOSS BY COUNTY**

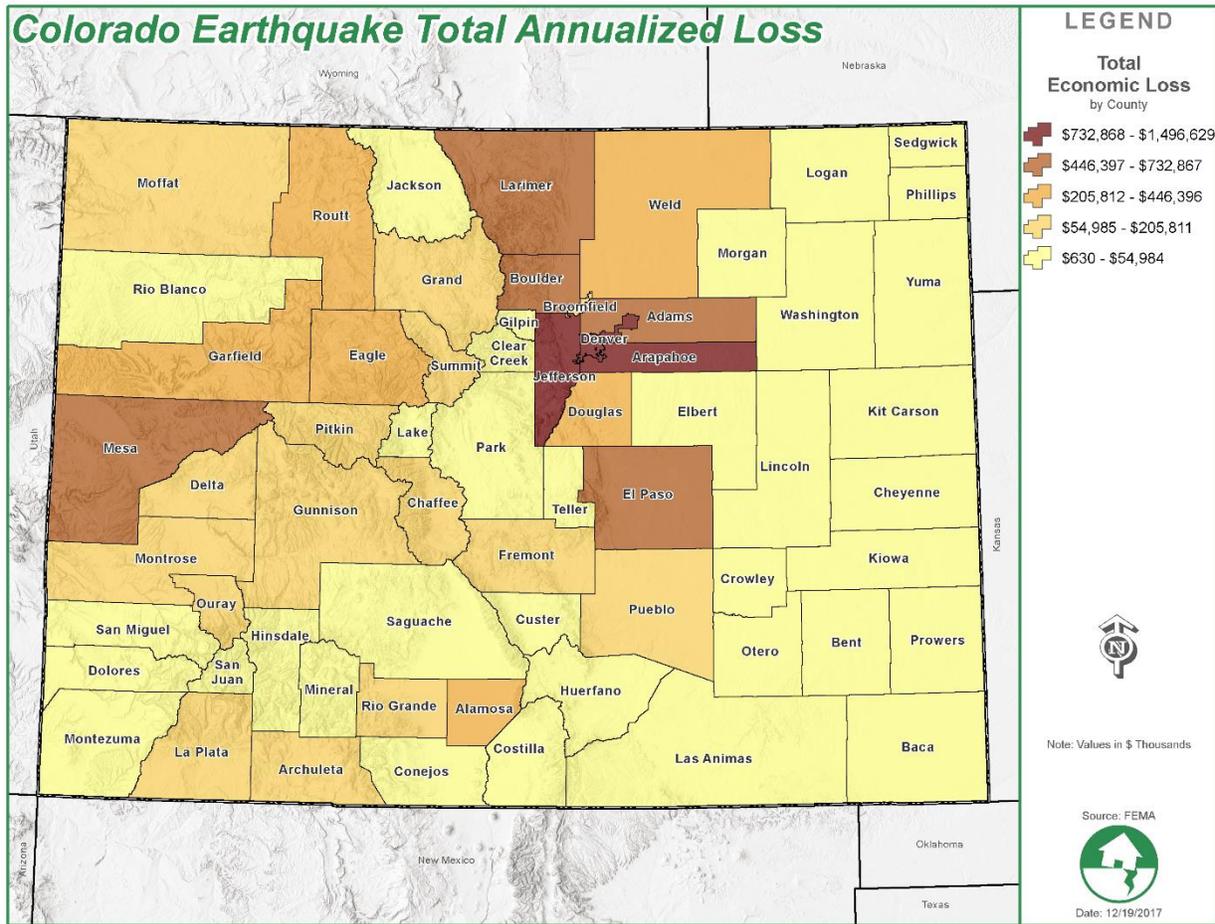
<b>County Name</b>	<b>Building Exposure (\$ Thousands)</b>	<b>Building Contents (\$ Thousands)</b>	<b>Total Exposure Building Exposure and Contents (\$ Thousands)</b>	<b>Annualized Earthquake Loss</b>	<b>Annualized Earthquake Loss Per Capita</b>
<b>Adams</b>	\$39,218,230	\$23,807,933	\$63,026,163	\$615,734	\$1.39
<b>Alamosa</b>	\$1,712,102	\$1,240,534	\$2,952,636	\$446,396	\$28.90
<b>Arapahoe</b>	\$64,864,504	\$40,051,173	\$104,915,677	\$981,831	\$1.72
<b>Archuleta</b>	\$1,838,618	\$1,058,826	\$2,897,444	\$72,361	\$5.99
<b>Baca</b>	\$461,077	\$310,796	\$771,873	\$1,919	\$0.51
<b>Bent</b>	\$470,963	\$285,811	\$756,774	\$2,468	\$0.38
<b>Boulder</b>	\$38,453,803	\$24,775,092	\$63,228,895	\$729,264	\$2.48
<b>Broomfield</b>	\$7,208,724	\$4,342,628	\$11,551,352	\$119,306	\$2.13
<b>Chaffee</b>	\$2,216,747	\$1,361,217	\$3,577,964	\$69,915	\$3.93
<b>Cheyenne</b>	\$218,709	\$152,097	\$370,806	\$742	\$0.40
<b>Clear Creek</b>	\$1,412,341	\$853,469	\$2,265,810	\$27,329	\$3.01
<b>Conejos</b>	\$685,018	\$400,024	\$1,085,042	\$43,749	\$5.30
<b>Costilla</b>	\$367,547	\$215,165	\$582,712	\$26,777	\$7.60
<b>Crowley</b>	\$322,107	\$187,407	\$509,514	\$2,463	\$0.42
<b>Custer</b>	\$692,680	\$402,177	\$1,094,857	\$15,124	\$3.55
<b>Delta</b>	\$2,787,248	\$1,727,125	\$4,514,373	\$113,361	\$3.66
<b>Denver</b>	\$73,548,361	\$49,948,824	\$123,497,185	\$1,496,629	\$2.49
<b>Dolores</b>	\$257,648	\$156,487	\$414,135	\$4,494	\$2.18

County Name	Building Exposure (\$ Thousands)	Building Contents (\$ Thousands)	Total Exposure Building Exposure and Contents (\$ Thousands)	Annualized Earthquake Loss	Annualized Earthquake Loss Per Capita
Douglas	\$37,906,598	\$21,306,636	\$59,213,234	\$394,729	\$1.38
Eagle	\$7,584,392	\$4,481,028	\$12,065,420	\$258,013	\$4.94
El Paso	\$66,837,839	\$40,464,231	\$107,302,070	\$732,867	\$1.18
Ebert	\$2,678,370	\$1,545,816	\$4,224,186	\$28,914	\$1.25
Fremont	\$3,862,874	\$2,390,003	\$6,252,877	\$69,799	\$1.49
Garfield	\$5,913,246	\$3,641,940	\$9,555,186	\$244,305	\$4.33
Gilpin	\$930,165	\$524,539	\$1,454,704	\$15,094	\$2.77
Grand	\$3,453,714	\$1,934,963	\$5,388,677	\$102,756	\$6.92
Gunnison	\$2,542,694	\$1,544,297	\$4,086,991	\$91,309	\$5.96
Hinsdale	\$402,077	\$215,853	\$617,930	\$10,680	\$12.67
Huerfano	\$937,741	\$588,387	\$1,526,128	\$17,666	\$2.63
Jackson	\$274,081	\$163,477	\$437,558	\$11,778	\$8.45
Jefferson	\$65,693,341	\$39,625,608	\$105,318,949	\$1,126,790	\$2.11
Kiowa	\$161,706	\$106,835	\$268,541	\$630	\$0.45
Kit Carson	\$868,132	\$600,068	\$1,468,200	\$2,680	\$0.32
La Plata	\$6,090,430	\$3,848,897	\$9,939,327	\$113,805	\$2.22
Lake	\$830,831	\$527,673	\$1,358,504	\$52,275	\$7.15
Larimer	\$33,795,465	\$20,885,762	\$54,681,227	\$571,635	\$1.91
Las Animas	\$1,719,907	\$1,096,055	\$2,815,962	\$22,437	\$1.45
Lincoln	\$480,784	\$310,470	\$791,254	\$2,800	\$0.51
Logan	\$2,158,903	\$1,474,076	\$3,632,979	\$6,894	\$0.30
Mesa	\$15,074,629	\$9,311,177	\$24,385,806	\$500,899	\$3.41
Mineral	\$293,044	\$159,511	\$452,555	\$9,384	\$13.18
Moffat	\$1,292,241	\$819,613	\$2,111,854	\$80,154	\$5.81
Montezuma	\$2,484,814	\$1,583,795	\$4,068,609	\$52,890	\$2.07
Montrose	\$4,087,215	\$2,654,412	\$6,741,627	\$205,811	\$4.99
Morgan	\$2,460,435	\$1,570,470	\$4,030,905	\$16,960	\$0.60
Otero	\$1,875,702	\$1,266,306	\$3,142,008	\$17,655	\$0.94

County Name	Building Exposure (\$ Thousands)	Building Contents (\$ Thousands)	Total Exposure Building Exposure and Contents (\$ Thousands)	Annualized Earthquake Loss	Annualized Earthquake Loss Per Capita
Ouray	\$806,429	\$487,231	\$1,293,660	\$130,450	\$29.41
Park	\$3,146,926	\$1,696,515	\$4,843,441	\$54,984	\$3.39
Phillips	\$516,090	\$353,677	\$869,767	\$1,795	\$0.40
Pitkin	\$3,401,414	\$2,184,911	\$5,586,325	\$129,510	\$7.55
Prowers	\$1,225,346	\$819,047	\$2,044,393	\$5,356	\$0.43
Pueblo	\$14,972,914	\$9,380,874	\$24,353,788	\$178,925	\$1.12
Rio Blanco	\$885,657	\$578,122	\$1,463,779	\$27,174	\$4.08
Rio Grande	\$1,446,497	\$918,150	\$2,364,647	\$108,962	\$9.09
Routt	\$3,745,901	\$2,265,411	\$6,011,312	\$272,806	\$11.60
Saguache	\$598,077	\$355,466	\$953,543	\$24,314	\$3.98
San Juan	\$139,821	\$83,577	\$223,398	\$3,201	\$4.58
San Miguel	\$1,563,369	\$921,467	\$2,484,836	\$35,994	\$4.89
Sedgwick	\$359,081	\$250,347	\$609,428	\$899	\$0.38
Summit	\$5,906,075	\$3,348,735	\$9,254,810	\$136,500	\$4.88
Teller	\$3,134,105	\$1,823,097	\$4,957,202	\$44,950	\$1.93
Washington	\$467,308	\$293,442	\$760,750	\$1,239	\$0.26
Weld	\$23,768,629	\$14,531,033	\$38,299,662	\$287,229	\$1.14
Yuma	\$988,969	\$682,713	\$1,671,682	\$2,558	\$0.25
<b>Total</b>	<b>\$535,570,073</b>	<b>\$331,844,031</b>	<b>\$867,414,104</b>	<b>\$10,978,315</b>	

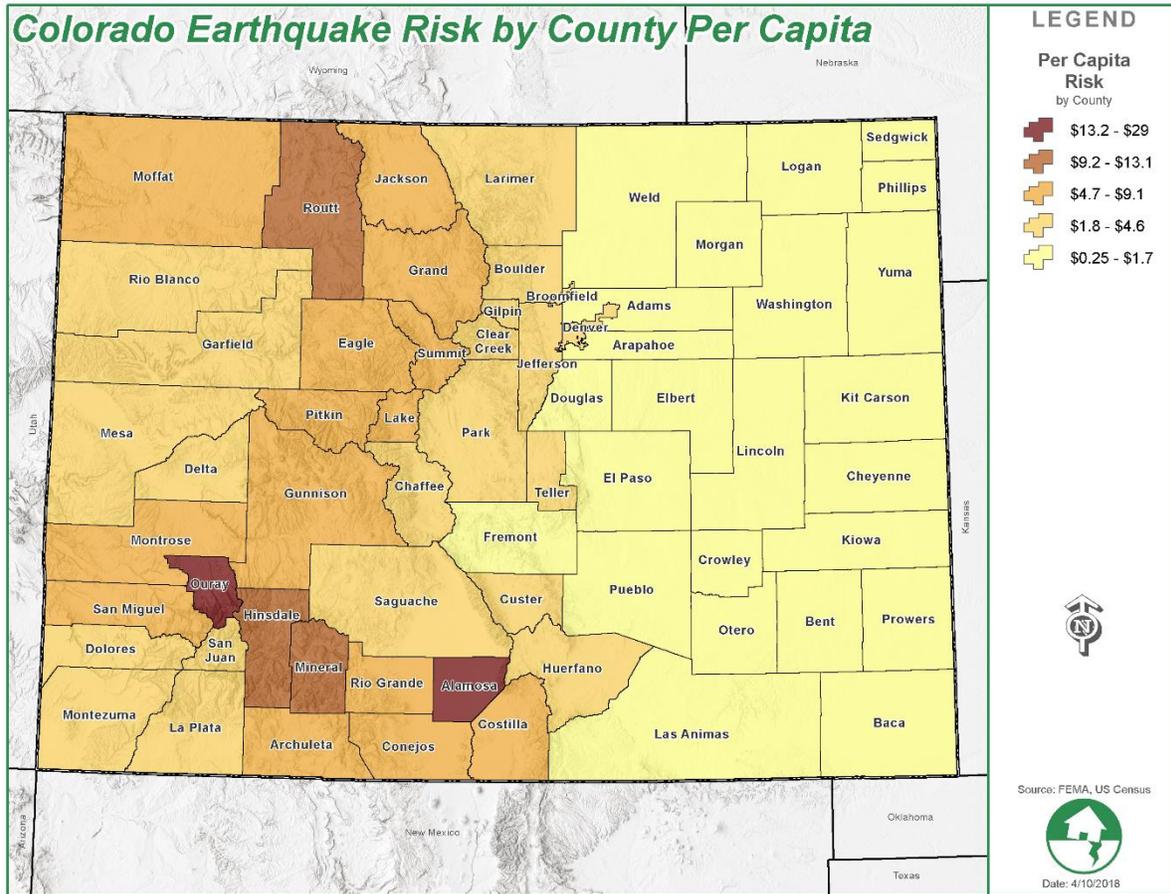
Source: FEMA

FIGURE 3-81 EARTHQUAKE TOTAL ANNUALIZED LOSS BY COUNTY



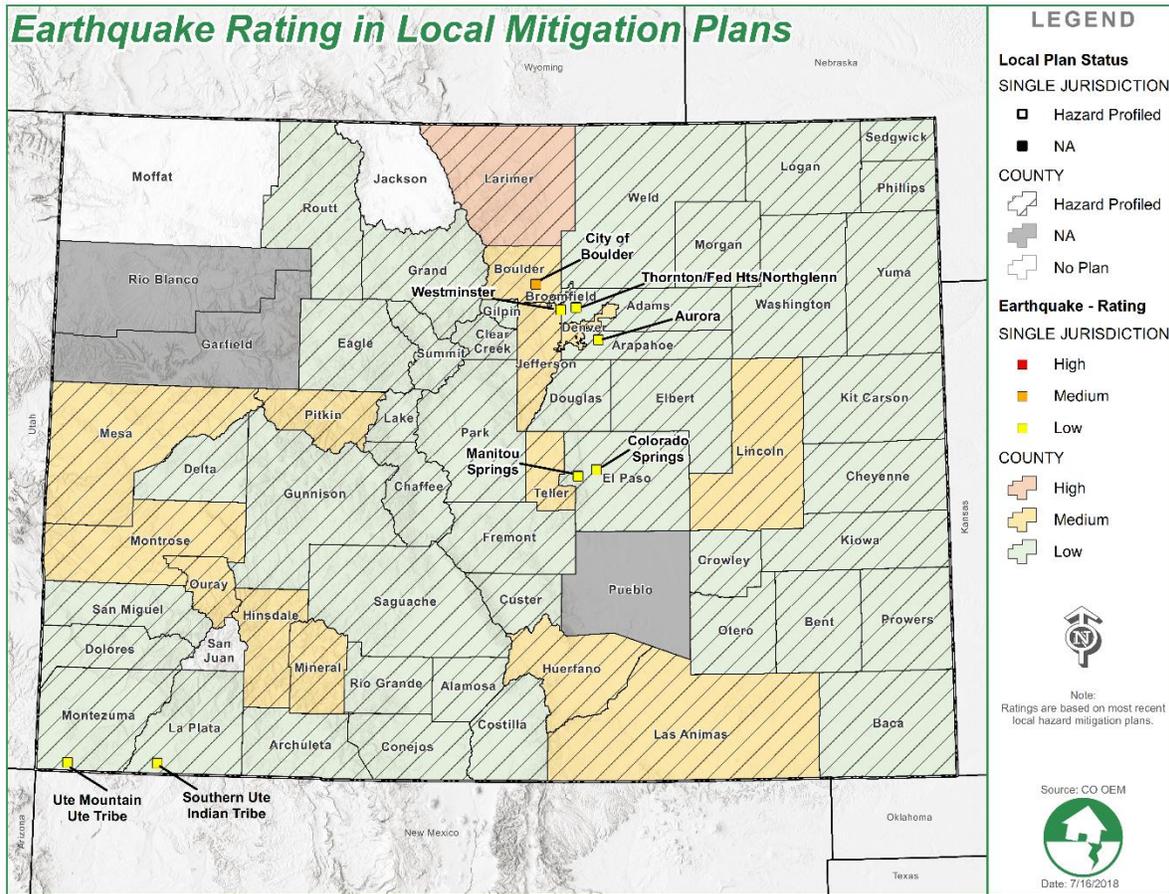
While Figure 3-81 displays total annualized economic loss across the state, Figure 3-82 more closely identifies annualized loss per capita. After dividing the annualized loss results by the county population, the general trend for earthquake risk is still concentrated in the western portion of the state. However, when loss is distributed across the population, the risk decreases for the more populous counties located in the Front Range (El Paso, Douglas, Jefferson, Arapahoe, Denver, Adams, Broomfield, Boulder, and Larimer) and increases in more rural counties such as Alamosa and Ouray.

FIGURE 3-82 EARTHQUAKE RISK BY COUNTY (PER CAPITA)



Based upon a recent (2018) review of local mitigation plans, Figure 3-83 shows which counties analyzed earthquake risk. The 2018 review of local mitigation plans indicates that 66 plans (out of 69 total) include an earthquake hazard chapter. Of these plans, earthquake received a “High Hazard” significance rating one time, “Medium Hazard” 14 times, and “Low Hazard” 51 times.

FIGURE 3-83 EARTHQUAKE HAZARD IN LOCAL MITIGATION PLANS



## 8. FUTURE DEVELOPMENT

Population growth in Colorado will not likely be dictated by earthquake risk. However, the central Western Slope region around Mesa County, one of the areas projected to have relatively high population growth over the next 30 years, tends to be one of Colorado’s higher hazard areas for earthquake. Counties in this area have adopted building codes but not at an average higher standard than the rest of Colorado.

Any new construction built to code should be able to withstand earthquakes, but the potential for nonstructural damage will increase with new development. Continued growth of population in the County could potentially expose more people to earthquakes and their related hazards.

Population growth and development contribute to increased exposure of people and property to earthquakes and their related impacts. Understanding changes in hazard exposure over time is an important element of comprehensive hazard mitigation planning. Among other things, increased population growth and development elevate exposure levels of property and people to the impacts of earthquakes.

Colorado continues to experience some of the largest population growth in the country and future projections seem to indicate a similar trend should be expected. Table 3-161 identifies the counties that have a large expected percent population change rate as well as high annualized earthquake estimations are most at risk for future exposure.

The following section provides county-scale earthquake exposure projections by comparing current earthquake risk with projected percent population change data.

**TABLE 3-159 EARTHQUAKE EXPOSURE PROJECTIONS**

Future Earthquake Exposure Projections					
		County Population Percent Change Projections, 2010 to 2030			
Earthquake Risk		-13% to 2%	3% to 17%	18% to 34%	35% to 89%
<b>High</b>  <b>Moderate</b>	3	Moderate	High	Severe	Extreme
	2	Slight	Moderate	High	Severe
	0-1	Negligible	Slight	Moderate	High

The risk calculations in Table 3-159 are based on the methodology outlined in Table 3-160. Values (between 0 and 3) have been assigned risk based on Annualized Annual Loss. The Jenks Natural Breaks algorithm was used to classify these historical data sets and assign the risk value for each county.

**TABLE 3-160 RISK METHODOLOGY**

Annualized Loss (2017)	Value
732.9K – 1.5M	3
287.2K – 732.9K	2
630 – 287.2K	1

Exposure to earthquakes is expected to intensify across the State of Colorado between 2010 and 2030 as population increases. The darker, more red colors in Table 3-161 illustrate relative rates of increase in exposure between counties. As Colorado’s population increases, infrastructure and businesses will follow these population centers. This further adds to the potential future exposure that counties face from earthquakes. Colorado’s population and related business and infrastructure is concentrated in, and will continue to intensify, in areas of high earthquake activity.

TABLE 3-161 EARTHQUAKE EXPOSURE PROJECTIONS, 2010 TO 2030

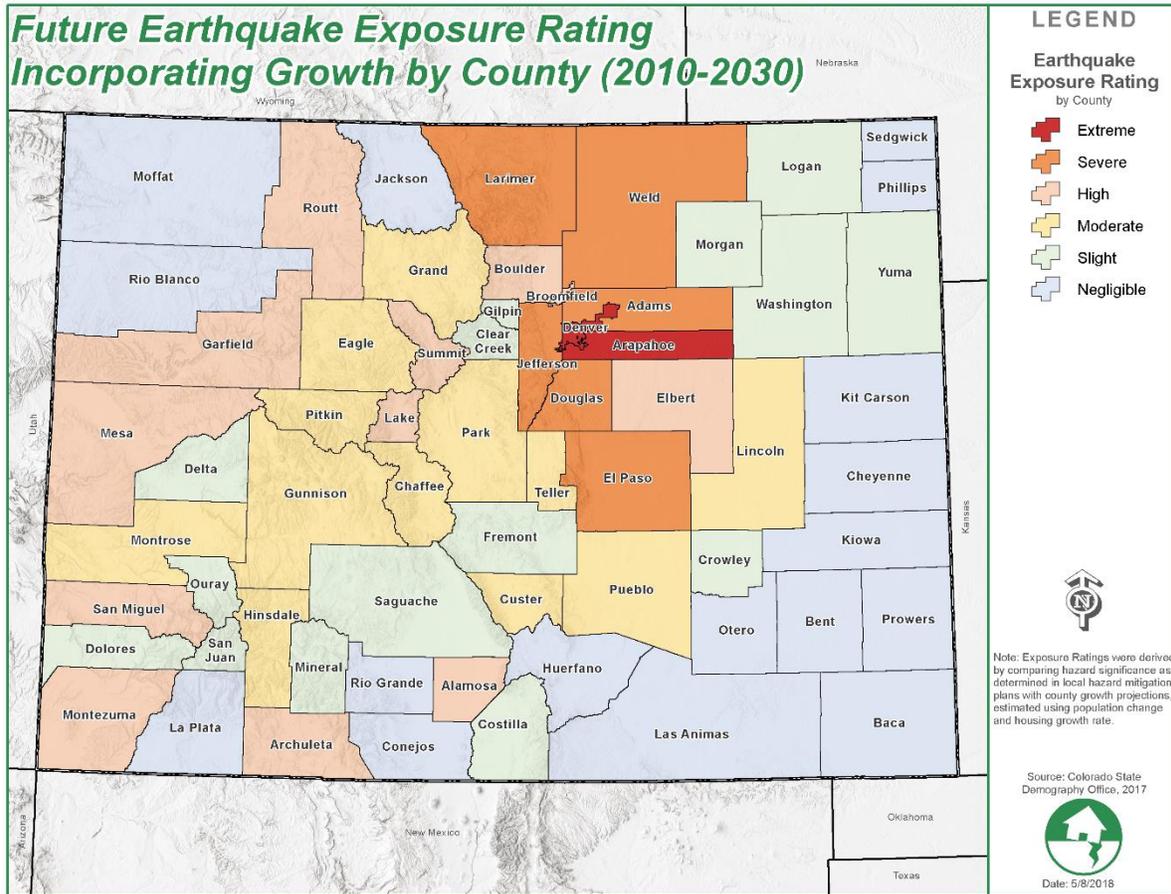
County Name	Annualized Earthquake Loss	Risk Rating	Population Change	Exposure
Arapahoe	\$981,831	3	36%	Extreme
Denver	\$1,496,629	3	42%	Extreme
Adams	\$615,734	2	48%	Severe
Douglas	\$394,729	2	44%	Severe
El Paso	\$732,867	2	36%	Severe
Jefferson	\$1,126,790	3	21%	Severe
Larimer	\$571,635	2	42%	Severe
Weld	\$287,229	2	81%	Severe
Alamosa	\$446,396	2	22%	High
Archuleta	\$72,361	1	40%	High
Boulder	\$729,264	2	28%	High
Broomfield	\$119,306	1	71%	High
Elbert	\$28,914	1	89%	High
Garfield	\$244,305	1	38%	High
Mesa	\$500,899	2	24%	High
Montezuma	\$52,890	1	37%	High
Routt	\$272,806	1	40%	High
San Miguel	\$35,994	1	59%	High
Summit	\$136,500	1	41%	High
La Plata	\$113,805	1	42%	High
Chaffee	\$69,915	1	29%	Moderate
Custer	\$15,124	1	20%	Moderate
Eagle	\$258,013	1	34%	Moderate
Grand	\$102,756	1	32%	Moderate
Gunnison	\$91,309	1	26%	Moderate
Hinsdale	\$10,680	1	29%	Moderate
Lincoln	\$2,800	1	21%	Moderate
Montrose	\$205,811	1	30%	Moderate
Park	\$54,984	1	34%	Moderate
Pitkin	\$129,510	1	18%	Moderate
Pueblo	\$178,925	1	20%	Moderate
Teller	\$44,950	1	25%	Moderate
Clear Creek	\$27,329	1	14%	Slight
Costilla	\$26,777	1	7%	Slight
Crowley	\$2,463	1	5%	Slight
Delta	\$113,361	1	8%	Slight
Dolores	\$4,494	1	5%	Slight
Fremont	\$69,799	1	5%	Slight
Gilpin	\$15,094	1	13%	Slight
Logan	\$6,894	1	14%	Slight

County Name	Annualized Earthquake Loss	Risk Rating	Population Change	Exposure
Mineral	\$9,384	1	16%	Slight
Morgan	\$16,960	1	16%	Slight
Ouray	\$130,450	1	17%	Slight
Saguache	\$24,314	1	9%	Slight
San Juan	\$3,201	1	5%	Slight
Washington	\$1,239	1	5%	Slight
Yuma	\$2,558	1	7%	Slight
Lake	\$52,275	1	17%	Slight
Baca	\$1,919	1	-13%	Negligible
Bent	\$2,468	1	-5%	Negligible
Cheyenne	\$742	1	2%	Negligible
Conejos	\$43,749	1	1%	Negligible
Huerfano	\$17,666	1	-1%	Negligible
Jackson	\$11,778	1	-7%	Negligible
Kiowa	\$630	1	-8%	Negligible
Kit Carson	\$2,680	1	-1%	Negligible
Las Animas	\$22,437	1	-9%	Negligible
Moffat	\$80,154	1	-3%	Negligible
Otero	\$17,655	1	-7%	Negligible
Phillips	\$1,795	1	-3%	Negligible
Prowers	\$5,356	1	-5%	Negligible
Rio Blanco	\$27,174	1	2%	Negligible
Rio Grande	\$108,962	1	-5%	Negligible
Sedgwick	\$899	1	-3%	Negligible

FEMA, Colorado State Demography Office, 2017

Arapahoe County and Denver City and County receive an exposure ranking of extreme based on the annualized loss value and population change greater than 35 percent, while Adams, Douglas, El Paso, Jefferson, Larimer, and Weld counties are projected to have severe exposure. The combination of a growing population and associated buildings and infrastructure results in increasing exposure to earthquake shaking. The results from this exposure analysis are reflected in Figure 3-84.

FIGURE 3-84 FUTURE EARTHQUAKE EXPOSURE



## 9. CLIMATE CHANGE

According to the best data available at the time of this plan update, the future impacts of climate change are not expected to influence future earthquake events.

## 10. RISK TO STATE ASSETS

Dating back to 2000, the Office of Risk Management reports two events impacting state assets. Although Colorado experienced the strongest earthquake in over 40 years in 2011, there were no reports of losses to state assets due to that event. However, losses would be significant if a large earthquake were to occur along the Front Range or in a county with a greater number or value of state assets.

Large earthquakes in Colorado, although the probability is low, are the greatest concern due to an overall impact on non-reinforced structures. Just as with the state's general stock of buildings, many state facilities are not designed to withstand a substantial earthquake. As shown in Table 3-162, over 20 percent of assets within the state risk pool are constructed with masonry

or concrete load-bearing walls. These assets with masonry or concrete load-bearing walls represent over \$1.89 billion in total value.

TABLE 3-162 STATE ASSET CONSTRUCTION TYPE AND TOTAL VALUE\*

Construction Type	Total Count	% of Total Count	Total Value	% of Total Value
Fire Resistive	10	0.2%	\$3,929,033	0.04%
Fireproof structural steel frame with concrete or steel floor	204	3.1%	\$178,037,899	1.89%
Frame, roof & walls of incombustible material	412	6.2%	\$128,994,156	1.37%
Heavy Timber	21	0.3%	\$2,252,179	0.02%
Masonry or concrete load-bearing walls with or without pilasters	1,348	20.4%	\$1,890,462,938	20.09%
Masonry/concrete walls, wood/steel roof & floor, slab	198	3.0%	\$98,304,221	1.04%
Metal bents, columns, girders, purlings and girts without fireproofing	1,091	16.5%	\$490,596,883	5.21%
Reinforced concrete columns and beams	346	5.2%	\$2,421,884,367	25.74%
Reinforced concrete frame & concrete or masonry	48	0.7%	\$211,102,093	2.24%
Structural steel columns and beams	317	4.8%	\$2,107,155,562	22.40%
Wood frame, floor & roof structure	326	4.9%	\$35,918,107	0.38%
Wood or Steel studs in bearing wall, wood or steel frame	1,644	24.8%	\$1,226,809,733	13.04%
None	653	9.9%	\$612,994,588	6.52%
<b>Total</b>	<b>6,618</b>		<b>\$9,408,441,758</b>	

Source: Office of Risk Management

\*Does not included Department of Higher Education Institutions

## 11. RESOURCES

- FEMA 366 Hazus Estimated Annualized Earthquake Losses for the United States April 2017
- Colorado Geological Survey (CGS)
- David, Evans. 1966. The Denver Area Earthquakes and the Rocky Mountain Arsenal Disposal Well. The Mountain Geologist, v. 3, 1966. P. 23-36.
- National Earthquake Information Center

- Spence, W., Langer, C.J., and Choy, G.L., 1996, Rare, large earthquakes at the Laramide deformation Front Range Colorado (1882) and Wyoming (1984): Seismological Society of America Bulletin, v. 86, no. 6, p. 1804–1819.
- United States Geological Survey

# EROSION AND DEPOSITION



## 1. DEFINITION

Erosion is the removal and simultaneous transportation of earth materials from one location to another by water, wind, waves, or moving ice. Deposition is the placing of the eroded material in a new location. All material that is eroded is later deposited in another location. Erosion is generally the result of ongoing natural geologic and atmospheric processes that occur slowly over time. Damaging erosion and deposition is usually the result of more extreme events associated with high wind, heavy rain, excessive runoff, landslides, and debris flows. In Colorado, erosion is usually initiated by water or wind; sometimes it is initiated or exacerbated by wildfires and human activity. Table 3-163 describes the hazard profile summary for erosion and deposition.

TABLE 3-163 HAZARD PROFILE SUMMARY

Consideration	Impact	Description
<b>Location</b>	Statewide	All counties experience erosion and deposition activities either through human-caused disruption of the land or natural causes.
<b>Extent</b>	Moderate	Limited or short-term property damage; no deaths or few injuries; little or no impact on critical services or facilities. May be a precursor to rockfalls and landslides. Typically, a slow-moving event.
<b>Probability</b>	Expected	This is an ongoing natural event which is aggravated by human activities that disturb the land. These natural and human activities are expected to continue as in the past.
<b>Previous Occurrences</b>	Perennial	Erosion and deposition is an ongoing natural event and a concern whenever human activities disrupt the land.

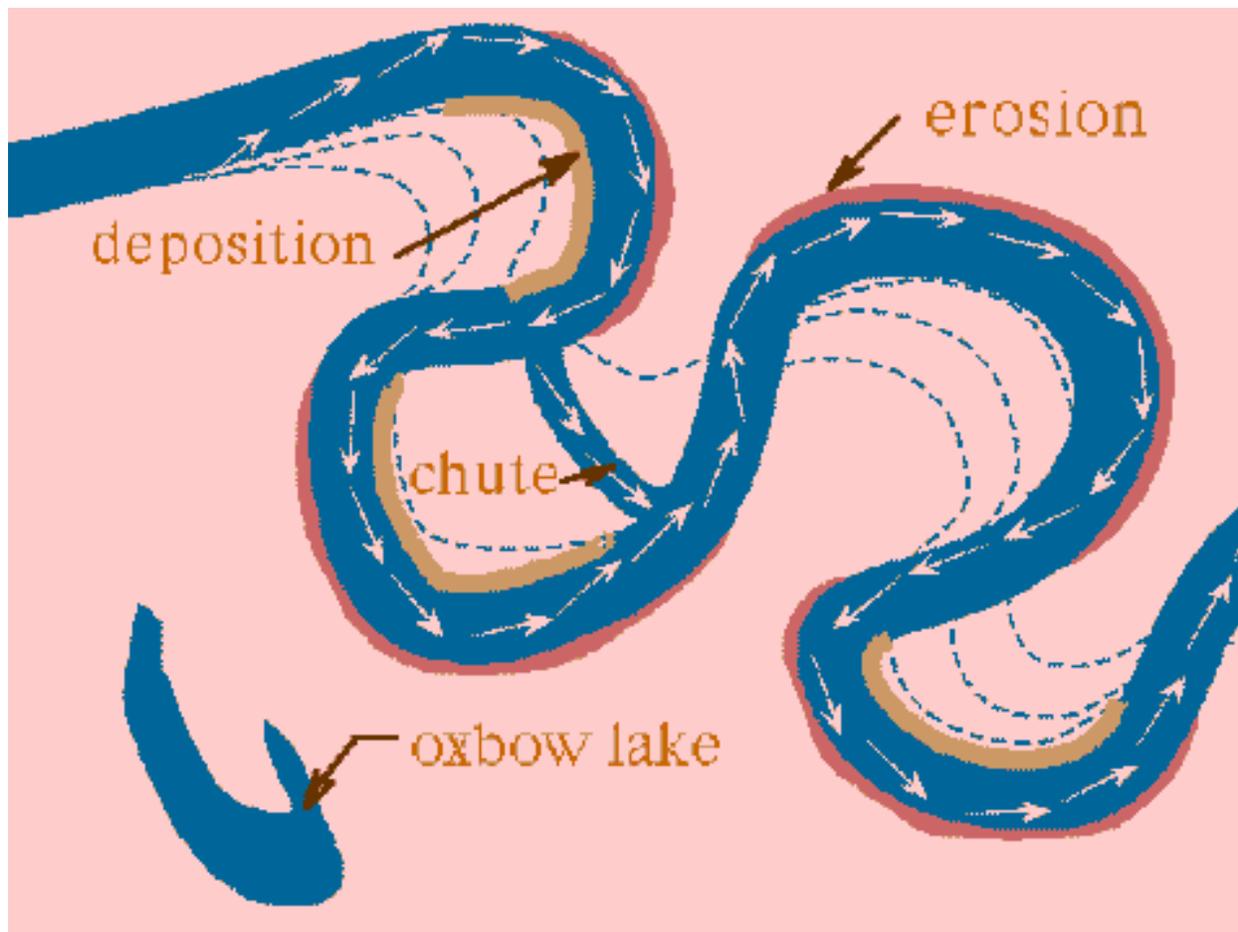
## 2. LOCATION

Erosion and deposition are occurring continually at varying rates all over Colorado. Point sources of erosion are common to construction sites or other areas where human interaction with the earth results in exposed soil or removal of vegetation. Natural waterways perpetually remove and carry soil from the earth to locations downstream. The Colorado River appears red during times of high runoff due to the amount of soil being carried. Erosion and deposition issues are also exacerbated in wildfire burn areas.

An example of one type of erosion and deposition system related to streams is shown in the following Figure 3-85.

Currently there is no statewide erosion hazard mapping for the state. In the future there will be more erosion hazard data for Colorado. As of 2018 the CWCB is creating pilot erosion hazard maps as a component of its RiskMAP flood mapping program.

FIGURE 3-85 STREAM EROSION AND DEPOSITION SYSTEM



Source: <http://edtech.mit.edu/cgi-bin/pgt?part=1.3.0.5&img=3>

### 3. EXTENT (MAGNITUDE/STRENGTH)

Erosion can result in minor inconveniences or major destruction of property and infrastructure. Severe erosion removes the earth from beneath bridges, roads, and foundations of structures adjacent to streams. By undercutting, it can lead to increased rockfall and landslide hazard. The deposition of material can block culverts, aggravate flooding, destroy crops and lawns by burying them, and reduce the capacity of water reservoirs as the deposited materials displace water, and cause overall degradation of the water supply.

Human activities greatly influence the rate and extent of erosion and deposition. Stripping the land surface of vegetation, altering natural drainages, and rearranging the earth through construction of highways, subdivision development, farmland preparation, and modification of

drainage channels for water control projects are significant factors in increased erosion and deposition. Natural causes such as wildfire are an additional precursor to soil erosion and deposition as runoff and permeability are changed by removal of vegetation and changes to the physical condition of the ground.

Riverine erosion has many consequences including land and development loss. It can also affect river sedimentation and degrade channel navigation. Other problems include water quality reduction due to high sediment loads, native aquatic habitat losses, damage to public utilities (roads, bridges and dams), and increased maintenance, prevention, and control costs. Sedimentation of streams degrades habitat essential for many aquatic organisms. Erosion and deposition can also increase risk of pollution of surface waters, as nutrients and pesticides from agricultural and residential uses are more easily carried off the surface by runoff. Colorado's recreation-based economy depends highly on the quality of waters for fishing, boating, and overall appeal of the state's many river valleys.

Wind erosion hinders agricultural production from topsoil loss and root exposure. Erosion can also contribute to dust storms. Wind-blown dust reduces visibility, causing automobile accidents and hindering machinery. Wind erosion can also have a negative effect on air quality, creating animal and human respiratory health concerns. Wind erosion also damages public utilities and infrastructure. Colorado has experienced dust storms in the southwest portion of the state that resulted in the deposition of particles on high mountain snow. Being less reflective than snow, the dust particles absorb heat with the result of an earlier snowmelt in some areas of the state. Early snowmelt may result in water supply and recreational use issues on waterways.

## 4. PROBABILITY

Erosion and deposition is aggravated by natural events such as heavy rain or stream flow, high wind, wildfires, or human activities that disturb the land. These natural and human activities are expected to continue as in the past resulting in ongoing erosion and deposition.

## 5. PREVIOUS OCCURRENCES

There is a high risk for erosion in the aftermath of a wildfire event. As a fire burns, it destroys plant material and the layers of litter that blanket the floor of an ecosystem. These materials, as well as trees, grasses, and shrubs, buffer and stabilize the soil from intense rainstorms. The plant materials slow runoff to give rainwater time to percolate into the ground. When fire destroys this protective layer, rain and wind wash over the unprotected soil and erosion occurs. In areas of Colorado affected by wildfire between 2013 and 2017 – including Archuleta, Rio Grande, Mineral, El Paso, Huerfano, Fremont, Rio Blanco, Jackson, and Boulder Counties – incidences of erosion events were significantly elevated.

Erosion and deposition is an ongoing natural event and a concern whenever human activities disrupt the land. Significant erosion and deposition is a post wildfire event issue in Colorado and

areas of concern may be correlated with wildfire event locations. Major flood events can also cause significant erosion, as can major windstorms.

### **5.1 CASE HISTORY**

The following information on previous occurrences of damage caused by erosion and deposition is reported on the Colorado Geological Survey (CGS) website:

Near the Town of Larkspur in Douglas County, an access road and shallow borrow ditch were cut to serve an airport runway uphill from the access road. During construction of the road and borrow pit a large area was stripped of vegetation. Heavy water runoff from above the runway and the runway itself was channeled down the borrow ditch. There were no control features to slow the velocity of the water or retard erosion. Within five years the borrow ditch was eight feet deep. Properly designed and installed water control structures, re-vegetation of the graded area, detention ponds, drop structures, and other measures would have paid for themselves in later maintenance and repair costs.

Erosion and deposition problems have also been noted in the Fountain Creek watershed near the City of Colorado Springs and downstream to as far as La Junta. There were historic erosion problems through Woodland Park with associated sedimentation, however these problems were exacerbated by the Waldo Canyon Fire of 2012. Erosion is also evident in the stream banks upstream of the Old Crystola Road. Sedimentation and flooding occur downstream in many reaches causing issue during periods of high streamflow. Flooding and erosion in this watershed have accelerated the loss of aquatic and wetland habitats, contributed to the loss of hundreds of acres of productive farmland, and caused the foundations of roads and homes to crumble.

The 2016 Colorado Energy Assurance Emergency Plan recognizes erosion as a hazard to the state and recounts the following past occurrences:

- Two months after the May 1996 Buffalo Creek Fire in Pike National Forest, flooding and erosion transported 30 times the annual rate of coarse sediment into the Strontia Springs Reservoir. At the time, the Strontia Springs Reservoir supplied the City of Denver with 75 percent of its drinking water. The Denver Water Department spent years cleaning up the reservoir after water quality tests proved that the burned materials and sediment were degrading water quality. In 2010, the Waterton Canyon Recreation Area was closed and the Strontia Reservoir dredged to remove the remaining sediment. A nine-mile-long pipeline was installed to carry the hundreds of thousands of tons of sediment down to the mouth of Waterton Canyon. In April 2012, nearly 16 years after the Buffalo Creek Fire and a decade after the Hayman Fire, the 75-ton dredge was removed and the project was finally completed.
- In 1998, Pikes Peak Highway was at the center of a lawsuit between the Sierra Club and the City of Colorado Springs and the USDA Forest Service. The unpaved highway was built without proper water control structures. Stormwater eroded the road and carried

thousands of tons of gravel and sediment down to natural watersheds every year. Over time, hundreds of gullies formed and increased the rate of erosion. The lawsuit was settled when the City of Colorado Springs and the US Forest Service agreed to pave the road. Paving began in 2001 and was completed in October 2011.

During droughts or following wildfire events, windstorms can cause significant erosion. NOAA's National Centers for Environmental Information (NCEI) Storm Events Database records four unique dust storm events since 2013. Counties affected by these storms included Crowley, Otero, Cheyenne, and Kit Carson.

Though riverine erosion is an ongoing process, major flood events can dramatically increase erosion rates. The 2013 floods on Colorado's Front Range caused extreme levels of erosion. A 2015 study from researchers at the University of Colorado Boulder found that the 2013 floods resulted in as much as 1,000 years' worth of erosion in the foothills west of Boulder, when compared to the average annual rate of erosion. The researchers also concluded that most erosion occurs as a result of extreme weather events.

## 6. IMPACT ANALYSIS

An overview of the impacts of erosion and deposition is found in Table 3-164.

TABLE 3-164 EROSION AND DEPOSITION EMAP IMPACT SUMMARY

Consideration	Description
<b>General Public</b>	Property owners, farmers, construction workers may be directly impacted by typically limited and localized events.
<b>First Responders</b>	Little if any exposure exists to personnel performing routine duties when event occurs. First responders will not directly report to erosion and deposition events, rather to cascading or unintended consequences resulting from it.
<b>Property</b>	Instances of property loss may occur if streamside property is undercut, construction activities induce an event, or buildings are placed in event prone geology. Physical loss of land may occur as erosion carries land from one property and deposits it on another.
<b>Facilities and Infrastructure</b>	Severe erosion may remove the earth from beneath bridges, roads and foundations of structures adjacent to streams.
<b>Economic</b>	None or limited loss of facilities or infrastructure function or accessibility and limited uninsured damages.
<b>Environment</b>	This event innately impacts land and water. Earth materials are physically moved from one place to another and under certain circumstances, may be significant. Water quality may be impacted from siltation.
<b>Continuity of Government and Services</b>	None or limited loss of facilities or infrastructure function or accessibility or ability to provide services.

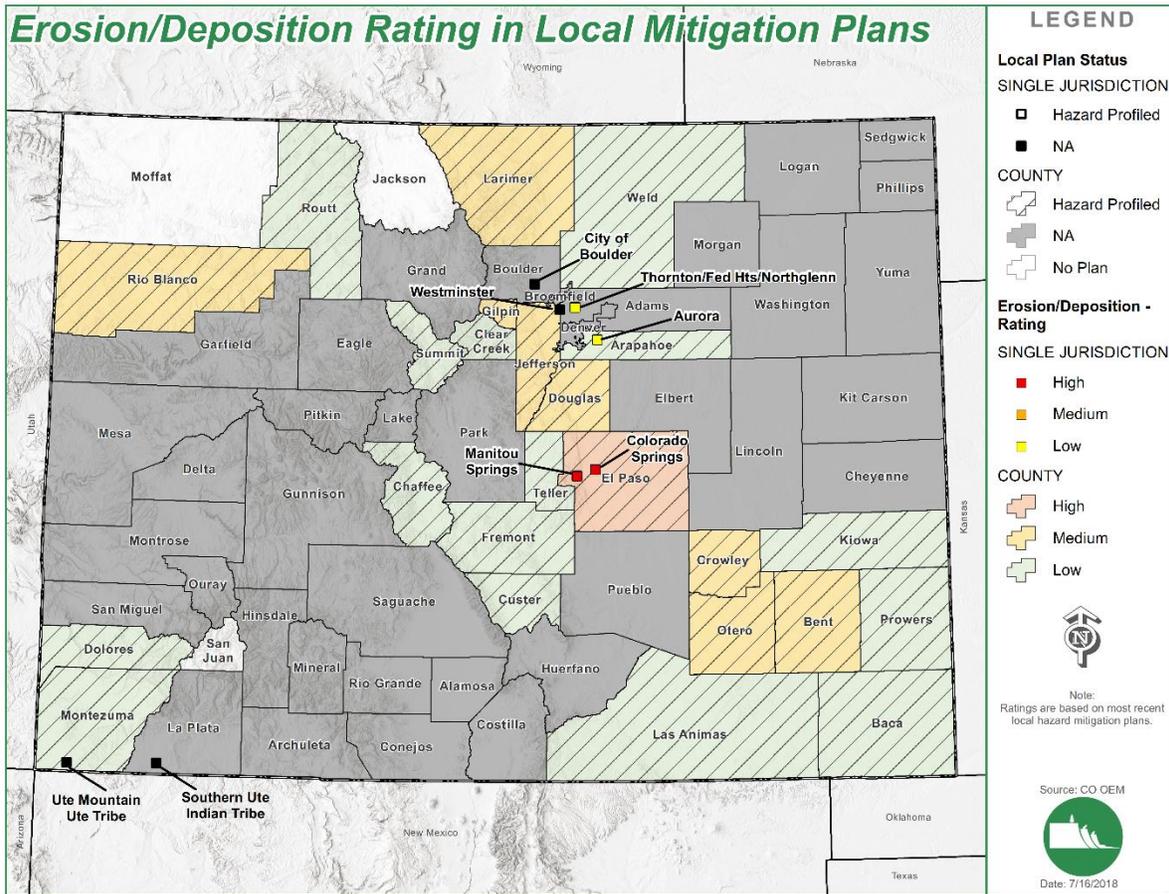
Consideration	Description
<b>Confidence in Government</b>	Event characteristics such as duration and speed of onset result in limited response and recovery functions for government beyond first responders. If infrastructure damage occurs, such as a road washout, quick and cost-effective repair is expected.
<b>Critical Assets</b>	Risk to critical assets is not anticipated; however, scour may result in bridge closures.

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

The processes of erosion and deposition cannot be stopped totally and all jurisdictions are vulnerable to erosion. This hazard can be reduced and controlled by surface drainage management, revegetation of disturbed lands, controlling stream-carried eroded materials in sediment catchment basins, and armoring of erosion-prone stream banks, especially adjacent to structures. Understanding these processes and taking preventative action can lead to development and land-use methods that minimize losses.

Of the 69 local plans evaluated (including 61 counties, 2 Indian Tribes, and 6 cities), 28 local plans have identified erosion and deposition as a hazard to their jurisdiction, as shown in Figure 3-86. Local plan hazard ratings are an indication of where vulnerability to erosion exists across the state, but this assessment does not necessarily identify all counties with erosion risk. For example, despite NCEI records of dust storms from wind-related erosion in four counties, two of these counties — Cheyenne and Kit Carson — do not identify erosion as a significant hazard in their local plans.

FIGURE 3-86 EROSION AND DEPOSITION HAZARD IN LOCAL MITIGATION PLANS



In cases where recent catastrophic flooding has disrupted the erosion and deposition stream bank equilibrium, there is new vulnerability that did not previously exist. This situation is prevalent along tributaries of the South Platte River from Fort Collins to Denver — including the St. Vrain, Big Thompson, Little Thompson, James, Boulder, Fourmile creeks, and others — due to the 2013 flooding which caused streams to shift from their historic channels. In some cases, these channels moved a quarter mile. Stream banks will continue to erode more rapidly as the stream carves away at the new channel in finding equilibrium. Life, property, and critical infrastructure with a lower vulnerability before the September 2013 flood may now be more or in some cases highly vulnerable.

## 8. FUTURE DEVELOPMENT

Ordinarily, erosion and deposition do not curtail land use, especially if efforts are made to minimize them. However, development can exacerbate issues of erosion and deposition if soil and stormwater impacts are not properly managed. By stripping surface of vegetation, altering natural drainage, increasing impervious surface, and/or reducing stormwater infiltration,

development can increase the likelihood of erosion and deposition. Erosion best management practices can help minimize impacts associated with future development.

Table 3-166 summarizes the projected exposure to erosion and deposition by county based on locally-rated hazard significance and projected population and housing percent change. Counties not listed are expected to have negligible exposure to erosion and deposition based on their not including erosion as a hazard of significance in their local hazard mitigation plans.

The Exposure Ratings in Table 3-166 are based on the methodology outlined in Table 3-165. All counties that profiled erosion and deposition in their local plans are reviewed. Rated Risk is based on the overall hazard significance assigned to erosion and deposition in each local plan. In addition to population percent change, Table 3-166 also shows projected housing percent change from 2010 to 2030 as an additional indicator of potential future exposure in each county.

**TABLE 3-165 EROSION AND DEPOSITION EXPOSURE PROJECTIONS**

Future Erosion and Deposition Exposure Projections					
		County Growth Population Percent Change Projections, 2010 to 2030			
Rated Risk (Erosion and Deposition)		-13% to 2%	3% to 17%	18% to 34%	35% to 89%
<b>High</b>  <b>Low</b>	H	Moderate	High	Severe	Extreme
	M	Slight	Moderate	High	Severe
	L	Negligible	Slight	Moderate	High

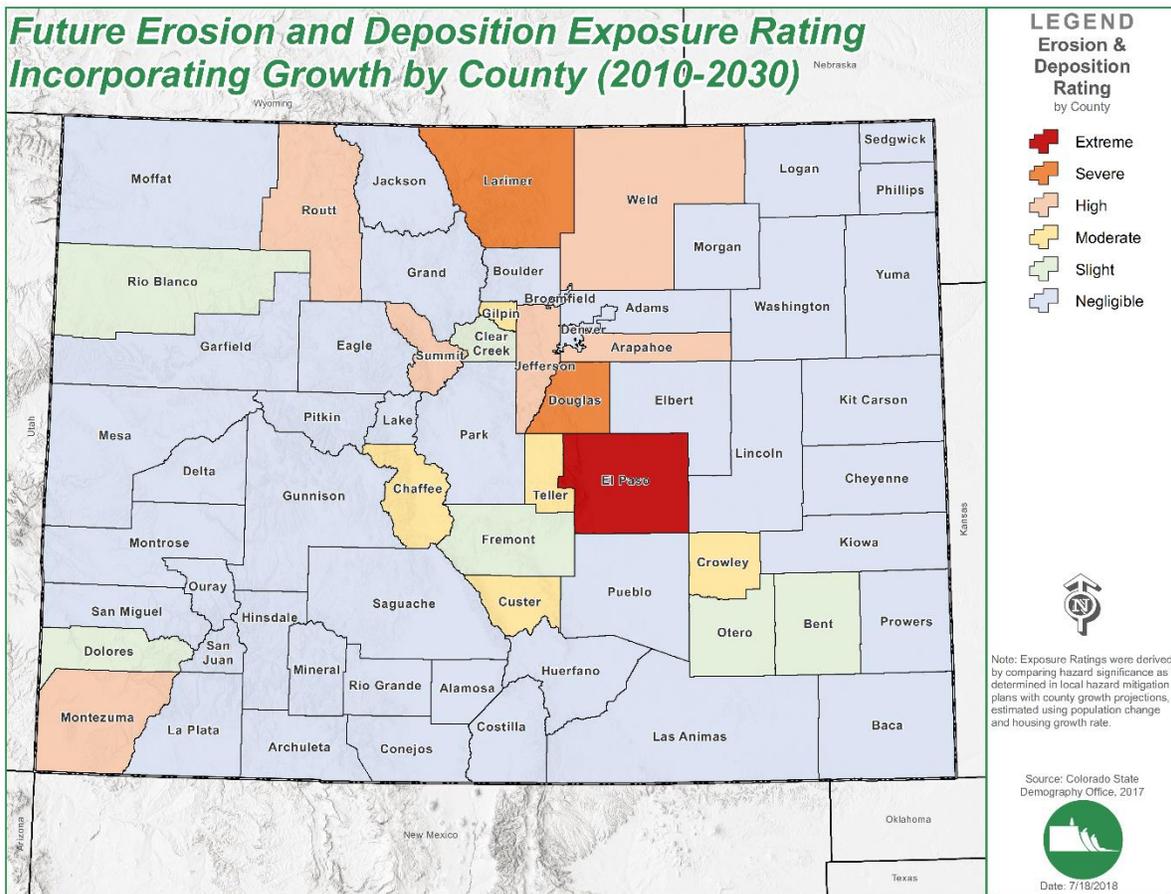
**TABLE 3-166 EROSION AND DEPOSITION EXPOSURE PROJECTIONS, 2010 TO 2030**

County	Rated Risk	Housing Percent Change	Population Change	Exposure Rating
El Paso	H	40%	36%	Extreme
Douglas	M	67%	44%	Severe
Larimer	M	47%	42%	Severe
Jefferson	M	30%	21%	High
Weld	L	93%	81%	High
Arapahoe	L	52%	36%	High
Summit	L	49%	41%	High
Routt	L	46%	40%	High
Montezuma	L	37%	37%	High
Chaffee	L	38%	29%	Moderate
Crowley	M	26%	5%	Moderate
Custer	L	41%	20%	Moderate
Gilpin	M	12%	13%	Moderate

County	Rated Risk	Housing Percent Change	Population Change	Exposure Rating
Teller	L	23%	25%	Moderate
Bent	M	7%	-5%	Slight
Clear Creek	L	20%	14%	Slight
Dolores	L	4%	5%	Slight
Fremont	L	28%	5%	Slight
Rio Blanco	M	10%	2%	Slight
Otero	M	6%	-7%	Slight
Baca	L	-6%	-13%	Negligible
Kiowa	L	12%	-8%	Negligible
Las Animas	L	23%	-9%	Negligible
Prowers	L	3%	-5%	Negligible

Based on this assessment, El Paso, Douglas, and Larimer Counties are projected to face the highest exposure to erosion and deposition through 2030. Figure 3-87 displays this information in a statewide map.

FIGURE 3-87 EROSION AND DEPOSITION EXPOSURE PROJECTIONS



## 9. CLIMATE CHANGE

According to the best data available at the time of this plan update, the future impacts of climate change are expected to influence future erosion and deposition events. The following Table 3-167 presents a breakdown of these projected changes in terms of hazard: location, extent/intensity, frequency, and duration.

**TABLE 3-167 CLIMATE CHANGE IMPACTS**

<b>Location</b>	The area at risk to erosion and deposition is not expected to change.
<b>Extent / Intensity</b>	The extent of erosion and deposition are expected to increase as frequency of wildfire increases across the state. Intensity is not expected to change.
<b>Frequency</b>	Fire erosion is expected to increase as frequency of wildfire increases across the state. Additionally, increases in the frequency and duration of droughts improve the conditions for wind-driven erosion, particularly along the Eastern Plains.
<b>Duration</b>	The duration of erosion and deposition events is not expected to change.

## 10. RISK TO STATE ASSETS

Erosion more than deposition poses risks and results in substantial losses to state assets. Erosion in the “natural” sense poses little harm to state assets. However, when state assets are placed in proximity to erosion-prone environments such as a valley near a stream or riverbank, the vulnerability increases significantly. When events such as heavy rain result in increased stream flow, the erosion of riverbanks and increase in scour may pose significant risk to state assets. The layout of Colorado’s state highway system is significantly influenced by our mountainous terrain, and road and bridge infrastructure is often located in valleys where flash flooding occurs.

The state’s road and bridge infrastructure is prone to flood impacts and resulting disruptions, which can have considerable economic impacts. The potential losses associated with bridges that were determined to be at risk from scour during flooding events are estimated by the Federal Highway Administration’s National Bridge Inventory. Statewide, 253 bridges were determined to be scour critical as of 2016.

In 2013, Colorado’s Front Range, particularly the northernmost counties, experienced a catastrophic flood event. This flood event provides a benchmark for road and bridge infrastructure losses associated with a large-scale flood event and the associated erosion. As of March 2015, CDOT estimated that damages to state and local roads and bridges would cost

\$590 million to repair. The losses include damage to 486 miles of roads and 120 bridges across multiple counties.

Temporary emergency repairs made to the state roads and bridges from the 2013 floods are even more vulnerable to increased stream flow and will continue to be until the stream channel reaches equilibrium with the erosion and deposition process and permanent repairs are made.

The Office of Risk Management (ORM) reports only one loss to state assets due to erosion in the past decade. The event occurred in June 2011 in Glenwood Canyon just west of Hanging Lake Tunnel in which high water erosion caused over \$897,000 in damage to a biking and walking path.

## 11. RESOURCES

- Colorado Geological Survey (CGS)  
<http://coloradogeologicalsurvey.org/geologic-hazards/erosion/>
- 2016 Colorado Energy Assurance Emergency Plan
- Colorado Climate Plan, 2015
- Fountain Creek Watershed District
- PhysicalGeography.net
- NOAA National Centers for Environmental Information (NCEI)
- University of Colorado Boulder
- Colorado Department of Transportation (CDOT)

# EXPANSIVE SOILS AND HEAVING BEDROCK



## 1. DEFINITION

Expansive, or swelling soils or rock, are defined as soils or soft bedrock that increase in volume as they get wet and shrink as they dry out. They are also commonly known as bentonite or montmorillinitic soils. The Colorado Geological Survey (CGS) is the primary source for the information related to expansive soils described below.

Swelling soils contain a high percentage of certain kinds of clay particles that are capable of absorbing large quantities of water. Soil volume may expand 10 percent or more as the clay becomes wet. The powerful force of expansion is capable of exerting pressures of 20,000 per-square-foot or greater on foundations, slabs or other confining structures. Subsurface Colorado swelling soils tend to remain at constant moisture content in their natural state and are usually relatively dry at the outset of disturbance for construction on them. Exposure to natural or human-caused water sources during or after development results in swelling. In many instances, the soils do not regain their original dryness after construction, but remain moist and expanded due to the changed environment.

### ***1.1 TECHNICAL DESCRIPTION – SHRINK-SWELL POTENTIAL OF SOIL***

Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special considerations for structural design are common to mitigate against expansive soils.

## 1.2 TECHNICAL DESCRIPTION – HEAVING/DIPPING BEDROCK

Heaving bedrock is a geological hazard that is related to expansive soils, but it is more complex in terms of its uplift morphologies, deformation mechanisms, and regional distribution. It is common along Colorado's Front Range piedmont where steeply dipping sedimentary bedrock containing zones of expansive claystone is encountered near to the ground surface.

The heave features associated with heaving bedrock are distinctly linear and are caused by differential swelling and/or rebound movements within the bedrock. Heaving bedrock has caused exceptional damage to houses, roads, and utilities along the base of the Front Range since suburban-type development began in the early 1970s. Much of this damage may be attributed to the longstanding tendency to assume that the bedrock may be treated, for site - exploration and design purposes, as an expansive soil having essentially uniform properties. This approach ignores the disparate nature of some bedrock. Table 3-168 describes the hazard profile summary for expansive soils and heaving bedrock.

TABLE 3-168 HAZARD PROFILE SUMMARY

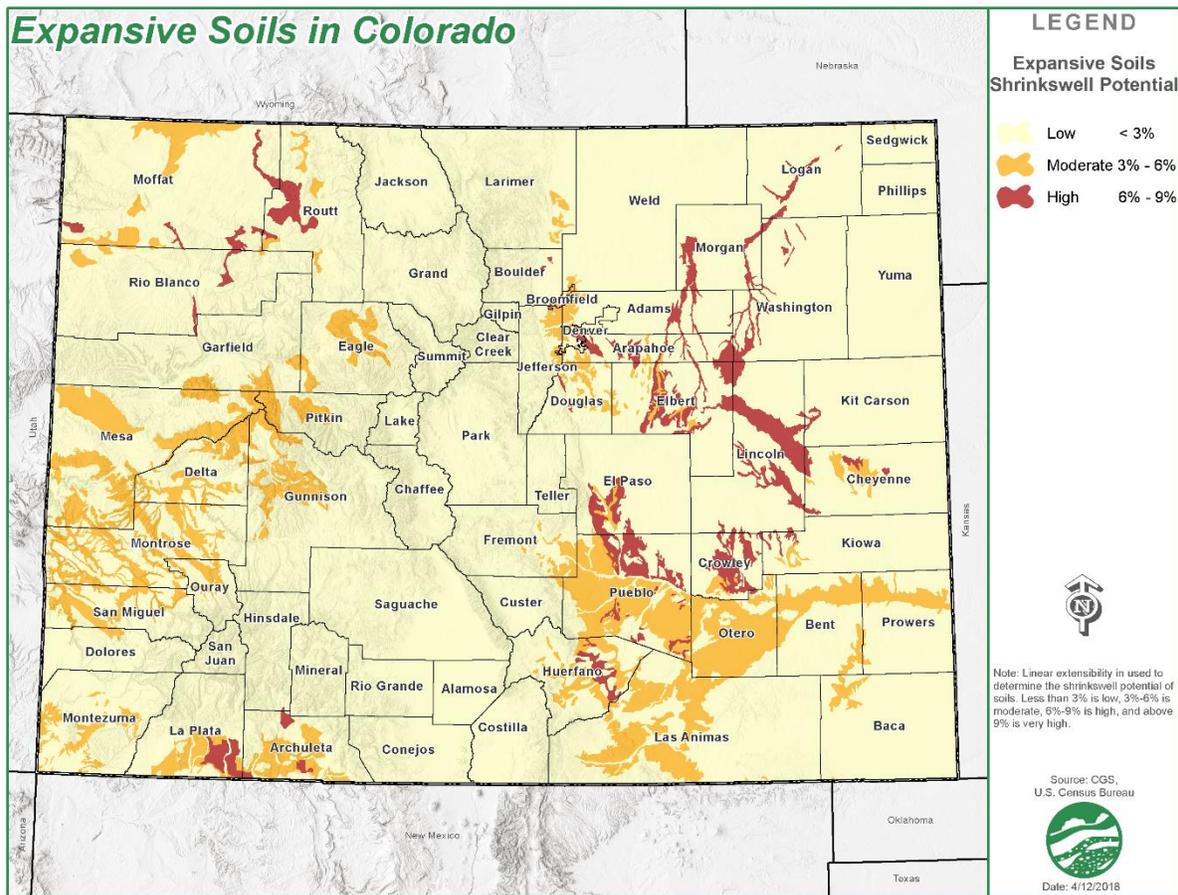
Consideration	Impact	Description
<b>Location</b>	Statewide	Statewide with heaving bedrock concentrated along the Front Range.
<b>Extent</b>	Extensive	Major or long-term property damage with potential to threaten structural integrity. Limited or no loss of life or injury. One of Colorado's most prevalent causes of damage to buildings and construction.
<b>Probability</b>	Expected	Conditions related to natural causes such as precipitation and drought cycles, in addition to development and land use prevalent in the past, are expected to continue.
<b>Previous Occurrences</b>	Perennial	Ongoing event resulting from natural causes such as drought and precipitation and human-caused development activities.

## 2. LOCATION

Expansive soils occur throughout Colorado, although the shrink-swell potential varies by area. Rocks containing swelling clay are generally softer and less resistant to weathering and erosion than other rocks and therefore, more often occur along the sides of mountain valleys and on the plains than in the mountains. However, the potential for shrinking and swelling soils in Colorado is evaluated statewide. Figure 3-88 shows expansive soils across the state. The darker the red coloring shown on the map, the greater potential for shrinking and swelling soils.

Soils in portions of the eastern counties of Elbert, Lincoln, Cheyenne, Crowley, Pueblo, Huerfano, El Paso, Arapahoe, Adams, Morgan, Washington, and Logan, the southwestern counties of La Plata and Archuleta, and the northwestern counties of Moffat, Routt, and Rio Blanco have very high linear extensibility, or the potential for shrinking and swelling.

FIGURE 3-88 EXPANSIVE SOILS IN COLORADO



### 3. EXTENT (MAGNITUDE/STRENGTH)

Expansive soils vary by the potential for linear extensibility. The higher the shrink-swell potential of the soil, the greater the damage that may occur to buildings or infrastructure built in those areas. Expansive soils with linear extensibility potential of less than 3 percent have a low shrink-swell potential, 3-6 percent is moderate, and 6-9 percent is high, and above 9 percent is very high. The most expansive soils in Colorado are found sporadically along the Front Range and Eastern Plains, and the in far northwest and southwest.

### 4. PROBABILITY

Conditions related to natural causes of expansive soils, such as precipitation and drought cycles, in addition to development and land use prevalent in the past, are expected to continue. Expansion of soils is a naturally occurring process that has occurred historically and will continue to do so.

## 5. PREVIOUS OCCURRENCES

Official data sources do not provide meaningful updates since the 2013 Plan Update to report. About 15 percent of Colorado's soil has a moderate to very high potential for shrinking, and swelling is a perpetual natural phenomenon. Swelling is generally caused by expansion due to wetting of certain clay minerals in dry soils. Therefore, arid or semi-arid areas such as Colorado with seasonal changes of soil moisture experience a much higher frequency of swelling problems than eastern states that have higher rainfall and more constant soil moisture.

### 5.1 CASE HISTORY

The following information on previous occurrences of damage caused by expansive soils is reported on the Colorado Geological Survey (CGS) website:

In 1970, the state of Colorado spent nearly \$500,000 to repair cracked walls, floors, ceilings, and windows caused by swelling-clay damage at a state institution near Denver. A college building in western Colorado and a National Guard armory near Denver are among the other state buildings severely damaged by swelling clays.

In 1972, the library at Southern Colorado State College, now Colorado State University Pueblo Campus (CSU-Pueblo) required \$170,000 to repair swelling-clay damage. A six-year old, \$2 million building on the same campus was closed pending repairs to structural components pulled apart by swelling clay. Structures on the CSU-Pueblo campus were damaged because swelling soils were not recognized or compensated for adequately in design, construction and maintenance of buildings, sidewalks, driveways, and water lines. Water percolating into dry soils exposed by construction excavation caused the clays to expand, exerting tremendous upward pressures. Floors, walls, ceilings, sidewalks, water lines, driveways, and other improvements have sustained an estimated \$1.5 million in damages.

In 1976 at the site of the new maximum-security facility for the Colorado State Prison in Fremont County, swelling soils and bedrock were shown on geologic maps. Field investigations and soils tests resulted in a remediation plan by the geologic and soils engineers, architect, builder, and others on foundation design, drainage, and landscaping. Millions of dollars in potential damages were avoided.

No figures are available for the total damage to homes in Colorado from swelling clays. However, CGS notes that several examples are known where the cost of repairs exceeded the value of the structure.

Highways in some areas of Colorado have required frequent and very expensive reconstruction or maintenance due to damage from swelling clay. As much as one foot of uplift from swelling clay forced the repair of two concrete lanes of an interstate highway in eastern Colorado only six months after completion of paving. In the same area, additional right-of-way had to be purchased, and the highway design had to be

revised to eliminate cuts and fills in order to prevent similar problems with the two remaining lanes.

## 6. IMPACT ANALYSIS

Swelling soils are one of the nation's most prevalent causes of damage to buildings and construction. Annual losses are estimated in the range of \$2 billion. The losses include severe structural damage, cracked driveways, sidewalks, and basement floors, heaving of roads and highway structures, condemnation of buildings, and disruption of pipelines and sewer lines. The destructive forces may be upward, horizontal, or both.

Rocks containing swelling clay are generally softer and less resistant to weathering and erosion than other rocks and therefore, more often occur along the sides of mountain valleys and on the plains than in the mountains. Because the population of Colorado is also concentrated in mountain valleys and on the plains, most of the homes, schools, public, and commercial buildings, and roads in the state are located in areas of potentially swelling clay. Swelling clays are also not a well-publicized hazard in Colorado. Swelling clays are, therefore, one of the most significant, widespread, and costly geologic hazards in Colorado.

Damage from swelling clays can affect, to some extent, virtually every type of structure in Colorado. Some structures, such as downtown Denver's skyscrapers, generally have well engineered foundations that are too heavily loaded for swelling damage to occur. At the opposite extreme are public schools and single-family homes, which are generally constructed on a minimal budget and which may have under-designed lightly loaded foundations that are particularly subject to damage from soil movements. Homeowners and public agencies that assume they cannot afford more costly foundations and floor systems often incur the largest percentage of damage and costly repairs from swelling soil.

Design and construction of structures while unaware of the existence and behavior of swelling soils can worsen a readily manageable situation. Where swelling soils are not recognized, improper building or structure design, faulty construction, inappropriate landscaping, and long-term maintenance practices unsuited to the specific soil conditions can become a continuing, costly problem. Design problems might include improper foundation loading, improper depth or diameter of drilled pier, insufficient reinforcing steel, and insufficient attention to surface and underground water. Miscalculating the severity of the problem for a particular clay soil can result in damage although some mitigating measures were taken.

Construction problems related to swelling soils include lack of reinforcing steel, insufficient or improperly placed reinforcing steel, mushroom-topped drilled piers, and inadequate void space between soils and grade beams. Allowing clays to dry excessively before pouring concrete and permitting the ponding of water near a foundation during and after construction also are contributing factors in swelling-soil related construction problems. Building without allowance for basement or ground floor movement in known swelling soils areas is a very common source of

property damage. Improper landscaping problems include inadequate management of surface drainage and planting vegetation next to the foundation so irrigation water enters the soil.

Impacts from expansive soil are summarized in Table 3-169.

**TABLE 3-169 EXPANSIVE SOILS EMAP IMPACT SUMMARY**

<b>Consideration</b>	<b>Description</b>
<b>General Public</b>	Risk is related to anything built on the ground that may be affected from slow movement. Homeowners, developers, and owners of public facilities and infrastructure. CGS reports that one in five people is affected by expansive soils.
<b>First Responders</b>	Some exposure exists to personnel performing routine duties after a specific site is impacted and unstable.
<b>Property</b>	Instances of property losses due to shrinking and swelling can cause major or long-term property damage impacting structural stability.
<b>Facilities and Infrastructure</b>	Instances of infrastructure damage due to shrinking and swelling can cause major or long-term structural damage.
<b>Economic</b>	None, or limited loss of facilities or infrastructure function or accessibility, and limited uninsured damages.
<b>Environment</b>	Limited impact anticipated to the environment other than changes in soil characteristics.
<b>Continuity of Government and Services</b>	None, or limited loss of facilities or infrastructure function or accessibility, or ability to provide services. May have limited power interruption if not adequately equipped with backup generation.
<b>Confidence in Government</b>	Characteristics of expansive soils such as duration and speed of onset result in limited response functions for government beyond building inspection and repair.
<b>Critical Assets</b>	Risk to any critical asset that does not have adequate mitigation actions taken during construction.

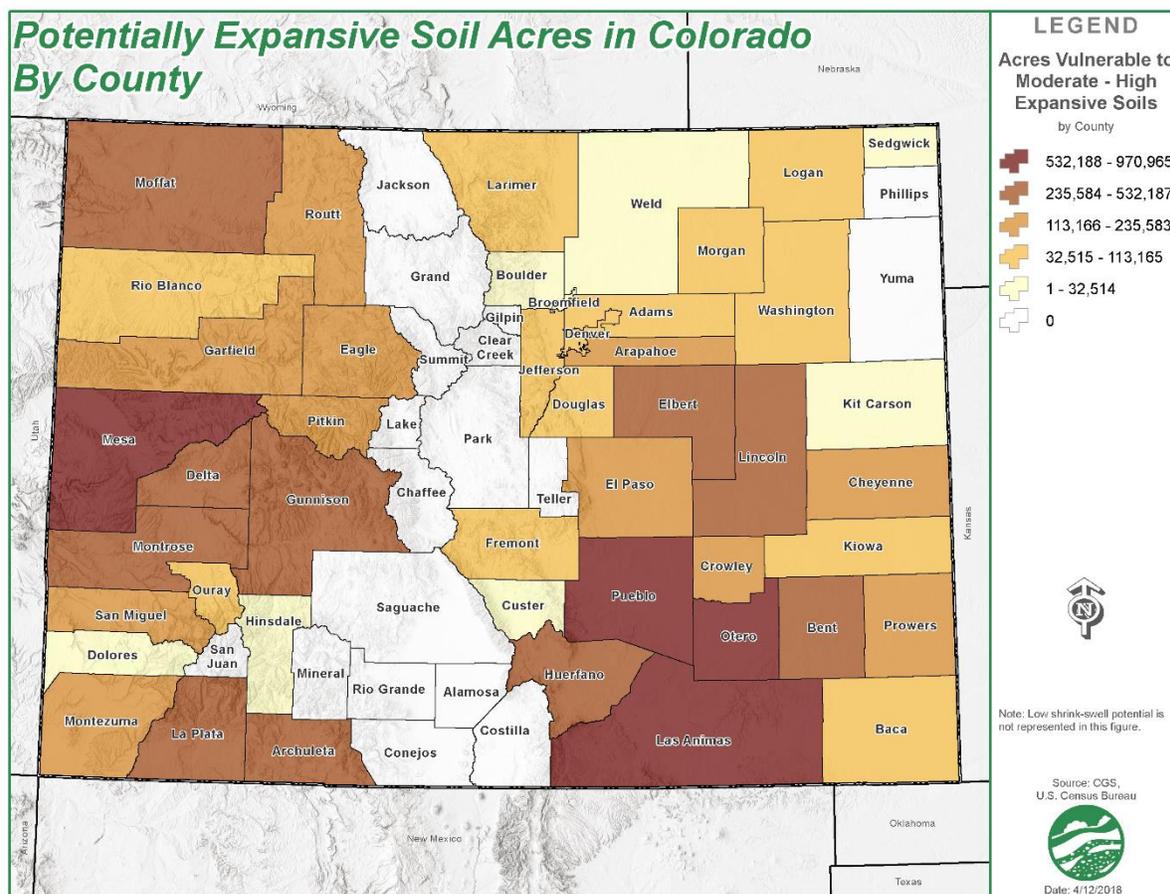
## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

Based on the distribution of expansive soils shown in Figure 3-88, about 15 percent of the state is located on soils with moderate or higher shrink-swell potential. Losses by jurisdiction are difficult to ascertain, but the likelihood of long-term damages to infrastructure and buildings will be greater where the shrink-swell potential is higher.

Figure 3-89 shows acres by county exposed to soils with moderate (3-6%) and above shrink-swell potential. The counties with the most exposure are Mesa, Pueblo, Las Animas, and Otero. Unfortunately, exposure does not relate well to vulnerability as high concentrations of development on small areas of highly expansive soils may cause more damage than occurs in the high exposure counties. For example, there are developments in Douglas County near

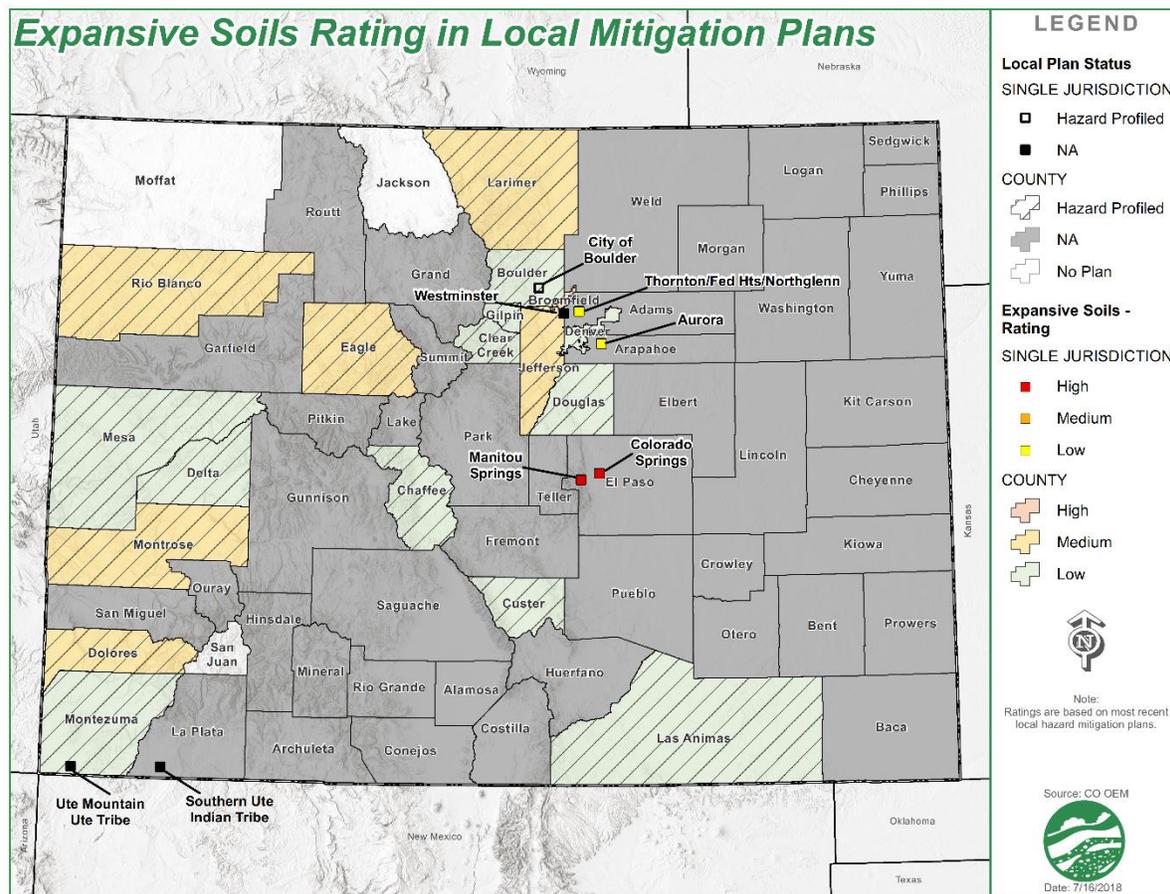
Roxborough State Park trending north into Jefferson County that have incurred residential and road infrastructure damage related to expansive soils, but they show only medium risk.

**FIGURE 3-89 EXPANSIVE SOILS AND HEAVING BEDROCK RATING IN COLORADO BY COUNTY**



Of the 69 local plans evaluated (including 61 counties, 2 Indian Tribes, and 6 cities), 21 local plans have profiled expansive soils and assigned a hazard significance rating for their jurisdictions, as shown in Figure 3-90. The City and County of Broomfield noted expansive soils as a high significance hazard and estimate that the entire jurisdiction, which is underlain by the Pierre Shale, is at risk of expansive soils damage. Property at risk includes approximately 23,000 housing units. This analysis indicates that many jurisdictions underlain by expansive soils are not addressing this hazard risk in their local mitigation plans.

**FIGURE 3-90 EXPANSIVE SOILS AND HEAVING BEDROCK HAZARD IN LOCAL MITIGATION PLANS**



## 8. FUTURE DEVELOPMENT

Development will continue to occur on soils with moderate or higher shrink-swell potential. Local or site-specific soil survey data should indicate that an area contains soil with a high shrink-swell potential. With appropriate mitigation taken through development techniques and code enforcement, potential losses from expansive soils should be minimized.

Table 3-171 summarizes the projected exposure to expansive soils by County based on hazard significance as rated in each jurisdiction’s local hazard mitigation plan compared to projected population and housing change. All other counties not listed are expected to have negligible exposure to expansive soils.

The Exposure Ratings in Table 3-171 are based on the methodology outlined in Figure 3-90. All counties that profiled expansive soils in their local plans are reviewed. Rated Risk is based on the overall hazard significance assigned to expansive soils in each local plan. County Growth Projection is taken as an average of population and housing change.

TABLE 3-170 FUTURE EXPANSIVE SOILS EXPOSURE PROJECTIONS

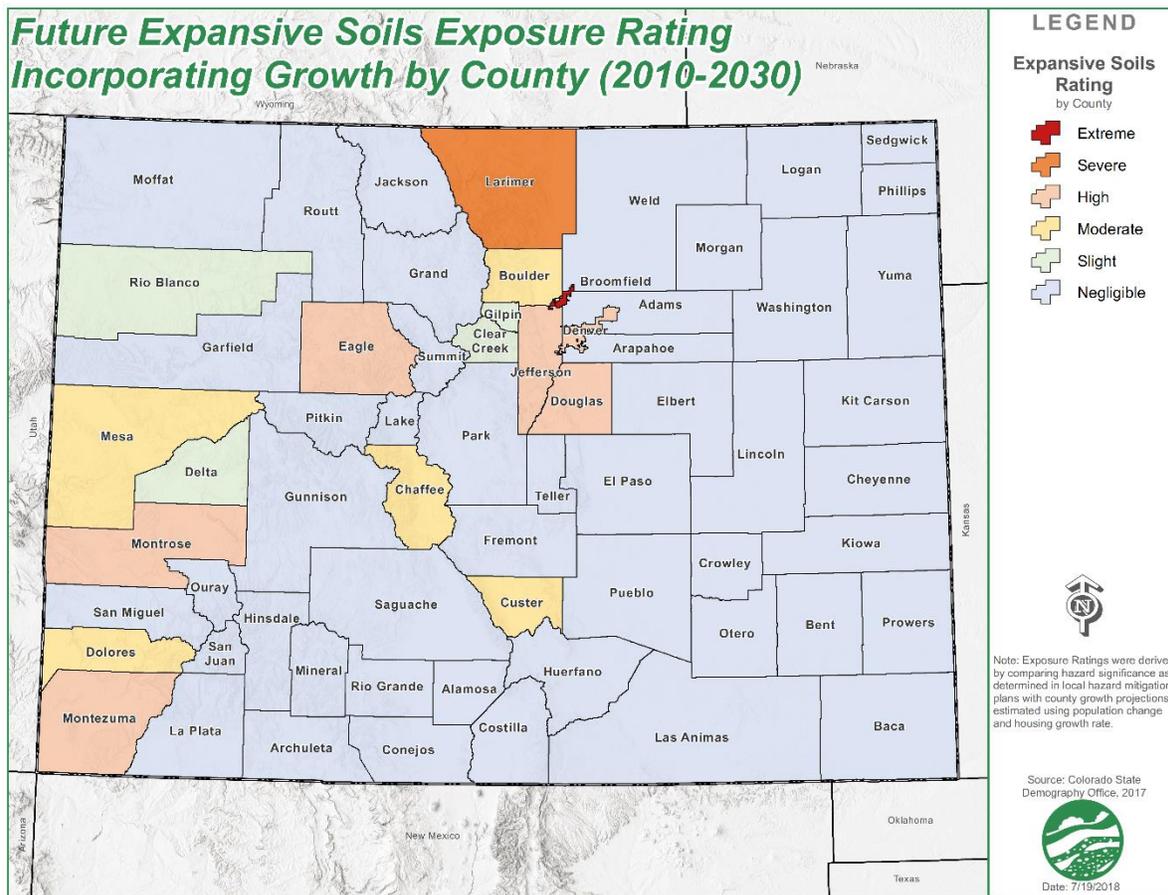
Future Expansive Soils Exposure Projections					
Rated Risk (Expansive Soils)		County Population Percent Change Projections, 2010 to 2030			
		-13% to 2%	3% to 17%	18% to 34%	35% to 89%
High ↑ Low	H	Moderate	High	Severe	Extreme
	M	Slight	Moderate	High	Severe
	L	Negligible	Slight	Moderate	High

TABLE 3-171 EXPANSIVE SOILS EXPOSURE PROJECTIONS, 2010 TO 2030

County	Rated Risk	Housing Percent Change	Population Change	Exposure Rating
Broomfield	H	78%	71%	Extreme
Larimer	M	47%	42%	Severe
Douglas	L	67%	44%	High
Denver	L	37%	42%	High
Eagle	M	56%	34%	High
Jefferson	M	30%	21%	High
Montezuma	L	37%	37%	High
Montrose	M	61%	30%	High
Boulder	L	37%	28%	Moderate
Chaffee	L	38%	29%	Moderate
Custer	L	41%	20%	Moderate
Dolores	M	4%	5%	Moderate
Mesa	L	38%	24%	Moderate
Clear Creek	L	20%	14%	Slight
Delta	L	35%	8%	Slight
Gilpin	L	12%	13%	Slight
Rio Blanco	M	10%	2%	Slight
Huerfano	L	13%	-1%	Negligible
Las Animas	L	23%	-9%	Negligible

Based on this assessment, Broomfield, Montrose, Eagle, and Larimer Counties are expected to have the highest exposure to expansive soils through 2030. This projection is further supported by the high level of housing growth expected according to housing percent change projections for these counties. Figure 3-91 displays this information in a statewide map.

FIGURE 3-91 FUTURE EXPANSIVE SOILS EXPOSURE PROJECTIONS



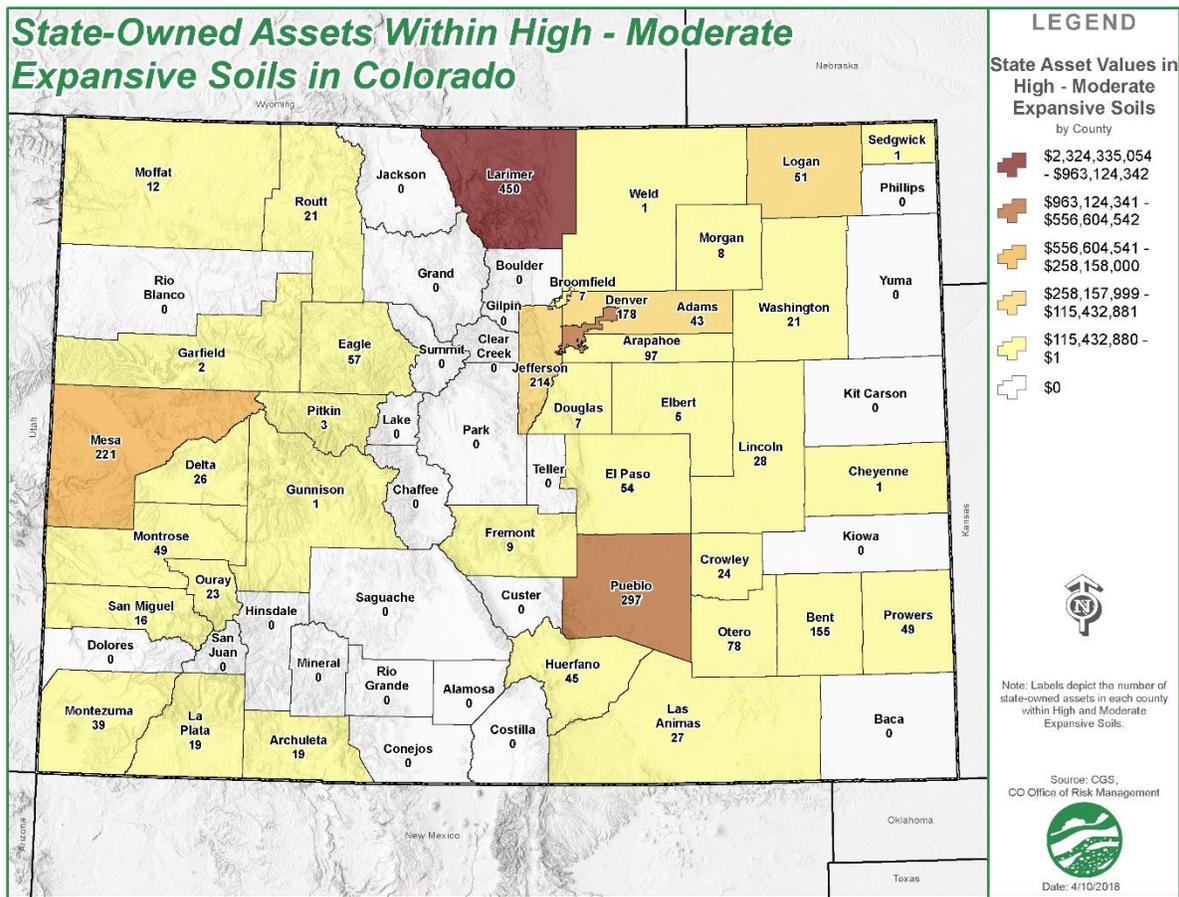
## 9. CLIMATE CHANGE

According to the best data available at the time of this plan update, the future impacts of climate change are not expected to directly influence future hazard events. However, the projected increase in frequency and duration of droughts due to climate change may cause an increase in the frequency of expansive soil events.

## 10. RISK TO STATE ASSETS

State assets exposed to a shrink-swell potential of soil greater than three percent are at risk of damage. There are 8,232 state assets with a value of \$20.2 billion exposed to soils with high, moderate, or low shrink-swell potentials at which expansion may cause damage to buildings, roads, and other structures. Figure 3-92 shows the value of state asset exposure to expansive soils by county.

FIGURE 3-92 STATE ASSET EXPOSURE TO EXPANSIVE SOILS BY COUNTY



There are 502 state assets with value of \$1.64 billion exposed to soils with high shrink-swell potential. Within the Moderate risk level, there are 1,856 state assets with a total value of \$4.14 billion.

Pueblo, Denver, Adams, and Logan Counties all have a high value of state assets exposed to soils with high potential for shrinking and/or swelling. Additionally, Larimer, Mesa, Jefferson, Bent, and Pueblo Counties have a high value of state assets exposed to soils with moderate potential for shrinking and/or swelling.

Although expansive soils cause millions of dollars of damage in Colorado every year, the Office of Risk Management (ORM) does not report any losses to state assets due to expansive soils in the past decade. Typically, state facilities are appropriately designed with a solid enough foundation to withstand swelling damage. As long as the expansive soil risk is accounted for with appropriately designed and loaded foundations, and appropriate landscaping techniques adjacent to foundations are employed, state assets will continue to experience relatively little loss to this hazard.

## 11. RESOURCES

- Colorado Geological Survey (CGS)  
<http://coloradogeologicalsurvey.org/geologic-hazards/swelling-soils/definition/> and  
<http://coloradogeologicalsurvey.org/geologic-hazards/heaving-bedrock/>
- Handy, Ryan Maye. (2016) Denver Post.  
<http://www.denverpost.com/2016/04/22/warnings-did-not-stop-development-in-colorado-springs-landslide-zone/>

# LANDSLIDES, MUD/DEBRIS FLOWS, AND ROCKFALLS



## 1. DEFINITION

In Colorado, geologic hazards such as landslide, mud/debris flow, and rockfall are having increasingly significant effects on people, property, infrastructure, and the natural environment. Although landslide mitigation is primarily a local responsibility, the magnitude of costs, as well as the extent of impacts can be so great that significant state support is often required. If present trends continue, expected losses could also become high enough to disrupt the state’s economic well-being. The impacts of landslides range from inconvenient debris removal, to life-threatening failure of a steep slope. Additionally, the interaction of geologic hazards with other events such as seismicity and flooding increases the overall threat to people, community services, and facilities. Colorado’s landslide exposure is directly related to the understanding of existing conditions, location of population centers, land use patterns, and mitigation efforts.

**Landslides** are the downward and outward movement of slopes composed of natural rock, soils artificial fills, or combinations thereof. Common names for landslide types include slump, rockslide, debris slide, lateral spreading, debris avalanche, earth flow, and soil creep.

**Mud/debris flows** are a mass of water and fine-grained earth materials that flows down a stream, ravine, canyon, arroyo, or gulch. If more than half of the solids in the mass are larger than sand grains, the event is called a debris flow.

**Rockfalls** are the falling of a newly detached mass of rock from a cliff or down a very steep slope.

Table 3-172 describes the hazard profile of landslides, mud/debris flows, and rockfalls, while also identifying the impacts for the State of Colorado.

TABLE 3-172 HAZARD PROFILE SUMMARY

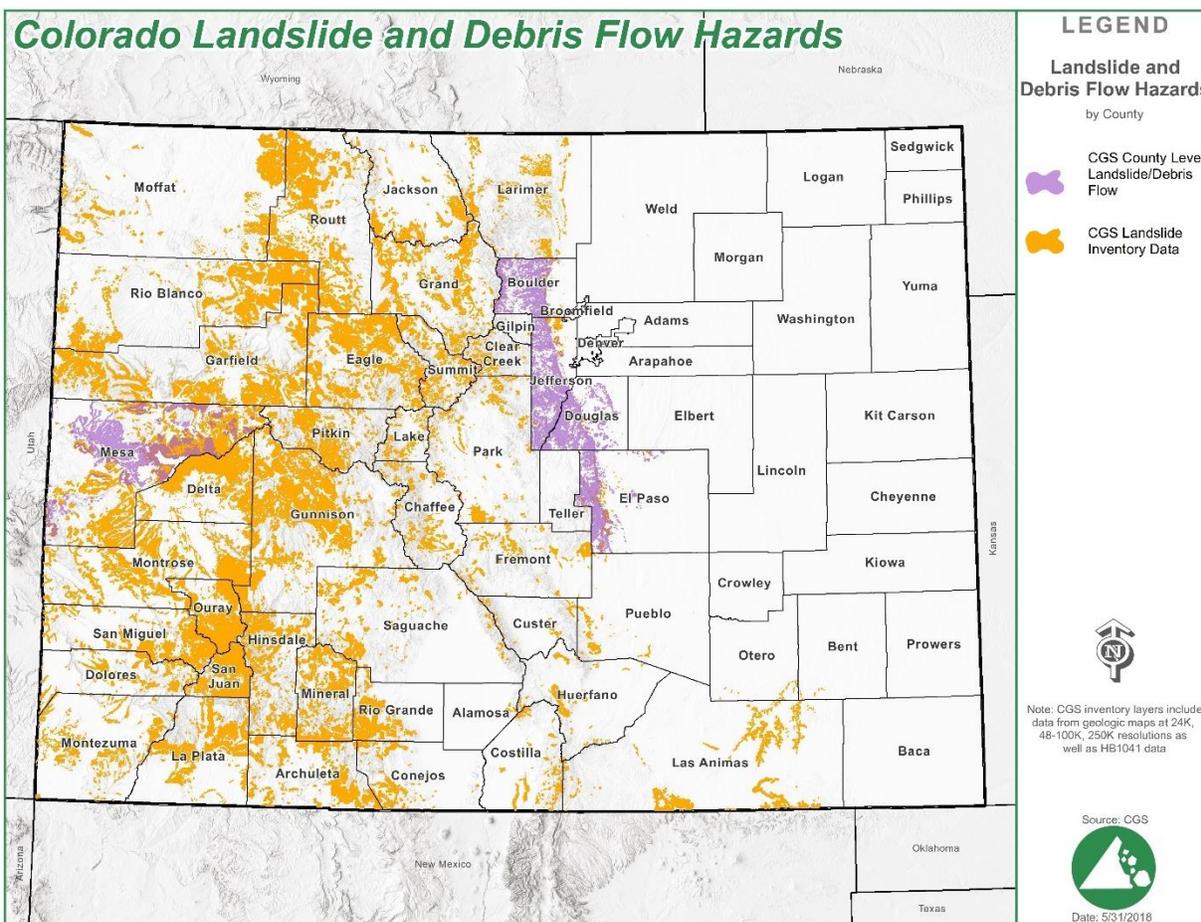
Consideration	Impact	Description
<b>Location</b>	Regional	Concentrated along the Front Range, central mountains, and western part of the state and typically associated with areas of significant slope, grade, or overall elevation change.
<b>Previous Occurrence</b>	Perennial	Land movement in the form of landslides, rockslides, and mud/debris flows are a natural and ongoing event. Human activity disrupting the land and periods of significant precipitation increases the likelihood of occurrence.
<b>Probability</b>	Expected	Natural and human-caused factors accounting for historic land movement is expected to continue.

Consideration	Impact	Description
Extent	Moderate	Most events will have limited property damage that does not threaten structural integrity; limited or no deaths and injuries; little or no impact to critical services or facilities. However, single events may have significant impact such as deaths or cause significant damage to public infrastructure.

## 2. LOCATION

Land movement related to landslides, mud and debris flows, and rockfalls occurs naturally across Colorado on an ongoing basis. Figure 3-93 below shows mapped landslide deposits based on a compendium of landslide GIS databases from the Colorado Geological Survey (CGS). Because this hazard is correlated with slope and elevation change, landslides, mud/debris flow, and rock fall events largely occur in the mountainous region from the Front Range to the Western Slope, with the threat generally increasing with slope and susceptibility.

FIGURE 3-93 LANDSLIDES AND DEBRIS FLOW HAZARDS IN COLORADO



### 3. EXTENT (MAGNITUDE/STRENGTH)

Many landslides in Colorado occur naturally; some are caused by human actions. Landslides can be massive or they may disturb only a few cubic feet of material. Landslides can recur time and time again in virtually the same location. Landslides occur when the stability of a slope changes and it loses equilibrium. The degree of steepness, soil moisture, soil thickness, the angle at which rock debris lies, and the presence of vegetation combine to produce a slope that will tend to stay put until something changes.

Often the determining factor in magnitude and frequency is elevated soil moisture or groundwater pressure as a result of heavy precipitation or melting snowpack that leads to soil saturation. Other mechanisms may also precipitate a slide, such as the loss of vegetation as after a wildfire, erosion of the toe of the slope by rivers, or earthquakes.

In addition to areas that are mapped as prone to landslides, post-wildfire burn areas are susceptible debris flow events. After a wildfire, the probability of a mud and debris flow increases significantly. The loss of the vegetative cover in burn areas increases run-off rates. The burned and barren slopes are more prone to erosion, resulting in increased peak discharge and bulking rates. Relatively frequent storm events of high intensity, and short durations, have the potential to cause unusually large mudflow events in post-wildfire conditions. The burning of organic material matter on the ground can: (1) create high temperatures on the ground causing hydrophobicity, which is the tendency of the soil to resist wetting or infiltration of moisture; (2) decrease the roughness of the ground; and (3) increase the erosive capacity of the soil. In 2012, an event such as this occurred after the Waldo Canyon Fire outside Colorado Springs. The 1994 debris flows on Storm King Mountain west of Glenwood Springs are other key examples.

### 4. PROBABILITY

Geologic hazards such as landslides, mud and debris flows, and rockfalls may be sporadic and somewhat unpredictable; however, geologic studies can determine the location of historic paths and deposits as a potential indicator of future events. Landslides, debris flows and rockfall occur somewhere in the state every year, although the number, frequency, and severity fluctuate. Precipitation, temperature variations, topography, and geology affect landslides. For example, landsliding in areas of Colorado intensified during the 1980s and late 1990s due to higher than normal annual precipitation levels. Typically there is a landslide and rockfall “season” in Colorado that occurs during springtime freeze-thaw cycles and increased precipitation as rain.

Known instabilities of hillsides and cliff faces can be instrumentally measured to determine if movement is occurring. These events can occur at any time of the year from almost any location along a slope. What is more predictable is that the natural and human-caused factors accounting for recent land movement are expected to continue.

## 5. PREVIOUS OCCURRENCES

Table 3-173 provides a summary of notable landslide, mud flow, and rockfall events in Colorado from the early 1900s to 2017.

**TABLE 3-173 NOTABLE LANDSLIDE, MUD/DEBRIS FLOW/ROCKFALL EVENTS IN COLORADO FROM 1903 TO 2017**

Year	Location	Description
1903	South of Glenwood Springs, Garfield County	Debris flow. Rainstorm caused mud and rock to cover a railroad line. Train wreck, one member of train crew killed.
1912	Brownville, Clear Creek County	Debris flows. Community engulfed and destroyed.
1914	Telluride, San Miguel County	Debris flows in Coronet Creek, flooding in San Miguel River.
1924	DeBeque Canyon, Mesa County	Landslide. Blocked Colorado River, resulted in forced relocation of a small community, highway and railroad.
1930s, 1940s	Marble, Gunnison County	Debris flows. Town nearly destroyed.
1937	Glenwood Springs, Garfield County	Debris flow. Much of town covered. Mud 2 feet deep.
1969	Telluride, San Miguel County	Debris flows in Coronet Creek, flooding in San Miguel River.
1976	Big Thompson Canyon, Larimer County	Interrelated landslide/ flood event. Mountain torrent flood.
1977	Glenwood Springs, Garfield County	Debris flow. Losses between \$500,000-\$1 million. 200 acres of residential district covered up to 14' deep.
1981-1982	Ouray, Ouray County	Debris flows in Canyon, Cascade, Portland Creeks, etc. Flooding in Uncompahgre River.
1983, 1984	Dowds Junction, Eagle County	Landslides blocked Interstate 70. Highway closed.
1984	15 Western Slope Counties: Delta, Dolores, Eagle, Garfield, Gunnison, Hinsdale, mesa, Moffat, Montrose, Ouray, Pitkin, Rio Blanco, Routt, Saguache, San Miguel counties.	Floods and landslides. Declared disaster areas by President (DR-719). Related to spring runoff. Over \$6.6 million spent in federal, state, and local disaster assistance.
1984	Grand Junction, Mesa County	Most homes in a subdivision affected. Some condemned.
1984	Approximately 7 miles SW of Telluride, San Miguel County	A 24-year old woman student at Western State College in Gunnison died a gruesome death after the car she and a friend were driving back to school washed off Highway 145 near Trout Lake Sunday [May 13th] afternoon and tumbled about 150 feet before coming to rest upside down in the mud.

Year	Location	Description
1985	Two Western Slope Counties (further details not available)	Floods and landslides. State emergency declaration. \$1.4 million in damages.
1996	Approximately 1 mile SW of Aspen, Pitkin County	Two debris flows between May 13 and May 14 left a parking lot covered with mud and debris about 5-ft thick. Six cars were virtually buried (4 were totaled). The mud and debris flowed into and structurally damaged the Music Hall and partially filled the large pond beside the Music Hall.
1997	I-70 near Palisade, Mesa County	Four-mile stretch of westbound Interstate 70 closed due to mudslide.
1999	El Paso County (and other counties for flood)	Floods, mudslides, landslides. Presidential disaster declaration. Estimated over \$30 million in infrastructure and property damage, including road repairs and twisted utility lines. Several residences condemned.
2003	Central Colorado River Basin west of Glenwood Springs, Garfield County	A large rock slide crashed into seven vehicles and covered the west bound lanes of Interstate 70 near the South Canyon exit, about five miles west of Glenwood Springs. A passenger in one vehicle was killed when a three-foot-diameter boulder caved in the passenger side of the vehicle. At least six other people were injured. The rock slide was initiated over 200 feet above I-70 and was likely caused by a cycle of freezing and thawing.
2004	Near Glenwood Springs, Garfield County	Massive rock slide closes Interstate 70. Between 30 and 40 large rocks tumbled onto the road, including boulders up to 8 feet by 10 feet.
2005	Grand Valley near Grand Junction, Mesa County	An Amtrak train derailed west of Grand Junction in Ruby Canyon after it hit a 12x12 foot boulder. Three engines and five cars went off the tracks. An Amtrak spokesman said the accident injured four crew and two passengers "in the category of bumps and bruises."
2006	I-70 Mountain corridor, Garfield County	Rockslide in canyon kills 1, closes Interstate 70
2006	Jefferson County	Rain that fell at nearly 2 inches/hr. destroyed buildings, devastated highways and caused massive mud, tree and boulder slides.
2006	Northwestern San Juan Mountains, southwest of Ouray County	A rockslide fell onto Camp Bird Road just south of Ouray and killed the driver of a Jeep when a boulder crashed through the roof of the vehicle. A passenger received minor injuries.
2007	Alpine, Chaffee County	Ninety-eight people evacuated. \$33,000 in infrastructure damage. Homes filled with mud, propane tanks pushed off foundations.
2008	Archuleta County	Xcel Energy pipeline was ruptured along the East Fork Road

Year	Location	Description
2009	Buttermilk Ski Area, Pitkin County	Landslide
2010	Glenwood Springs, Garfield County	Rockslide closes 17-mile stretch of Interstate 70
2011	Red Rocks Park, Jefferson County	Seven injured in rockfall at Red Rocks park
2012	South of Aspen, Pitkin County	1 hiker dead, 1 injured after rock slide
2013	Manitou Springs, El Paso County	At least one person is dead and three went missing in Manitou Springs on August 9th, 2013, after a mudslide and flash flooding event caused massive damage in an area burned by the Waldo Canyon wildfire from 2012.
2013	Boulder County, El Paso, San Miguel	Mudslides damage property and kill 3 (1 in Jamestown and 2 in Boulder) in aftermath of catastrophic September flooding
2013	Chaffee County	5 hikers killed by rockslide near Mt. Princeton
2013	US Highway 550, between mile markers 84 and 86, about four to six miles north of the summit of Red Mountain Pass, San Juan County	Mudslides trapped three motorists and closed Red Mountain Pass for five hours. A total of three slides were reported
2014	Mesa County	A "rock avalanche" moved almost 3 miles down the valley of West Salt Creek, burying almost 600 acres of land under 38 million yd <sup>3</sup> of debris. Highest reported speed was 140 mph. 3 men were killed.
2015	El Paso County	Over 30 homes were affected, causing over \$7 million in damage. FEMA issued a Major Disaster Declaration and is undergoing a buyout process for residents.
2016	Delta County	More than 100 tons of debris tumbled onto Colorado Highway 133. The highway experiences over 1,100 vehicles per day, of which six percent are trucks. The slide resulted in a multi-day road closure, with a suggested detour that added up to 3 hours of travel.
2016	Glenwood Canyon, Garfield County	A massive rock slide on I-70 in Glenwood Canyon forced thousands of motorists onto a 146-mile detour. Roadways were damaged from unstable rocks on February 15, 2016, at about 9pm, just west of the Hanging Lake Tunnel. Boulders tumbled into three vehicles and the rocks gouged holes in the asphalt, damaging guardrails. No injuries were reported.

Source: Colorado Geological Survey, CDOT, Denver Post, USA Today

### 5.1 CASE HISTORY

**Jefferson County- March 1974:** A boulder the size of a small car hurtled down the steep west side of the Lyons hogback in Jefferson County. It bounced into a new subdivision and stopped after penetrating a wall in the back of a 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.

**Routt County- Mid to Late 1990s:** A technique called “long-wall mining” is often the most economical method for underground extraction of coal. In the mid to late 1990s, a long-wall mining operation at the Foidel Creek Mine was extended below the surface exposure of a Twenty Mile Sandstone. This rock face is comprised of a 100-foot thick, massively bedded, sandstone cliff that is exposed on the slope above Routt County Road 27. The strain from the ground subsidence fractured and broke almost 1½ miles of the exposed sandstone cliff, resulting in several large rockfall events with some rock blocks the size of small homes. Mitigation techniques included introducing a milelong span of ditches and berms that were constructed on the slope above Routt County Road 27.

**Jefferson County – June 2005:** A high-profile rockslide event occurred on June 21, 2005 along U.S. Highway 6 in Clear Creek Canyon, approximately 10 miles west of Golden, CO. Two-thousand (2,000) cubic yards of rock slid from a pre-existing road cut on the north side of the road and completely covered the road. Two tractor-trailers were caught in the rockslide and were pushed off the road by the debris. The tractor-trailers were totaled, but only minor injuries were sustained by the drivers. The road was closed until the end of August 2005, marking the longest full road closure in Colorado’s history.

**Town of Alpine - July 2007:** Following a week of daily low intensity rainstorms, a heavy rainstorm that dumped approximately 3 inches of rain between 6:30 and 7:30 pm on July 21, 2007 mobilized several debris flows (“mudslides”) in Weldon Gulch that impacted the town of Alpine, Colorado. Several structures, roads, and utilities were damaged and two nearby county roads had to be closed. The town and upstream communities were subsequently evacuated. Although no injuries or loss of life resulted, approximately 65 people were directly affected by the debris flow.

**Glenwood Canyon, Garfield County - March 2010:** Early on the morning of March 8th, 2010, a large rockfall in Glenwood Canyon shut Interstate 70, Colorado’s primary east-west thoroughfare. Twenty boulders, ranging from 3 feet to 10 feet in diameter, fell on the interstate. As they fell, these heavy rocks punched many holes through the roadway, including one that was 20 feet by 10 feet. The largest boulder weighed 66-tons. Colorado Department of Transportation crews were able to restore one lane in each direction within four days. Between maintenance, traffic control and repairs, the total cost of the incident was \$2.2 million.

**Boulder County – July 2011:** After the 2010 Four Mile Canyon fire ravaged over 6,400 acres in Boulder County, several models suggested probabilities of debris-flow occurrence greater than 60 percent, and many more had probabilities greater than 45 percent<sup>1</sup>. Two episodes of post-fire

---

<sup>1</sup> Ruddy, B.C., Stevens, M.R., Verdin, K.L., and Elliott, J.G., 2010, Probability and volume of potential post wildfire debrisflows in the 2010 Fourmile burn area, Boulder County, Colorado: U.S. Geological Survey Open-File Report 2010-1244, 5 p

debris flows were documented in the Fourmile Canyon burn area. On July 7, 2011, four reported debris flows occurred at mile marker 8 and beyond, in Fourmile Canyon. On July 13, 2011, six roads (including Four Mile Road and Gold Run at Dixon) were closed due to debris flows. The 2010 total estimated costs for debris-flow mitigation in the Fourmile Canyon wildfire-burned area was \$1,809,540<sup>2</sup>.

**Mesa County – May 2014:** On May 25, 2014, the longest landslide in Colorado’s historical record occurred in west-central Colorado, six miles southeast of the town of Collbran in Mesa County. The 2.8-mile-long slide covered a square mile of the West Salt Creek valley and resulted in three fatalities. Local seismometers recorded a magnitude 2.8 earthquake from the event with a seismic wave train duration of approximately 3 minutes. The toe of the landslide came within 200 ft. of active gas-production wellheads and the loss of irrigation ditches and water impacted local ranches and residents<sup>3</sup>.

## 6. IMPACT ANALYSIS

Landslides, mudslides, debris flows, and falling rocks damage and destroy homes, roads, railroads, pipelines, electrical and telephone lines, mines, oil and gas wells, commercial buildings, canals, sewers, dams, bridges, seaports, airports, forests, parks, and farms. Earth movement hazards will also cause significant costs and delays to travelers, workers, the delivery of services, and local economies. In some instances, entire communities have been impacted. The 19th century mining camp of Brownsville just west of Silver Plume was buried beneath a rain triggered landslide that became a debris flow. Landslides occur commonly throughout Colorado, and the annual damage is estimated to be in the millions of dollars.

Mud/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 mountainous areas, portions of valleys have been eroded to a depth of several feet by the flow process.

Although rare, deaths and injuries occur from landslides, rockfall and debris flow. Table 3-174 below shows that, between 1960 and 2017, 18 deaths and 24 injuries were reported in Colorado from these significant landslide, mud/debris flow, and/or rockfall hazard events. Garfield County, home to the rugged Glenwood Canyon, shows the most reported events along with Mesa County.

---

<sup>2</sup> Boulder County Fourmile Emergency Stabilization Team Report, 2011, p. 9

<sup>3</sup> White, Jonathan L., Matthew L. Morgan, and Karen A. Berry. "Bulletin 55 - The West Salt Creek Landslide: A Catastrophic Rockslide and Rock/Debris Avalanche in Mesa County." Bulletin. Golden, CO: Colorado Geological Survey, 2015. Bulletin 55.

TABLE 3-174 LANDSLIDE, MUD/DEBRIS FLOW, AND ROCKFALL EVENTS THAT LED TO INJURIES AND DEATHS 1960-2017

County	Number of Events	Deaths	Injuries
Boulder	1	3	0
Chaffee	1	5	0
El Paso	1	1	3
Garfield	2	3	6
Jefferson	1	0	7
Mesa	2	3	6
Ourray	1	1	1
Pitkin	1	1	1
San Miguel	1	1	0
<b>TOTAL</b>	<b>11</b>	<b>18</b>	<b>24</b>

Source: CGS, CDOT, NOAA's NCEI, SHELDUS

Many of Colorado's landslides occur along transportation networks because soil and rock along the transportation corridor has been disturbed by roadway construction. Construction along roads can occur with or without proper landslide hazard mitigation procedures. The typical costs to maintain, cleanup, monitor, and repair roads and highways from landslide, rockfall and debris flow activity is discussed further in the Risk To State Assets section.

Landslide events occurring on, or near, Colorado railways always have the potential to significantly impact rail transportation in Colorado, as there is no cost-effective way of routing railroads around landslides, especially rockfall. Some tunnels exist through hazardous areas, but they are extremely expensive to build. Railroads are routinely subject to rockfall, and (or) rock slides, and the railroads have therefore devised various ways of dealing with this hazard.

Approaches include the use of small scout vehicles that sweep the tracks for rocks ahead of a moving train, and trip-wires that indicate a rockfall or rock slide in particularly susceptible areas known to cause ongoing problems. Railways are very vulnerable to landslides.

Although the effects can be documented, it is difficult to acquire costs from landslide damage to railways, as costs are not normally provided to the public. Additional information on impacts from this hazard is provided in Table 3-175.

TABLE 3-175 LANDSLIDE, MUD/DEBRIS FLOW, ROCKFALL EMAP IMPACT SUMMARY

Consideration	Description
<b>General Public</b>	At risk are people in areas burned by wildfires, motorists along highways, tourists and recreationists on or near steep slopes. Possible deaths, injuries, and property loss.

Consideration	Description
<b>First Responders</b>	Some exposure exists to personnel performing routine duties when event occurs; some post-event duties may expose personnel to areas of geologic instability.
<b>Property</b>	Limited damage to personal property occurs from this event. Occasional vehicles are struck by falling rocks or debris. Post-precipitation events in burn areas have resulted in active debris flows causing significant damage.
<b>Facilities and Infrastructure</b>	Transportation infrastructure is typically the most impacted resource in Colorado from landslides and rockfalls though residential structures have also been impacted. State assets include \$627 million in potential landslide areas.
<b>Economic</b>	With a large enough event, closure of transportation routes may negatively impact Colorado's tourism industry.
<b>Environment</b>	Events may expose addition earth that is prone to the same movement, perpetuating the hazard.
<b>Continuity of Government and Services</b>	None or limited loss of facilities or infrastructure function or accessibility or ability to provide services.
<b>Confidence in Government</b>	Duration of response and repair to closed or blocked roadways is a visible and often reported in the media which may lead to public perceptions of capability.
<b>Critical Assets</b>	Limited buildings and equipment are exposed to this hazard but damage to such should not typically amount to disruption or debilitating damage.

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

Counties in the central and western mountains of Colorado have a significantly higher number of acres vulnerable to landslide, mud/debris flow, and rockfall than the rest of the state. Based upon a recent (2018) review of local mitigation plans, there is a reasonably good correlation between hazard rank for landslides, mud/debris flows, and rockfalls with counties that address these hazards within their local mitigation plan. There are also multiple areas of opportunity to close gaps. The recent review indicates that 54 plans (out of 69 total) include a landslide hazard chapter. Of these plans, landslide was received a “High Hazard” significance rating 12 times, “Medium Hazard” 20 times, and “Low Hazard” 22 times. Landslides, mud/debris flows, and rockfall are considered one of the top four hazards facing the City of Manitou Springs (El Paso County), as well as Eagle, Grand, Mesa, Ouray, Pitkin, San Miguel counties. Using information taken from local hazard mitigation plans, Table 3-176 below identifies property and critical facility exposure for the counties that include landslide in the top four highest risk hazards.

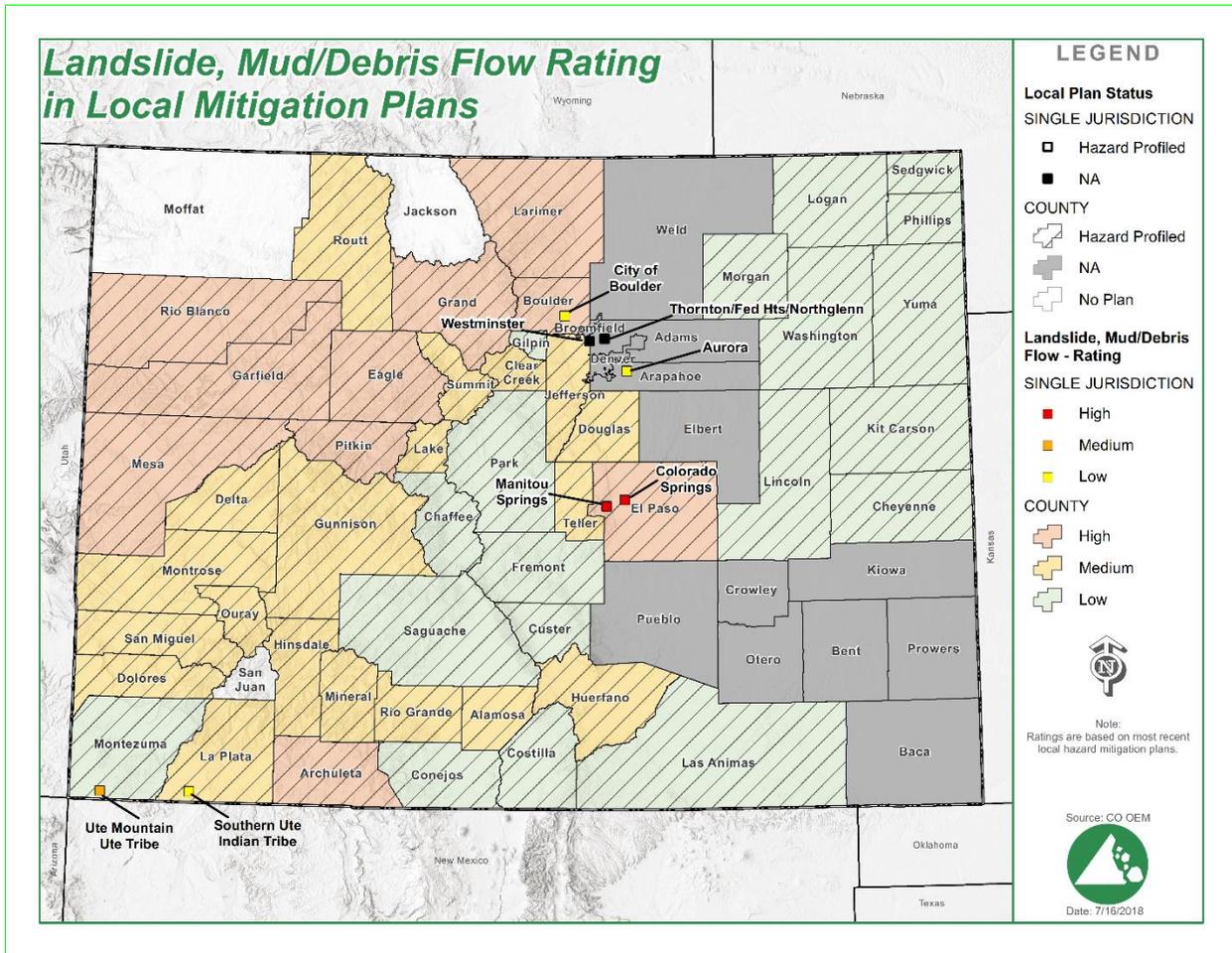
TABLE 3-176 LANDSLIDE VULNERABILITY FOR COUNTIES WITH HIGH RISK IN LOCAL PLANS

County	Structures Exposed to Landslide Hazard	Critical Facilities Exposed to Landslide Hazard	Total Loss Estimation
<b>Eagle</b>	10,279	No specifics	\$12.89 billion
<b>Grand</b>	326	4	\$117.3 million
<b>Mesa</b>	No specifics	No specifics	No specifics
<b>Ouray</b>	163	2	\$102.3 million
<b>Pitkin</b>	No specifics	No specifics	No specifics
<b>San Miguel</b>	No specifics	7	No specifics
<b>City of Manitou Springs (El Paso)</b>	820 parcels	13	\$132.5 million

Based on the information provided above, Eagle County has the greatest number of structures/critical facilities at risk to landslide hazard events. In terms of values exposed, Eagle County has significantly more assets at risk, totaling close to \$13 billion.

Figure 3-94 highlights the hazard ranking and varying degrees of significance across the state.

FIGURE 3-94 LANDSLIDE HAZARD RATING IN LOCAL HAZARD MITIGATION PLANS



## 8. FUTURE DEVELOPMENT

Future development could be vulnerable to landslides, as well as the infrastructure required to support this growth, if not accounted for in siting and design. Growth in many areas in mountain counties are constrained by federal lands and this sometimes forces growth onto alluvial fans and hillsides that might be prone to landslides, debris flow, mudslides, or rockfall. In addition, there are continuing pressures for residential and business growth in areas potentially susceptible to landslides and related hazards due to the beauty and seclusion of many of the areas. Coupled with the state's surge in population growth and the correlated growth in the mountain tourism industry, increased traffic is occurring in the mountainous areas, notably along the Interstate 70 corridor and US 6 in Clear Creek Canyon. In general, this exposes more vehicles and people to rock fall hazards.

Table 3-177 presents the method used to assign overall risk categories for landslide hazards by county, based on a combination of projected percent change in population from 2010-2030 and the counties' assessed risk as noted in each local hazard mitigation plan. Counties with high

projected percent increases in population implies growth in housing and related infrastructure; those counties and counties with high landslide risk per their local hazard mitigation plans face the most overall risk in the future (summarized under Table 3-178).

TABLE 3-177 FUTURE LANDSLIDE RISK CATEGORIZATION METHOD

Future Landslide Risk Categorization Method					
		County Population Percent Change Projections, 2010 to 2030			
Local HMP Risk Categorization (Landslide)		-13% to 2%	3% to 17%	18% to 34%	35% to 89%
<b>Extreme Risk</b>  <b>Negligible Risk</b>	High	Moderate	High	Severe	Extreme
	Medium	Slight	Moderate	High	Severe
	Low	Negligible	Slight	Moderate	High
	Not Applicable (N/A)	N/A	N/A	N/A	N/A

TABLE 3-178 COMBINED FUTURE LANDSLIDE RISK RANKING

County	Risk Categorization from Local HMP	Population Change Percent (2010-2030)	Growth Risk Rating
El Paso	H	36%	Extreme
Garfield	H	38%	Extreme
Archuleta	H	40%	Extreme
Larimer	H	42%	Extreme
Pitkin	H	18%	Severe
Mesa	H	24%	Severe
Boulder	H	28%	Severe
Grand	H	32%	Severe
Eagle	H	34%	Severe
Routt	M	40%	Severe
Summit	M	41%	Severe
La Plata	M	42%	Severe
Douglas	M	44%	Severe
San Miguel	M	59%	Severe
Jefferson	M	21%	High
Alamosa	M	22%	High
Teller	M	25%	High
Gunnison	M	26%	High

County	Risk Categorization from Local HMP	Population Change Percent (2010-2030)	Growth Risk Rating
Hinsdale	M	29%	High
Montrose	M	30%	High
Montezuma	L	37%	High
Rio Blanco	H	2%	Moderate
Dolores	M	5%	Moderate
Delta	M	8%	Moderate
Clear Creek	M	14%	Moderate
Mineral	M	16%	Moderate
Ouray	M	17%	Moderate
Lake	M	17%	Moderate
Custer	L	20%	Moderate
Lincoln	L	21%	Moderate
Chaffee	L	29%	Moderate
Park	L	34%	Moderate
Rio Grande	M	-5%	Slight
Huerfano	M	-1%	Slight
Washington	L	5%	Slight
Fremont	L	5%	Slight
Yuma	L	7%	Slight
Costilla	L	7%	Slight
Saguache	L	9%	Slight
Gilpin	L	13%	Slight
Logan	L	14%	Slight
Morgan	L	16%	Slight
Las Animas	L	-9%	Negligible
Phillips	L	-3%	Negligible
Sedgwick	L	-3%	Negligible
Kit Carson	L	-1%	Negligible
Conejos	L	1%	Negligible
Cheyenne	L	2%	Negligible
Baca	NA	-13%	N/A
Kiowa	NA	-8%	N/A
Jackson	NP	-7%	N/A
Otero	NA	-7%	N/A
Prowers	NA	-5%	N/A
Bent	NA	-5%	N/A
Moffat	NP	-3%	N/A
San Juan	NP	5%	N/A
Crowley	NA	5%	N/A
Pueblo	NA	20%	N/A
Arapahoe	NA	36%	N/A

County	Risk Categorization from Local HMP	Population Change Percent (2010-2030)	Growth Risk Rating
Denver	NA	42%	N/A
Adams	NA	48%	N/A
Broomfield	NA	71%	N/A
Weld	NA	81%	N/A
Elbert	NA	89%	N/A

H = High; M = Medium; L = Low; NA = Not Applicable; NP = No Plan

El Paso, Garfield, Archuleta, and Larimer Counties have the highest growth risk ratings based on both high risk noted in their local hazard mitigation plans as well as large percentages of projected population growth (ranging from 35% to 42%).

## 9. CLIMATE CHANGE

Climate change projections for more intense precipitation coupled with cycles of drought and/or wildfire events have the potential to increase landslide incidence. The following table presents a breakdown of these projected changes in terms of the hazard’s location, extent/intensity, frequency, and duration:

TABLE 3-179 CLIMATE CHANGE IMPACTS

Sector	Update Highlight
Location	Landslides, mud/debris flows, and rock falls are only a hazard in mountainous regions of the state. The area at risk to these hazards is not projected to change due to climate variability.
Extent / Intensity	There is no projected change in landslide extent or intensity due to climate variability.
Frequency	Flood events are projected to occur more frequently because of changing climate conditions, increasing the frequency of landslides. The increased frequencies of wildfires (often correlated to drought episodes and climate variability) will also contribute to landslides.
Duration	N/A

## 10. RISK TO STATE ASSETS

Due to this hazard being associated with slope change, state assets at risk tend to be located in the mountainous areas of the state. The latest 2017 state assets dataset for Colorado was queried spatially against the various landslide and geologic data layers. Overall, the following landslide hazard layers were used in the analysis: CGS compiled landslides from 24K scale maps, CGS compiled landslides from 48-100K scale maps, CGS compiled landslides from 250K scale maps, CGS compiled landslides from HB1041 maps, landslide and related geology hazards from Mesa County, landslide and debris flow hazards from Jefferson County, landslide

and debris flow hazards from Boulder County, landslide and related geology hazards from El Paso County, and landslide and related geology hazards from Douglas County.

Overall, there are 409 state assets with potential landslide exposure with a total value of over \$627 million. Of these state assets, the majority fall within Mesa County. Besides Mesa, Mineral and Rio Grande Counties both could incur over \$20 million in state asset losses due to landslide hazards, although Eagle County has the highest number of assets at risk after Mesa County. The potential loss summaries by county are presented in Table 3-180 below, in descending order of losses, and displayed in map form in Figure 3-95:

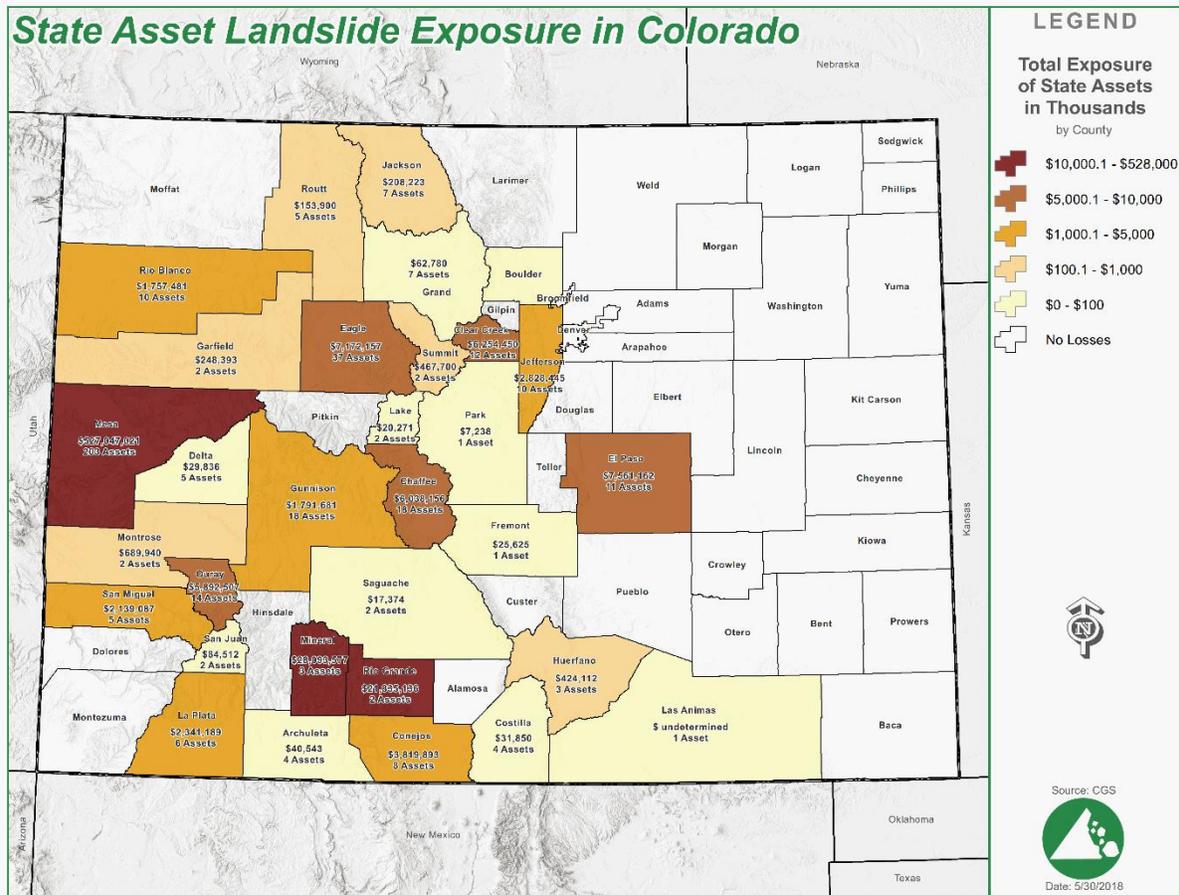
**TABLE 3-180 STATE ASSETS LANDSLIDE HAZARD EXPOSURE BY COUNTY**

<b>County</b>	<b>Total State Assets Value</b>	<b>State Assets Count</b>
<b>Mesa</b>	\$527,047,021	203
<b>Mineral</b>	\$28,093,577	3
<b>Rio Grande</b>	\$21,835,136	2
<b>El Paso</b>	\$7,561,162	11
<b>Eagle</b>	\$7,172,157	37
<b>Clear Creek</b>	\$6,254,450	12
<b>Chaffee</b>	\$6,038,156	18
<b>Ouray</b>	\$5,892,507	14
<b>Conejos</b>	\$3,819,893	8
<b>Jefferson</b>	\$2,828,445	10
<b>La Plata</b>	\$2,341,189	6
<b>San Miguel</b>	\$2,139,087	5
<b>Gunnison</b>	\$1,791,681	18
<b>Rio Blanco</b>	\$1,757,481	10
<b>Montrose</b>	\$689,940	2
<b>Summit</b>	\$467,700	2
<b>Huerfano</b>	\$424,112	3
<b>Garfield</b>	\$248,393	2
<b>Jackson</b>	\$208,223	7
<b>Routt</b>	\$153,900	5
<b>San Juan</b>	\$84,512	2
<b>Grand</b>	\$62,780	7
<b>Archuleta</b>	\$40,543	4
<b>Costilla</b>	\$31,850	4
<b>Delta</b>	\$29,836	5
<b>Fremont</b>	\$25,625	1
<b>Lake</b>	\$20,271	2
<b>Boulder</b>	\$17,374	2
<b>Saguache</b>	\$17,374	2

County	Total State Assets Value	State Assets Count
Park	\$7,238	1
Las Animas	**	1
<b>TOTAL</b>	<b>\$627,101,611</b>	<b>409</b>

\*\* Asset value not determined

FIGURE 3-95 STATE ASSETS LANDSLIDE EXPOSURE



There are a number of Colorado communities that have developed at the mouth of mountain canyons where the gradient of a stream abruptly decreases. The geographic extent of landslides, rockfalls, and mud/debris flows tend to associate with areas of significant elevation change over a short distance, although mud/debris flows have the capacity to move significantly further down channel than landslides and rockfalls.

Generally, there are many fewer state assets (buildings and related structures) at risk to the geologic characteristics of landslides and rockfalls than mud/debris flow areas. However, state assets may be more vulnerable to landslide related hazards than these maps indicate if the geographic extent overlaps with wildfire burn scars. The change in soil stability and loss of

vegetation has resulted in significant mud/debris flows in the Hayman, Four Mile, High Park, and Waldo Wildfire burn scars. Another exacerbating event that increases risk of this hazard to state assets is saturated soil, heavy rain, or rapid snowmelt.

Many state highways run along river valleys at the base of steep rock faces and talus slopes resulting in an increased vulnerability to these state assets from landslides, mud/debris flows, and rockfalls. Landslide and especially rockfall hazard occurs along cut slopes in mountainous regions. General slope instability and/or the exacerbating conditions mentioned prior may loosen rock that falls on and damages state highways.

In 2015 the Colorado Department of Transportation (CDOT) published a white paper titled “The Economic Impacts of Geologic Hazard Events on Colorado Transportation Facilities” (CDOT 2015). The document presents a detailed quantitative assessment of how rockfalls, rockslides, landslides, debris flows, and sinkholes affect the state’s transportation infrastructure. The statewide impacts from geologic hazards along CDOT highways can be grouped into two categories: (1) direct costs incurred by CDOT for maintenance labor and equipment, engineering, and construction activities and (2) indirect costs including but not limited to property damage, injury or fatalities, traveler delay, lost productivity, loss of revenue to businesses and communities, and environmental impacts. Based on a review of CDOT program activities, the estimated annual direct costs to the department from geologic hazard events is in the range of \$17M to \$20M, which includes the Maintenance Program. From 2010 to 2015, CDOT Maintenance staff input an average of 8,500 work orders for geologic hazard related response activities with an average cost of about \$600 per work order. This resulted in over \$4.5 to \$5.5M of annual expenses for high frequency but low-cost events. Based on a historical data review, the study estimates 50 geologic hazard events per year that require support above the CDOT maintenance level for non-routine work. Of these, approximately 20 percent have an indirect cost related to traffic impacts, property damage, and potentially injury.

The report goes on to summarize the economic impacts of three different events that occurred in 2014 and range from short to long term closures and with varying economic impacts. In 2014, the economic impact (including direct and user costs) from geologic hazards on CDOT roadways was estimated to be \$30M. Older historical data for significant events on interstate highways indicate the 2014 estimate may be conservative when high volume roadways are impacted or there are an increased number of larger events in a single year. The economic impacts of the three profiled events are presented in the table below and then described in the following text.

TABLE 3-181 DIRECT AND INDIRECT COSTS OF GEOHAZARDS EVENTS

Hazard Event	CDOT Cost	User Cost	Total Cost
<b>I-70 Eagle</b>	\$ 7,794	\$ 1,060,772	\$ 1,068,566
<b>US550 Red Mountain Pass</b>	\$ 2,832,411	\$ 6,205,596	\$ 9,038,007
<b>US24 (2 dates in 2014)</b>	\$ 331,582	\$ 159,941	\$ 491,523
<b>Combined Costs</b>	\$ 3,171,787	\$ 7,426,309	\$ 10,598,096

Source: CDOT, 2015

**I-70 MP 152.4 DEBRIS FLOWS – JULY 29, 2014**

A debris flow closed the west bound lanes of I-70 east of Eagle. Approximately 300 vehicles travelling on I-70 were reported to have been stuck in the slide debris with the last car removed about 2 hours after the event occurred. The delay cost from the incident, including initial stoppage and detour delay, is estimated to be approximately \$13,000. Further, operating and environmental costs total approximately \$8,000. The most significant component of the cost is the property damage, estimated to be over a million dollars, bringing the total cost of the incident to \$1,060,722.

**US550 RED MOUNTAIN PASS RUBY WALLS ROCKSLIDE – 2014**

On January 12, 2014, a large rock slide occurred above MP 89.9 on US 550, south of Ouray, Colorado and on the north side of Red Mountain Pass. Based on Federal-aid Highway Emergency Relief documents prepared by CDOT Region 5, the total estimated project expenses in 2014 were approximately \$2.75M. The incident is estimated to have impacted approximately 37,647 vehicles. While many of the cars impacted simply deferred making their trip, the cars and trucks that detoured around the Red Mountain Pass added approximately 168 miles to their trip. The delay cost from the incident, including initial stoppage and detour delay, is estimated to be approximately \$3.2M. Operating and environmental costs total approximately \$2.9M. Further, three vehicles were damaged in the incident, bringing the total direct user cost of the incident to approximately \$6.2M.

**US24 MP 148.9 ROCKFALL – APRIL AND DECEMBER 2014**

A rockfall event closed US 24 at MP 148.9 for 16 hours starting at 2:30 a.m. on April 22, 2014. The event deposited an estimated 150 tons of rock onto the highway and resulted in significant damage to the roadway. On December 27, 2014, a second rockslide occurred at the same location resulting in more highway damage and several days of closure for debris removal and roadway repair work. The total user cost for the April incident is \$48,248. Although it spanned 16 hours on a Tuesday, the total cost is reduced mainly because 2,207 vehicles were impacted, the detour was twenty miles, and there was only one property damage. Since this was a multi-day event, 50 percent of cars and 100 percent of trucks are assumed to use the detour,

resulting in approximately 6,866 affected vehicles. There was also one case of property damage in this incident. The total user cost is approximately \$111,693, largely made up by delay and operating costs

For these three events, the indirect costs ranged from about \$48,000 to \$1M, with an average of about \$386,000. Prior studies have estimated an approximate economic consequence of about \$800,000 for a day of closure for I-70. As a comparison, the average value of \$386,000 would correspond to about a half day closure of I-70.

Table 3-182 shows Transportation Commission contingency funding requests for geologic hazard events over the fiscal year period from 2008 to 2015 (ending in June 2015). There was not a recorded contingency request for a geologic hazard event in 2009 and the data excludes 2013 flood recovery related projects. During this seven-year period, there was an average of 2.5 requests per year. Individual requests ranged from \$2.4M to over \$17M, totaling \$48.5M, with an average annual cost of about \$6M.

**TABLE 3-182 TRANSPORTATION COMMISSION CONTINGENCY FUNDING REQUESTS, 2008-2015**

<b>Fiscal Year</b>	<b>Event</b>	<b>Transportation Commission Contingency Actions</b>	<b>Annual Total</b>
<b>2008</b>	Dowd Slide, Eagle County	\$9,000,000	\$10,849,000
<b>2008</b>	Hanging Lake Tunnel Rockfall, Garfield County	\$1,400,000	
<b>2009</b>	Not available	Not available	Not available
<b>2010</b>	Jackson Mountain Slide, Archuleta County	\$6,100,000	\$17,250,000
<b>2010</b>	Hanging Lake Tunnel Rockfall, Garfield County	\$2,000,000	
<b>2010</b>	Cerro Summit Slides, Montrose County	\$9,000,000	
<b>2011</b>	Cameron Pass Slide Repairs, Jackson/Larimer Counties	\$3,500,000	\$4,989,000
<b>2011</b>	Trout Lake Slide, San Miguel County	\$989,000	
<b>2012</b>	US 285 Slide Repair, Front Range	\$2,000,000	\$2,400,000
<b>2012</b>	Cerro Summit, Montrose County	\$400,000	
<b>2013</b>	Muddy Pass Slide, Jackson/Grand Counties	\$4,000,000	\$6,100,000

Fiscal Year	Event	Transportation Commission Contingency Actions	Annual Total
2013	Cripple Creek Sinkhole, Teller County	\$300,000	
2013	US 24 Sinkhole, west/east Colorado	\$1,800,000	
2014	US 550 Red Mountain Pass, north/south southwestern Colorado	\$1,000,000	\$3,500,000
2014	SH 5 Shoulder Repairs, route to Mt. Evans	\$2,500,000	
2015	SH 13 Landslide Report, north/south northwestern Colorado	\$3,450,000	\$3,450,000
<b>Grand Total</b>			<b>\$ 48,538,000</b>

Source: CDOT 2015

## 11. RESOURCES

- Colorado Department of Transportation (CDOT)
- Colorado Geological Survey (CGS)
- Denver Post. 2016. <https://www.denverpost.com/2016/02/16/i-70-will-be-closed-until-thursday-after-glenwood-canyon-rock-slide/>
- Federal Emergency Management Agency (FEMA)
- National Academy of Sciences, Transportation Research Board (TRB)
- National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC)
- Spatial Hazard Events and Losses Database for the United States (SHELDUS)
- USA Today newspaper. 2013. <https://www.usatoday.com/story/news/nation/2013/08/10/manitou-springs-colorado-floods/2638419/>
- United States Geological Survey (USGS)

# RADON (RN), CARBON MONOXIDE (CO), METHANE (CH4) SEEPS



## 1. DEFINITION

Every year, some Coloradoans are exposed to concentrations of harmful gasses, such as radon, carbon monoxide, or methane seepage. Individually the impacts of these exposures are localized and well within the response capability of local government. However, when added together they constitute a significant chronic public health risk.

**Radon** is a naturally-occurring colorless, odorless, radioactive gas that forms when uranium in the soil breaks down. Radon can then seep into homes and workplaces through cracks and openings in floors and crawlspaces, and become part of the atmosphere. Radon gas decays into radioactive particles that can get trapped in the lungs when inhaled.

Radon exposure does not create an acute or immediate hazard. However, long-term exposure can significantly increase the risk of lung cancer. Radon is the second-leading cause of lung cancer in the United States (behind smoking), and is the leading cause of lung cancer in nonsmokers. Each year, about 21,000 deaths in the United States are attributed to radon-caused lung cancer. Lung cancer typically occurs 5-25 years after exposure.

**Carbon monoxide** is an invisible and odorless gas produced by the incomplete burning of various fuels, including coal, wood, charcoal, oil, kerosene, propane, and natural gas. Carbon monoxide is also produced by internal combustion engine-powered equipment such as portable generators, cars, and lawn mowers. Breathing in high levels can lead to severe illness or death.

**Methane** is a colorless, odorless gas, and is the main component of natural gas. It is associated with fossil fuels, primarily coal beds, and is also created by microorganisms in marshes, bogs, and landfills. Methane is not a toxic human health hazard; it is not considered a carcinogen and does not cause adverse health effects from ingestion, inhalation, or adsorption. However, if methane accumulates in a confined or poorly ventilated space, an explosion hazard can be created, and because oxygen is displaced, an asphyxiation hazard may also be created. High levels of methane gas in groundwater have also been known to create a flammability hazard. (Note that this section only addresses naturally-occurring methane seeps. Hazards associated with natural gas provided by a utility service is addressed under Hazardous Materials.)

Table 3-183 summarizes the hazard profile for radon, carbon monoxide, and methane.

TABLE 3-183: HAZARD PROFILE SUMMARY

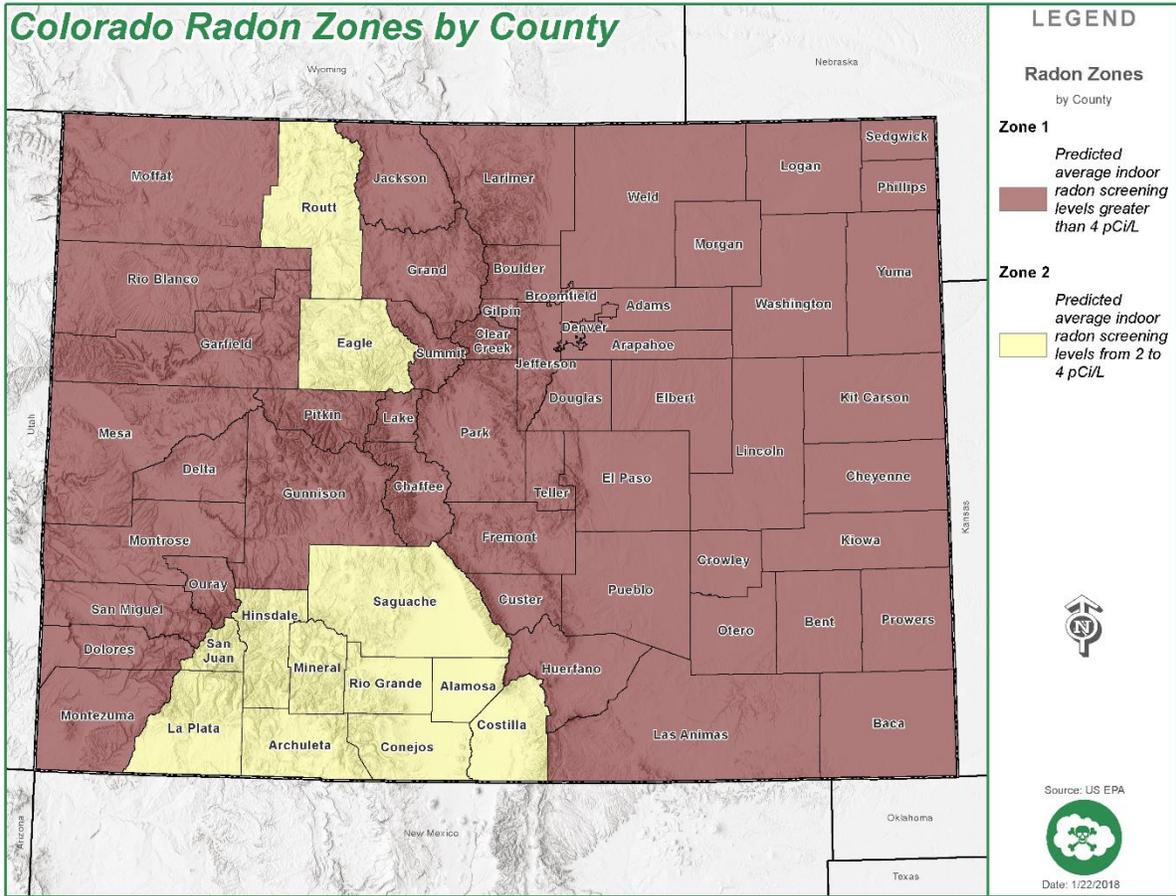
Consideration	Impact	Description
Location	Local	Radon, carbon monoxide, and methane exposures can occur anywhere statewide, but typically only affect a small, localized area.

Consideration	Impact	Description
<b>Previous Occurrence</b>	Year-Round	Radon, carbon monoxide, and methane exposures are slightly more common in winter months due to less ventilation, but can occur year-round.
<b>Probability</b>	Expected	Radon, carbon monoxide, and methane exposures happen every year in Colorado.
<b>Extent</b>	Limited/ Chronic	Individual radon, carbon monoxide, and methane exposures only affect a handful of people at a time, and are handled by local authorities without state assistance. However, taken together they constitute a significant chronic risk to public health.

## 2. LOCATION

**Radon** levels in all Colorado counties are rated by the US Environmental Protection Agency (EPA) as having predicted indoor radon levels greater than two picocuries per liter (pCi/L), well above the national average of 1.3 pCi/L. Additionally, as shown in Figure 3-96, all but 12 Colorado counties are rated as having predicted indoor radon levels greater than four pCi/L, which is the level at which the EPA recommends radon mitigation. However, even in those counties with average levels below four pCi/L, many individual homes will still have radon levels at or above those levels.

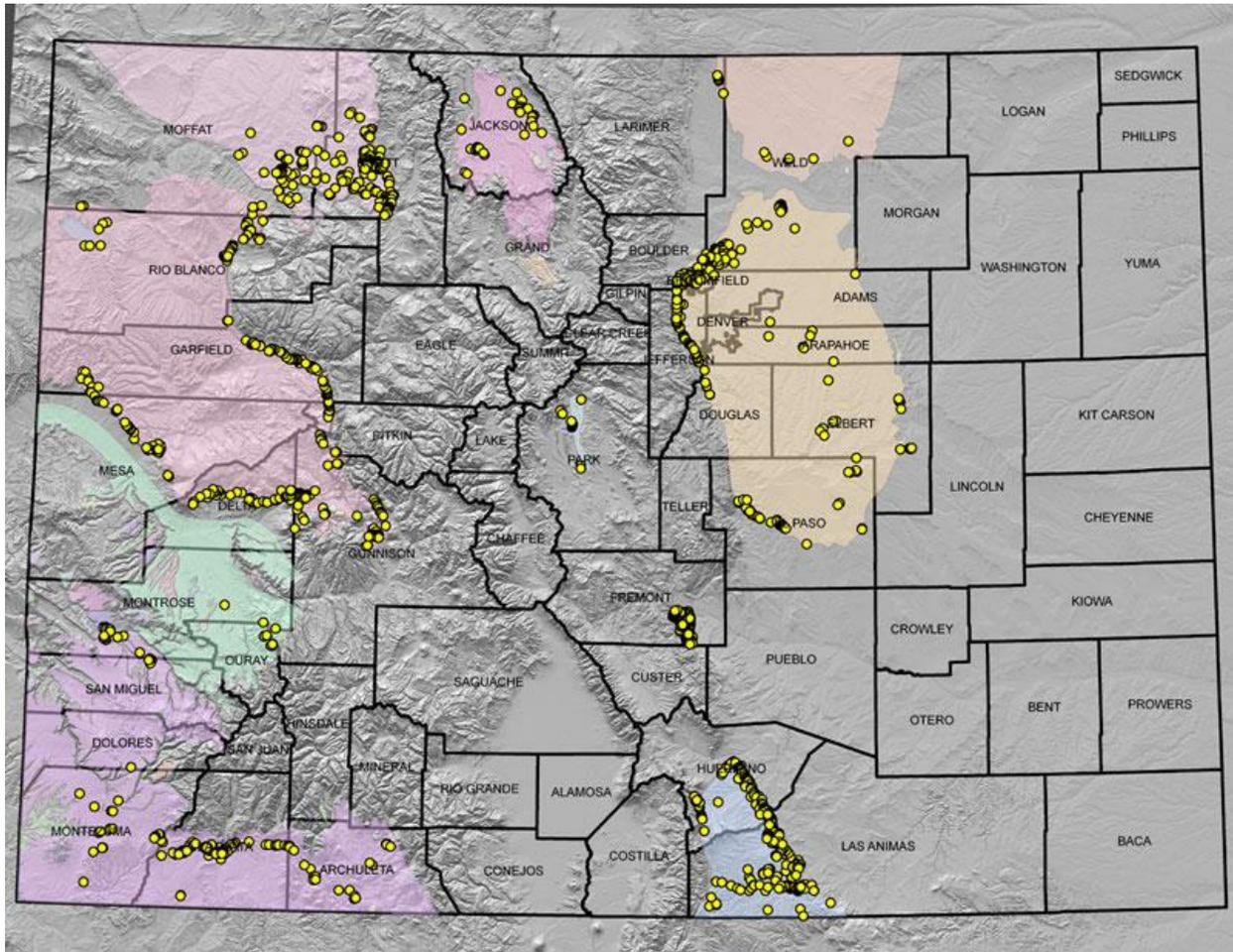
FIGURE 3-96: RADON ZONES IN COLORADO BY COUNTY



**Carbon monoxide** poisoning can happen anywhere in Colorado. Although the rate of carbon monoxide varies somewhat across the state, all Colorado counties have had deaths and/or hospitalizations from accidental carbon monoxide poisonings.

**Methane** seepage occurs naturally throughout much of Colorado, primarily in coal bed areas west of Interstate 25 (see Figure 3-97). These seeps are often created when a new well is drilled. Increased methane seepage is also associated with natural gas production, particularly in the San Juan Basin of southern Colorado, and the Niobrara shale formation in northern Colorado.

FIGURE 3-97: COAL BED FORMATIONS IN COLORADO



Source: Colorado Geological Survey

### 3. EXTENT (MAGNITUDE/STRENGTH)

**Radon** levels in about half of all Colorado homes exceed the EPA's recommended action level of four picoCuries per liter (pCi/L). Among people exposed to radon above this level, 62 out of every 1,000 smokers and seven out of 1,000 nonsmokers could get lung cancer. For nonsmokers, the lifetime risk of dying from this level of radon exposure is comparable to the risk of dying in a car crash; for smokers, the risk is comparable to five times the risk of dying in a car accident.

In the nine counties with average radon levels above 10 pCi/L, 150 out of 1,000 smokers and 18 out of every 1,000 nonsmokers could get lung cancer. For nonsmokers, the risk of dying from this level of radon exposure is comparable to 20 times the risk of dying in a house fire; for smokers, the risk rises to 200 times the risk of dying in a house fire.

Radon gas can also be found in some ground water sources, such as wells. However, the risk from radon exposure through water is significantly lower. Based on a National Academy of Science report, the EPA estimates that nationally radon in drinking water causes about 168 cancer deaths per year.

**Carbon monoxide** poisoning normally affects individuals or small groups or people, and can be handled by local government without state resources. However, if a large-scale carbon monoxide leak were to occur at a critical infrastructure site or a large public gathering, the impact could be much more severe and could require state assistance.

Most **methane** seepage incidents are localized and can be handled by local government without state resources. However, if a methane leak happened to impact a critical infrastructure site or a large public gathering, the effects could be much more severe and could require state assistance.

## 4. PROBABILITY

The risks from **radon** exposure are understood better than most other cancer-causing substances, because estimates of radon risks are based on studies of cancer in humans (particularly uranium miners). The risk of lung cancer from radon is almost 10 times higher for smokers compared to those who have never smoked. Smoking and radon together create greater risk of lung cancer than either one alone. For those who develop lung cancer, the overall mortality rate is around 83 percent.

**Carbon monoxide** poisoning can happen anywhere in Colorado. Although the rate of carbon monoxide varies somewhat across the state, all Colorado counties have had deaths and/or hospitalizations from accidental carbon monoxide poisonings.

While **methane** seepage is a known hazard in Colorado, the lack of reliable statistics makes it difficult to define the probability of occurrence, or to show if incidents are increasing. The odds are high that some sort of methane-related incident will occur each year, although many of these incidents are minor in nature, and may even go unreported. Similarly, there remains some debate as to whether increased natural gas production in Colorado has led to an increase in methane seepage incidents, with different studies reaching conflicting conclusions. State regulators found methane has penetrated groundwater at 64 percent of sites tested in northeastern Colorado since 1988, although one University of Colorado study concluded that 95 percent of the methane came from naturally occurring microbial processes, not the oil and gas industry.

## 5. PREVIOUS OCCURRENCES

**Radon:** Overall, Colorado's incidence rate of lung cancer is 42.2 cancers per 1,000 residents; this is well below the national average of 58.3, due primarily to Colorado's low smoking rates.

Nevertheless, from 1990 through 2015 more than 51,000 Coloradans died from lung cancer, an average of 1,970 deaths a year. While it is not possible to state definitively which of those cancers were due to radon exposure, the US Centers for Disease Control and Prevention (CDC) estimate that 13 percent of lung cancers are attributable to radon exposure; this equates to an estimated 255 deaths a year from radon-induced lung cancer in Colorado.

**Carbon monoxide:** In Colorado, from 1999 to 2009, an average of 11 Coloradans died every year due to accidental carbon monoxide poisoning not related to a fire, and more than twice that number were hospitalized. In 2009 Colorado passed a law requiring the installation of carbon monoxide alarms in most homes. Since 2010, the number of deaths has dropped slightly to 9.4 per year.

**Methane:** Historically, the explosion of several buildings and wells in Colorado have been linked to the buildup of methane gas:

- 2005, La Plata County: the explosion of a double-wide trailer was linked to methane gas in a coal-bed seam that traveled through an abandoned well under the trailer; one resident suffered severe burns.
- 2007, Huerfano County: a privately-owned well on a residential property exploded when methane in his water well suddenly ignited; fortunately, there were no injuries.
- 2007, Las Animas County: a methane explosion destroyed a home under construction, injuring three people. Investigators determined a plugged and abandoned well under the home was leaking gas.
- 2011, La Plata County: a methane explosion at a residence left one resident in the hospital.

In recent years, several homeowners in La Plata County and other locations have raised concerns about high levels of methane in samples taken from their drinking water. Similarly, some farmers in the San Luis Valley have reported crop losses due to irrigation water allegedly becoming contaminated with methane. The extent of the problem statewide is difficult to quantify.

## 6. IMPACT ANALYSIS

**Radon** is responsible for about 21,000 lung cancer deaths nationally every year – more than deaths from drunk driving. About 2,900 of these deaths occur among people who have never smoked. The EPA and the American Lung Association have concluded that most of those deaths could be preventable by mitigating against high radon levels.

Lung cancer is the only health effect which has been definitively linked with radon exposure. There is no evidence that other respiratory diseases, such as asthma, are caused by radon

exposure; nor is there evidence that children are at any greater risk of radon induced lung cancer than adults.

Colorado statute requires all schools to test for radon and to maintain records of the test results for disclosure upon request. However, the statute does not require schools to mitigate high radon levels; it is up to the school district and its constituents to decide how to address mitigation issues.

With **carbon monoxide**, the health effects depend on the concentration of carbon monoxide in the air, how long a person is exposed, and the health status of the person exposed. Unborn babies, infants, and people with respiratory problems, chronic heart disease, or anemia are most susceptible to the effects of carbon monoxide poisoning.

At low concentrations carbon monoxide can cause fatigue and other flu-like symptoms. It can also cause chest pain in people with heart disease. At higher concentrations carbon monoxide can cause impaired vision and coordination, headaches, dizziness, confusion, and nausea. Very high concentrations of carbon monoxide can lead to loss of consciousness and death within minutes.

Carbon monoxide is called the “silent killer” because, if the early signs are ignored, a person may lose consciousness and be unable to escape to safety. People who are sleeping or intoxicated can die from carbon monoxide poisoning without ever being aware of the symptoms.

The health effects of long-term exposure to low levels of carbon monoxide are not well understood, but exposure to high carbon monoxide levels during pregnancy is known to be associated with birth defects and fetal death. Exposure to moderate or high levels of carbon monoxide over long periods of time has also been linked to an increased risk of cardiovascular disease. Survivors of severe carbon monoxide poisoning may suffer from heart and brain damage, learning and memory impairment, emotional and personal changes, and sensory and motor disorders.

**Methane** seepage can impact public safety and welfare, the environment, and resource recovery in several different ways:

- Accumulation of explosive vapors
- Dead vegetation through oxygen (O<sub>2</sub>) displacement in the root zone
- Water well/shallow aquifer impacts, to include making water unsafe to drink or in some cases even flammable
- Inefficient reservoir production
- Greenhouse gas (GHG) emissions
- Hydrogen Sulfide (H<sub>2</sub>S) gas generation

- Property value impacts

A summary of the impacts of all three gasses is shown in Table 3-184.

**TABLE 3-184 RADON-CO-METHANE EMAP IMPACT SUMMARY**

<b>Consideration</b>	<b>Description</b>
<b>General Public</b>	Long-term radon exposure leads to an estimated 255 deaths a year from radon-induced lung cancer in Colorado. An average of nine Coloradans a year die from accidental carbon monoxide poisoning not related to a fire, and more than twice that number are hospitalized. Methane seepages lead to a handful of injuries or deaths per year.
<b>First Responders</b>	The risk to responders is generally the same as that to the general public.
<b>Property</b>	Radon and CO do not affect property or buildings, other than possible mitigation work to minimize their effects on inhabitants. Methane gas buildup in confined spaces can lead to explosions.
<b>Facilities and Infrastructure</b>	The risk to public facilities and critical infrastructure is the same as that to property in general.
<b>Economic</b>	The main economic impact of all three substances is in increased healthcare costs and loss of work from exposures. Mitigation costs are relatively minor.
<b>Environment</b>	Methane seepage can sometimes lead to localized vegetation death, and poisoning of water sources. Radon and CO have no significant environmental impacts.
<b>Continuity of Government and Services</b>	An explosion due to built-up methane gas in a critical infrastructure facility could have the potential to impact services. Radon and CO are unlikely to impact services.
<b>Confidence in Government</b>	Increased focus on the risks associated with these gasses could lead to increased expectations for government to do more to reduce those risks.
<b>Critical Assets</b>	Radon, CO and Methane represent minimal risks to critical assets.

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

Radon exposure throughout Colorado is above the national average, although exposure levels vary considerably by county. Figure 3-98 shows mean radon sampling rates collected by the CDPHE from 2011-2015.

FIGURE 3-98: MEAN INDOOR RADON TEST VALUES (2011-2015)

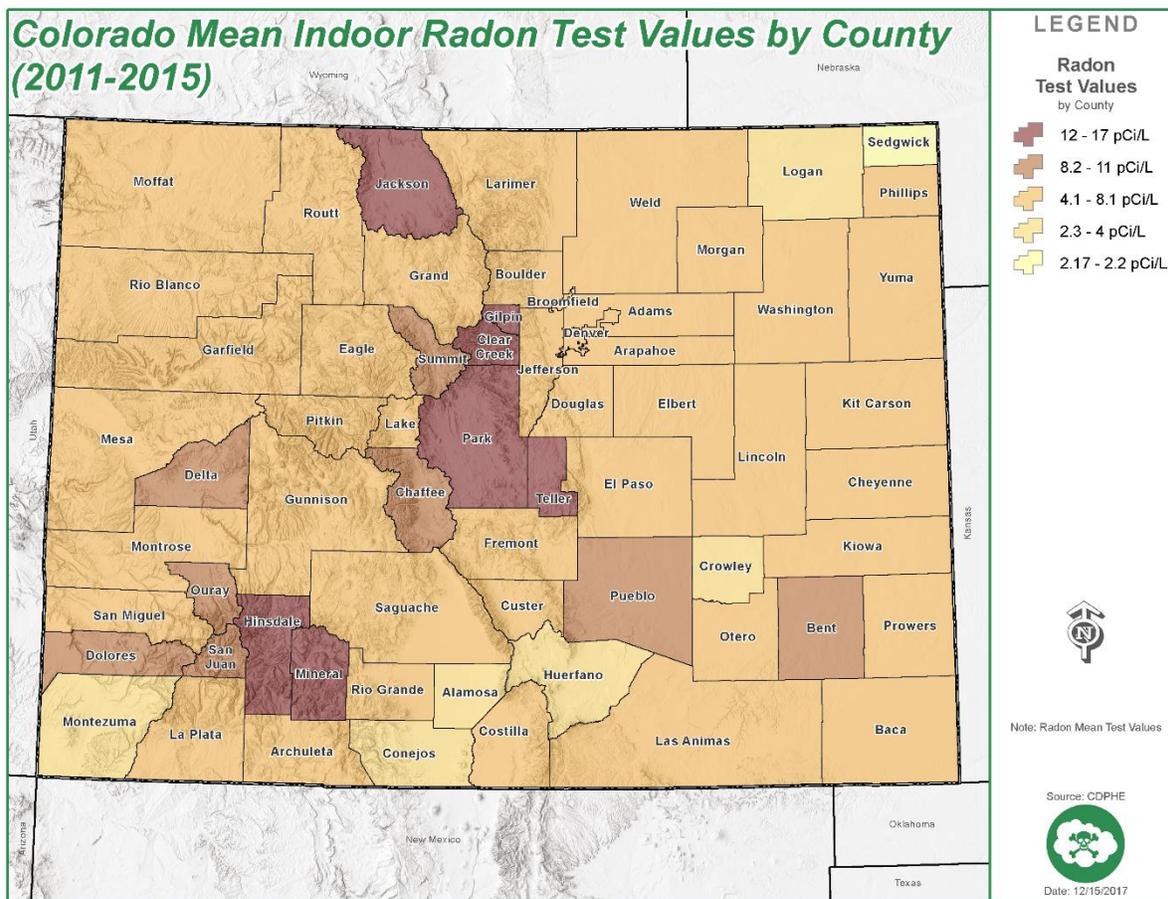
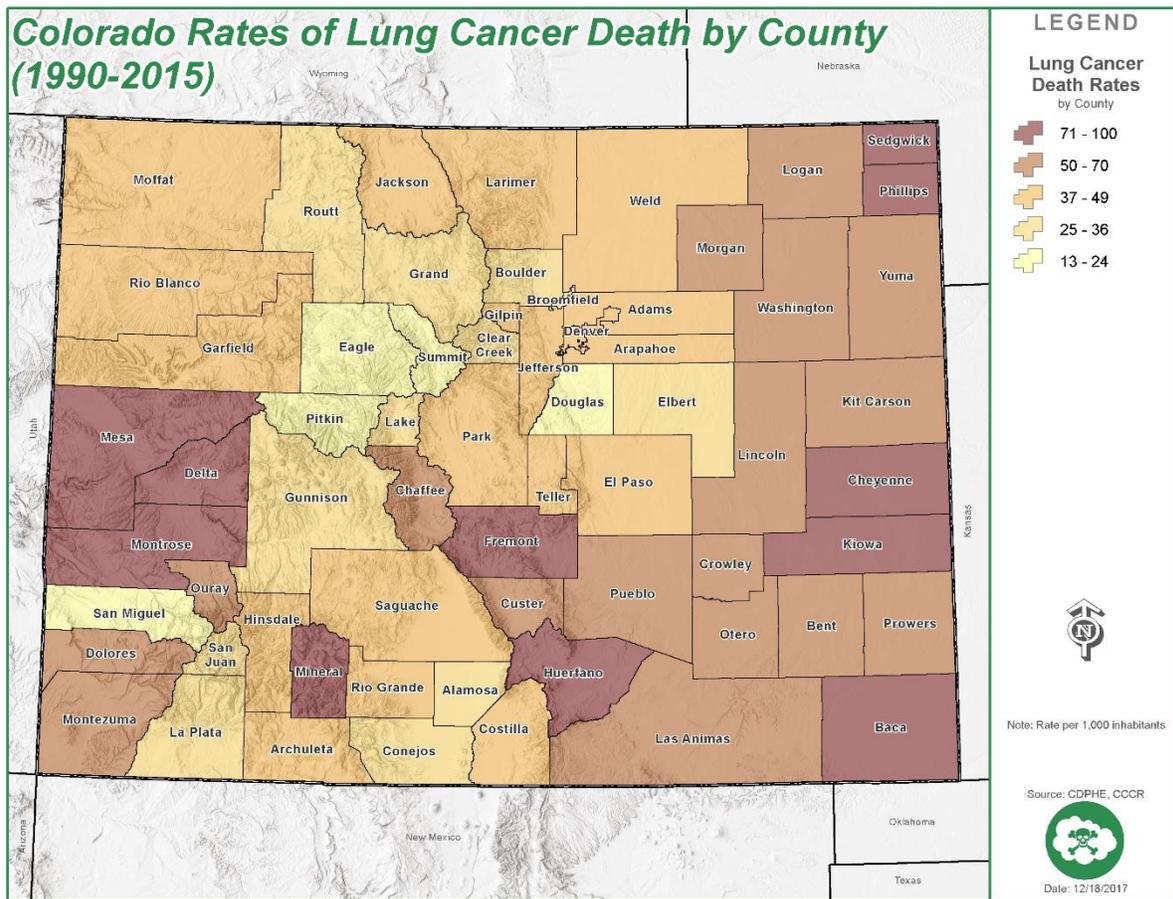


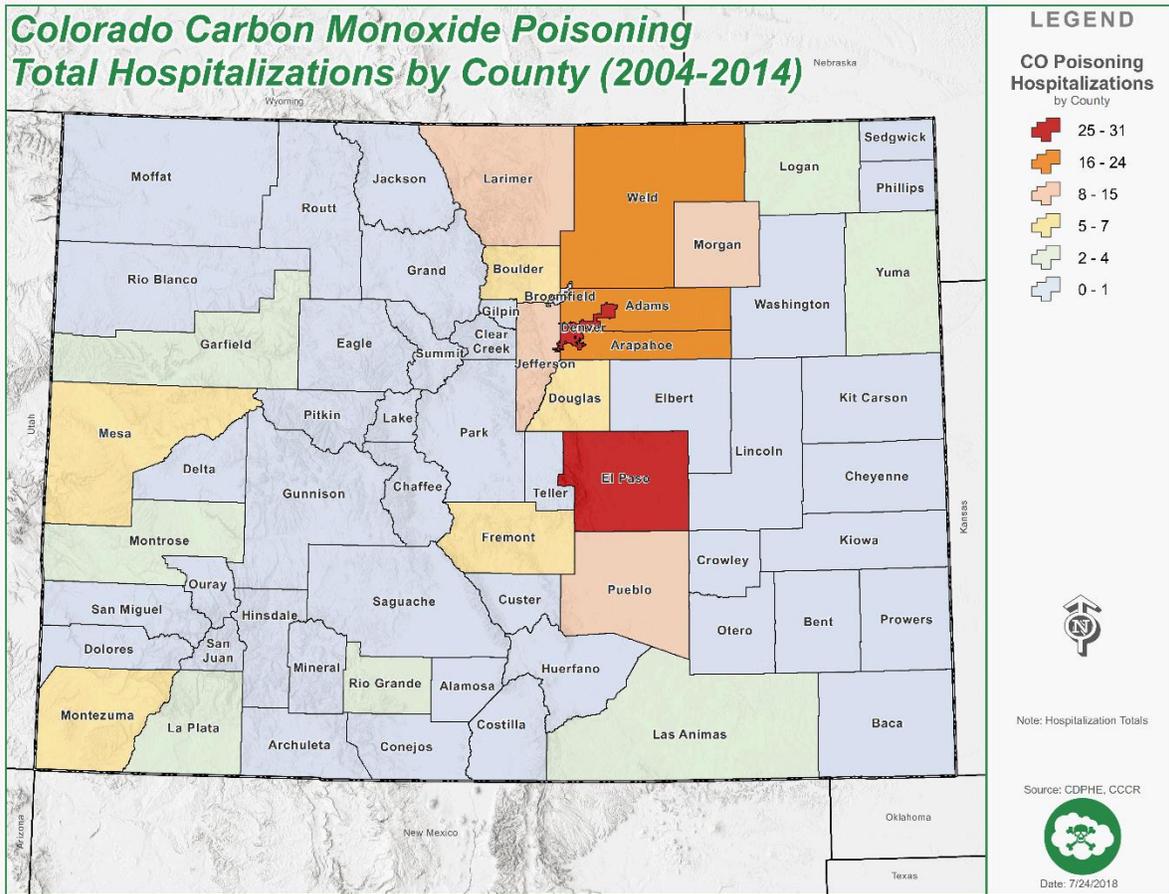
Figure 3-99 shows lung cancer death rates by county from 1990 through 2015. Note that the radon sampling rates shown above do not correlate strongly with lung cancer death rates ( $r = -0.14$ ). This is likely due to the fact that radon is only a secondary cause of lung cancer, compared to smoking.

FIGURE 3-99: LUNG CANCER DEATH RATES BY COUNTY (1990-2015)



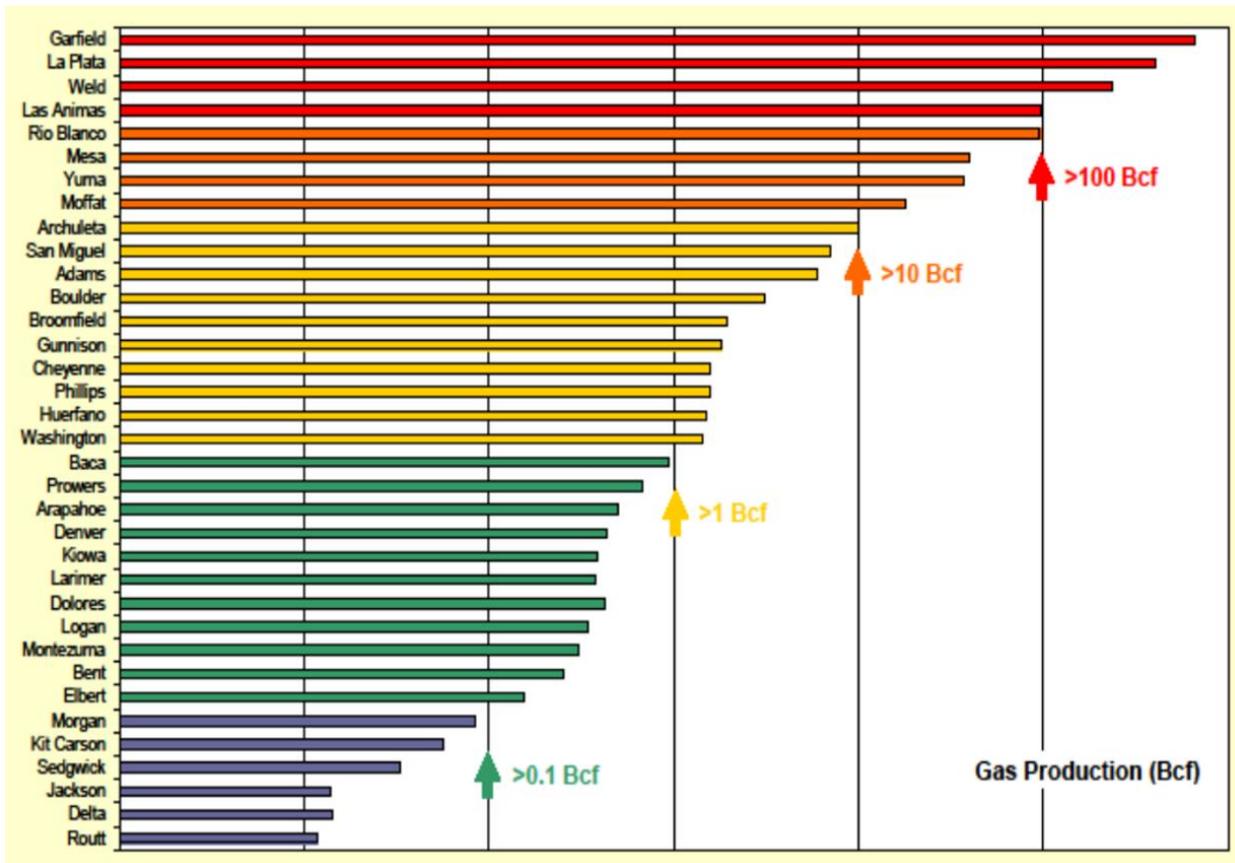
**Carbon monoxide** poisonings leading to hospitalization from 2004 through 2014 are shown by county in Figure 3-100. This data does not include people who did not receive medical care or received outpatient care. Conversely, an individual who was hospitalized multiple times for the same incident could be counted as multiple incidents.

FIGURE 3-100: CARBON MONOXIDE HOSPITALIZATIONS BY COUNTY



**Methane** seepage is a risk throughout much of Colorado, primarily in coal bed areas west of Interstate 25, and in areas of high natural gas production, such as the San Juan Basin of southern Colorado, and the Niobrara shale formation in northern Colorado. Statewide data on actual methane seepage incidents is not available. Figure 3-101 shows natural gas production rates by county, as a proxy for expected methane seepage rates.

FIGURE 3-101: COLORADO NATURAL GAS PRODUCTION BY COUNTY (2011)



Source: Colorado Geological Survey

Based upon an updated (2017) review of local mitigation plans, no local jurisdictions have profiled radon or carbon monoxide as a hazard. Only one local jurisdiction, Huerfano County, has profiled methane seepage, ranking it as a moderate hazard.

## 8. FUTURE DEVELOPMENT

**Radon** levels in both new and existing structures can easily be reduced to acceptable levels with minimal financial investment. Radon mitigation for existing buildings is becoming more common in Colorado and nationally, as more and more home buyers are insisting on radon testing. Even homes with very high radon levels can be reduced to acceptable levels relatively cheaply. Radon-resistant techniques are also becoming more common in new construction, and are even less expensive when included up front.

Population growth throughout Colorado could mean more people exposed to high levels of radon. However, the increased use of radon mitigation techniques in both new and existing homes can be expected to reduce that exposure considerably. Therefore, relating radon exposure levels to county growth rates is likely to give a misleading risk profile. Colorado should continue to promote radon awareness and encourage mitigation statewide.

The number of deaths from accidental **carbon monoxide** poisoning has dropped slightly since 2009, when the Colorado legislature passed a law requiring the installation of carbon monoxide alarms in most homes. It is hoped those numbers will continue to decline somewhat as carbon monoxide detectors become more common.

As with radon exposure, counties experiencing high levels of growth could expect to see an accompanying increase in the number of carbon monoxide poisonings. However, the new law mandating carbon monoxide alarms in most residences should continue to reduce the rate of poisonings. Additionally, the lack of good data on carbon monoxide poisonings means that tying county growth rates to carbon monoxide incidents is likely to give a misleading risk profile.

Increased attention and new state regulations have made it somewhat easier to ensure **methane** seepage is taken into account during new construction. As noted earlier, it is not entirely clear how much methane seepage incidents can be expected to increase or decrease based on rates of natural gas production.

Many counties experiencing high rates of growth are also located in areas with high levels of natural gas production, notably Weld, Broomfield, Archuleta, and Adams Counties. However, given that the link between natural gas production and methane seepage is still debated, it is not clear if tying population growth rates to natural gas production is a meaningful measure of risk. The state should continue to explore this link further.

## 9. CLIMATE CHANGE

According to the best data available at the time of this plan update, the future impacts of climate change are not expected to influence future hazard events.

## 10. RISK TO STATE ASSETS

**Radon** does not present any acute or immediate risk to state facilities. However, public-sector buildings are just as susceptible to radon as privately-owned buildings. Some state government buildings have had radon levels tested and taken remediation measures, but there is no requirement for state facilities or other critical facilities to do so.

**Carbon monoxide** poisoning is just as much of a risk to workers in state facilities as it is to the general public. Data on the number of state workers sickened or killed due to accidental carbon monoxide poisoning is not available. While schools and residences are required to have carbon monoxide detectors, there is no similar requirement for state government buildings.

**Methane:** State assets could be susceptible to problems associated with methane seepage, but a lack of data makes it difficult to quantify that risk.

## 11. RESOURCES

- Colorado Department of Natural Resources (DNR)
- Colorado Department of Public Health and Environment (CDPHE)
- Colorado Geological Survey (CGS)
- Colorado Oil and Gas Conservation Commission (COGCC)
- US Environmental Protection Agency (EPA)

# SUBSIDENCE & ABANDONED MINE LANDS



## 1. DEFINITION

Ground subsidence is the sinking of land over human caused or natural underground voids and the settlement of native low-density soils. Natural causes of subsidence include the development of sinkholes, rock sliding downward along faults, natural sediment compaction, and melting of permafrost. In Colorado, the type of subsidence of greatest concern is the settling of the ground over abandoned mine lands (AMLs), also referred to as undermined areas. Collapsing and settling soils are relatively low-density materials that shrink in volume when they become wet, and/or are subjected to great weight such as from a building or road fill. The process of collapse with the addition of water is also known as hydro-compaction.

Land subsidence incidents may occur abruptly - virtually instantly - or gradually over many years. It may occur uniformly over a wide area as local depressions or pits separated by areas which have not visibly subsided. In Colorado, it is most common in the sedimentary rocks over abandoned coal, hard rock, and clay mines. The crystalline rocks in which most metals are mined have greater strength and are less likely to settle or collapse. Subsidence can also occur where underground water has dissolved subsurface materials or has been withdrawn by wells. Although serious in other western states, these latter types of subsidence are less common in Colorado than sinking caused by the caving in of underground mine workings.

Collapsing and settling soils have considerable strength when dry, and generally are not a problem to structures and improvements. When they become wet, they are subject to rapid collapse and can be reduced in volume as much as 10 to 15 percent. Surface ground displacement of several feet can result. Similar processes frequently affect old landfills or poorly placed earth fills.

In addition to undermined areas, ground subsidence hazards also occur where evaporite bedrock (gypsum, anhydrite, and rock salt) dissolves. Subsidence also occurs in areas with karst morphology, which occurs when bedrock dissolves. It is characterized by underground drainage systems such as caverns or caves. Table 3-185 describes the hazard profile summary for subsidence and AMLs.

TABLE 3-185 HAZARD PROFILE SUMMARY

Consideration	Impact	Description
<b>Location</b>	Regional	South-central, southwest, and northwest are impacted by this hazard. Distributed across the state with areas of denser concentration in heavily mined areas.
<b>Previous Occurrence</b>	Perennial	Ongoing event resulting from natural causes such as drought and precipitation, and human-caused development activities.
<b>Probability</b>	Expected	Conditions related to natural causes such as precipitation and drought cycles, in addition to development and land use prevalent in the past, are expected to continue.
<b>Extent</b>	Extensive	Major or long-term property damage with potential to threaten structural integrity. Limited or no loss of life or injury; one of Colorado’s most prevalent causes of damage to buildings and construction.

## 2. LOCATION

Subsidence, undermined areas, and collapsible soils tend to be problematic along the Front Range, Western Slope, and in the Central Mountains. The Eastern Plains are largely void of this hazard.

Eagle, Garfield, Summit, Routt, Larimer, and Lake Counties have concentrations of subsidence-prone areas that cluster around steep slopes across the Rocky Mountains. Additionally, El Paso and Fremont Counties are also at risk to subsidence at the base of the Front Range. Subsidence-prone areas are highlighted in Figure 3-102.

AMLs or undermined areas occur in point locations throughout the mountains and foothills. In addition to AMLs, ground subsidence hazards also occur where evaporitic bedrock (gypsum, anhydrite, and rock salt) dissolves. Undermined areas are concentrated along the eastern-most border of the Rocky Mountains, stretching from Las Animas County (New Mexico/Colorado border) through Huerfano, Fremont, El Paso, and Broomfield Counties. There are also undermined areas amongst the central Rockies in Gunnison, Delta, Mesa, Garfield, and Routt Counties, as shown in Figure 3-103. The Colorado Geological Survey (CGS) Abandoned Mine Land Inventory (AMLI) project identified roughly 18,000 abandoned mine-related features on National Forest System lands in Colorado between 1991 and 1999. The mine-related features include mine openings, waste rock dumps, tailings dumps, and mine structures. The Colorado Division of Reclamation, Mining, and Safety (DRMS) estimated that there are approximately 23,000 abandoned mines in Colorado (<http://mining.state.co.us/Programs/Abandoned/Pages/impwelcomepage.aspx>). General locations of inactive coal mines are shown in Figure 3-104. Figure 3-105 shows the location of historic underground coal mine extents and reported coal mine-related subsidence events.



FIGURE 3-103 POTENTIAL UNDERMINED AREAS IN COLORADO

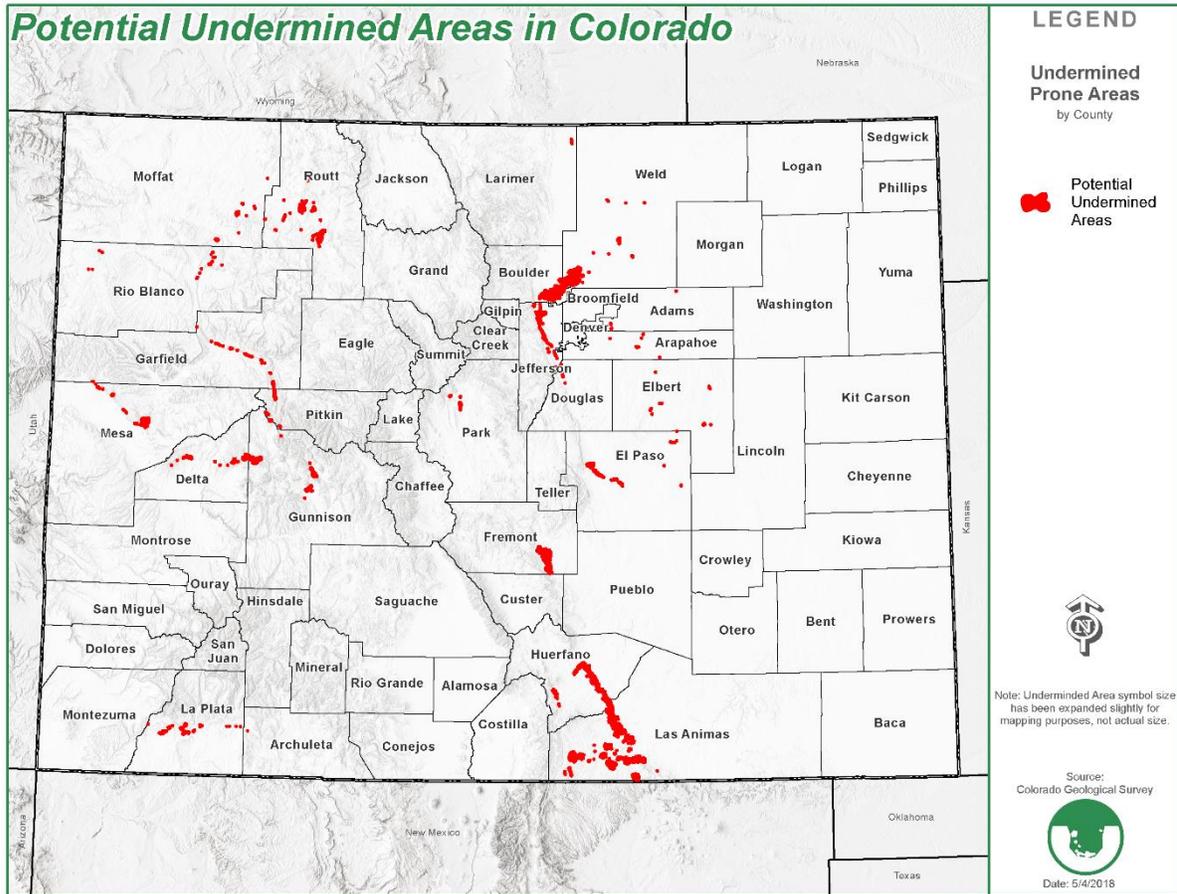
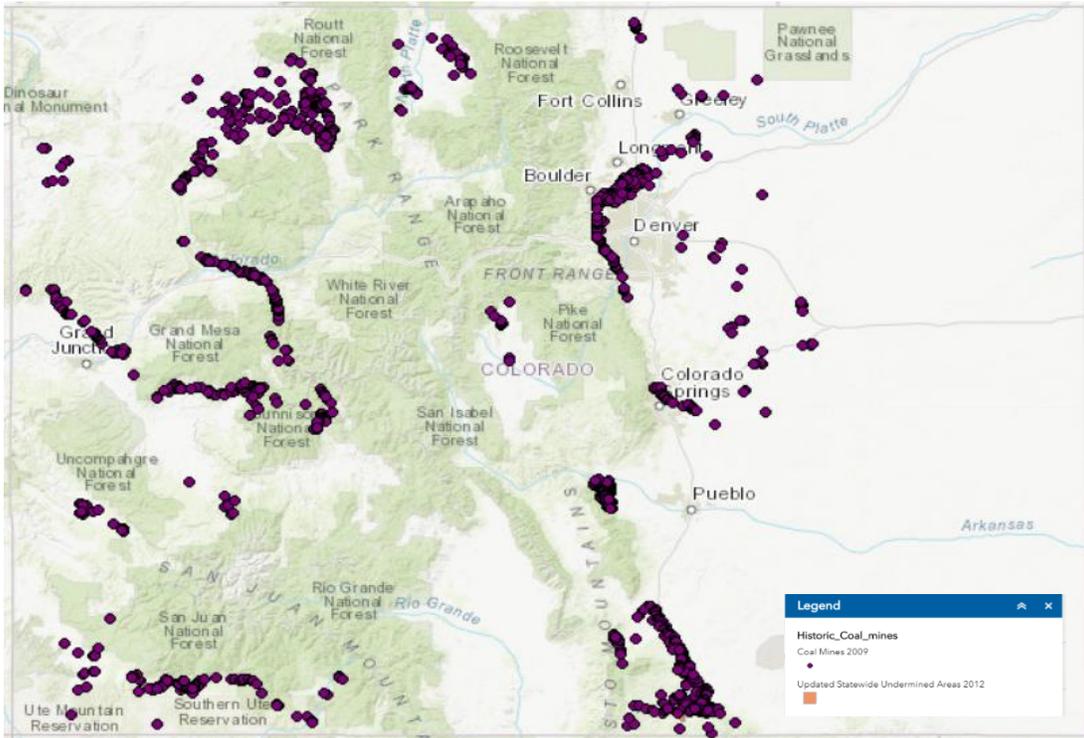


FIGURE 3-104 INACTIVE COAL MINE LOCATIONS



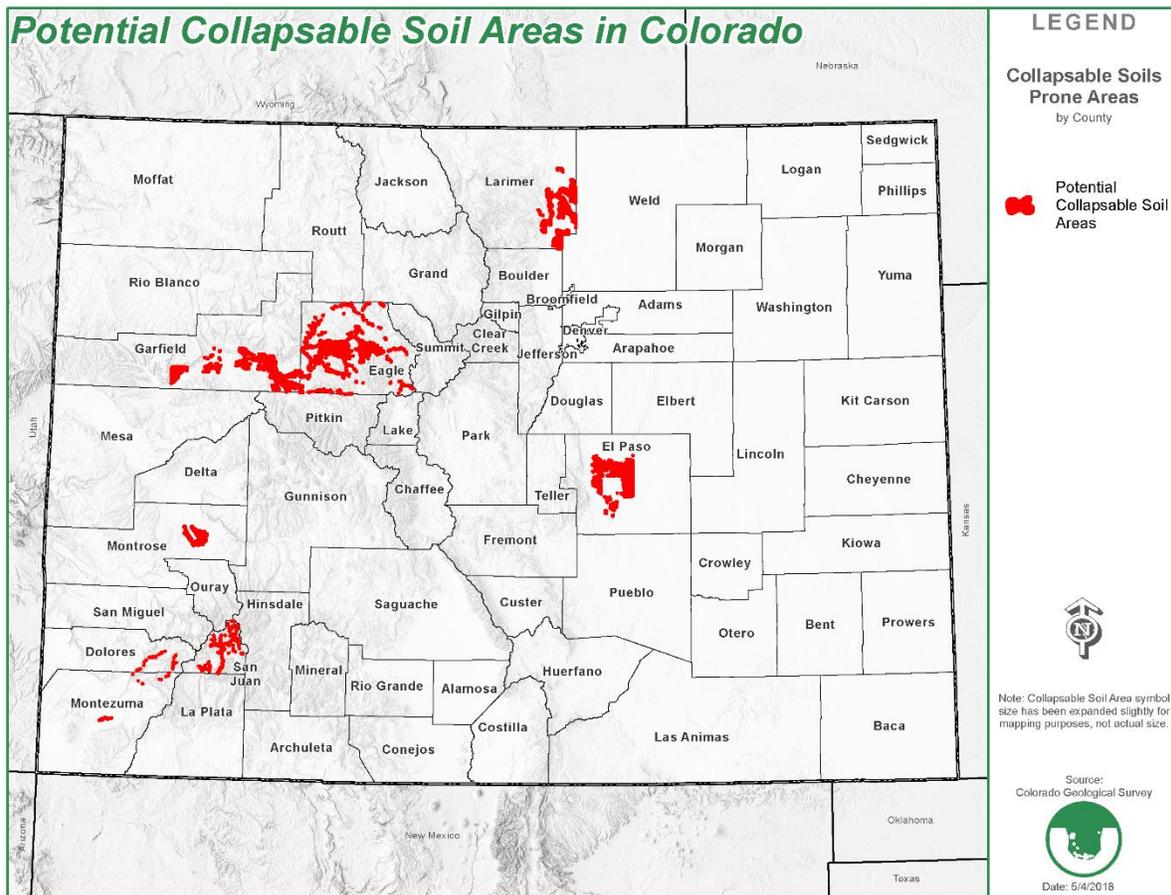
Source: Colorado Geological Survey

FIGURE 3-105 STATEWIDE HISTORIC UNDERGROUND COAL MINE EXTENTS AND REPORTED COAL MINE-RELATED SUBSIDENCE EVENTS



Source: Colorado Geological Survey

FIGURE 3-106 POTENTIAL COLLAPSIBLE SOIL AREAS IN COLORADO



### 3. EXTENT (MAGNITUDE/STRENGTH)

Although infrequent, subsidence may occur abruptly - virtually instantly - as dangerous ground openings that could swallow any part of a structure that happens to lie at that location, or leave a dangerous steep-sided hole.

In Colorado, the types of subsidence of greatest concern are settlement related to collapsing soils, sinkholes in karst areas, and the ground subsidence over AMLs. There are many factors that affect the extent of a subsidence hazard. These may include the size of a mine, the susceptibility of the soil to collapse, and composition of the soil. Areas may appear to be free of subsidence for many years, and then undergo renewed gradual or even drastic subsidence.

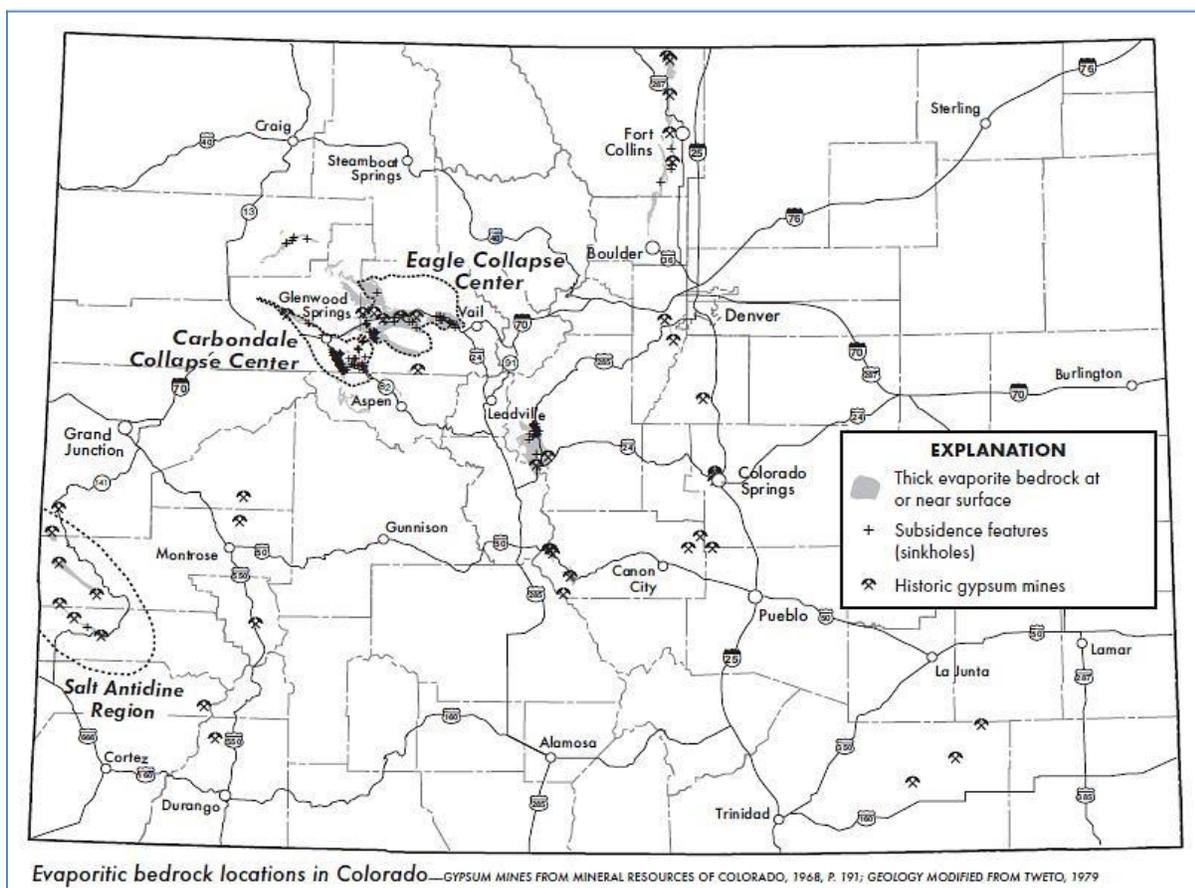
### 4. PROBABILITY

Natural processes will be continuous and indefinite, and as development pressures continue in areas of undermined areas, subsidence hazards may be exacerbated.

#### 4.1 EVAPORATIVE KARST SUBSIDENCE

In Colorado, most of the sinkholes (dolines) are a product of the dissolution of evaporite rocks. According to the Colorado Geological Survey, evaporite karst hazards have been recognized in several areas of the state, including high growth areas. As shown in Figure 3-107, the highest densities of surface sinkholes in Colorado occur in the Roaring Fork River - Carbondale area of Garfield County, the Eagle River around Gypsum, and Edwards in Eagle County, the Buford-North Fork White River area in Rio Blanco County, and Park County south of Fairplay. These areas lie in regional collapse centers where subsidence of hundreds to thousands of vertical feet has occurred by the dissolution and deformation of evaporite rocks.

FIGURE 3-107 EVAPORATIVE BEDROCK LOCATIONS IN COLORADO



Source: Colorado Geological Survey

#### 4.2 ABANDONED MINE LANDS

Many old mines are located near present urban areas. With Colorado's population growth in the last 25 years, not only have many homes been built over abandoned mines, but many homeowners are unaware of previous mining or the extent of mining in an area.

Subsidence over abandoned coal mines is a potential hazard for thousands of homes along the Front Range urban corridor, and these numbers will continue to grow as more people move into the state. Periodic flooding and draining of abandoned mines can increase the risk of

subsidence as mine structures shift underground. Development activities that cause ground vibrations may also accelerate the AML subsidence process.

A residence or other structure may be subject to subsidence if it is located over or close to an undermined area. Therefore, the first step in determining the subsidence potential at a specific location is to discover if the area is undermined.

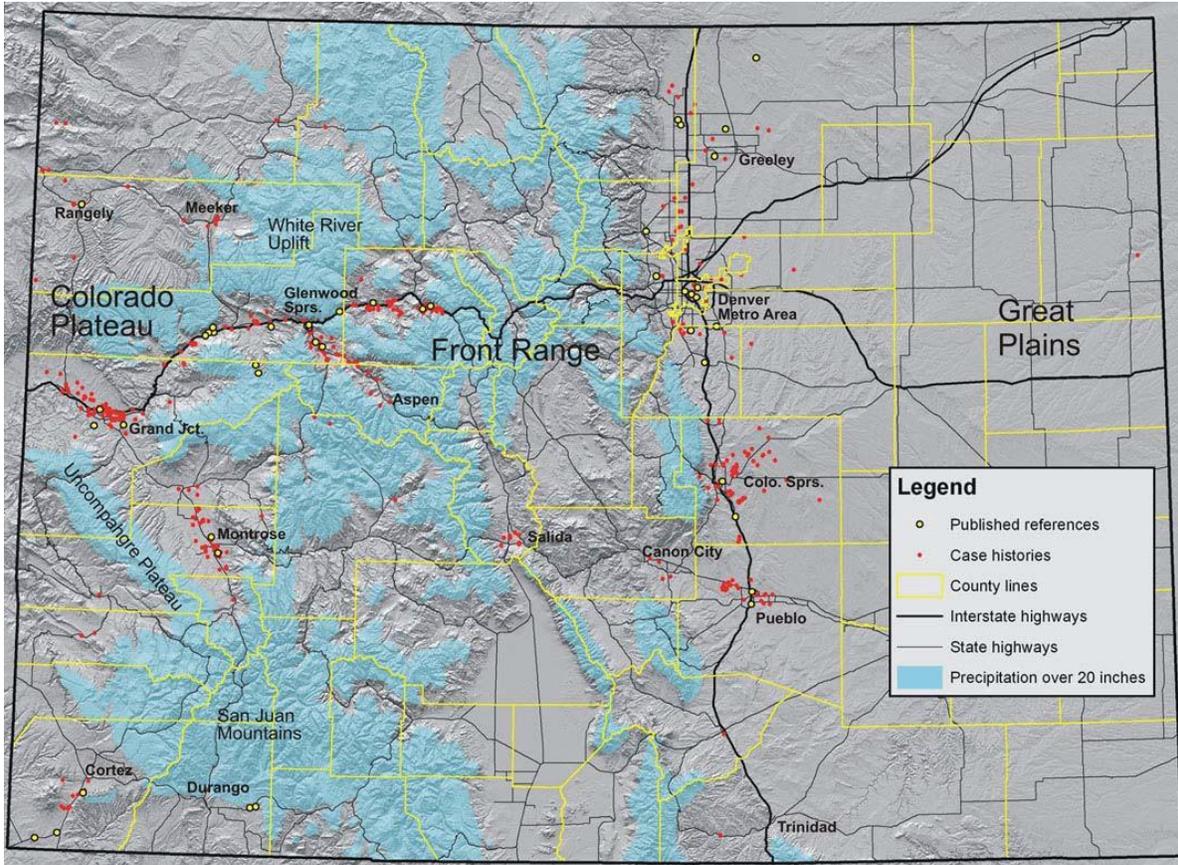
Housing developments in the Front Range urban corridor have had subsidence hazard investigations completed prior to development. Individual site-specific investigations involve examining the available data and drilling exploratory holes for information on the present condition of the mine. These investigations are completed to determine how the subsidence hazard can affect proposed development, if safe building areas exist, and what areas should be avoided. These studies, when available, are often on file with the builder, city, or county. They also may be available for inspection from the files of the Colorado Geological Survey.

#### **4.3 COLLAPSIBLE SOILS**

With few exceptions, soil collapse appears to occur in dry areas that have less than 20 inches of annual precipitation. Local groundwater levels generally never rise into these mantles of soil so they never become saturated. Only through human development and land use do local groundwater levels rise. The soils become introduced to moisture, through combinations of field irrigation, lawn and landscaping irrigation, capillary action under impervious slabs, leaking or broken water and sewer utilities, and altered drainage.

Figure 3-108 shows the combination of high precipitation and historic case studies that may result in favorable environments for collapsible soils.

FIGURE 3-108 COLLAPSIBLE SOIL CASE HISTORIES IN COLORADO



Source: Colorado Geological Survey

## 5. PREVIOUS OCCURRENCES

Occurrences of subsiding and collapsing soils date back to Colorado's early history throughout the locations with natural or human-caused characteristics that make it prone to this hazard.

### 5.1 SINKHOLE OR EVAPORATIVE KARST SUBSIDENCE

**Larimer County – May 1999:** On May 1, 1999, a sinkhole spontaneously opened on the westbound shoulder of U.S. Highway 34 within the Colorado Department of Transportation (CDOT) right-of-way, about three miles west of Loveland. Just north of the sinkhole the beds of gypsum were historically mined by the United States Gypsum Company. The mine had closed and the property was being redeveloped as a gated community. The roadside sinkhole was approximately 25 feet in diameter and 20 feet deep. (Source: CDOT)

**Garfield County – February 2003:** A 24-foot wide sinkhole spontaneously opened on a soccer field at the Colorado Mountain College (CMC) Roaring Fork Campus near Spring Valley, about 7 ½ miles southeast of Glenwood Springs. After filling by the CMC physical plant maintenance staff, the sinkhole reopened the next year and enlarged to about 35 feet in diameter. (Source: CGS)

**Garfield County – January 2005:** A large sinkhole opened off of County Road 109, across the Roaring Fork River from Highway 82, between Glenwood Springs and Carbondale. The sinkhole occurred in the Iron Bridge community development, previously known as the Rose Ranch. In 2002, the CGS published a map of evaporite karst hazards for this area of the state. The sinkhole opened up at the clubhouse golf cart maintenance and storage facility. Reportedly, a small hole, about 10-foot by 10-foot, opened very early Sunday morning that quickly enlarged to a 42-foot diameter and 40-foot deep sinkhole by the middle of the day. (Source: CGS)

## **5.2 AMLS**

**Boulder County – 1974:** One evening in 1974 a Lafayette, Colorado, mobile home park resident noticed a two-foot hole in his front yard. By morning the hole was 10 feet deep and 10 feet across. The mobile home was moved as the hole continued to grow until it was about 25 feet deep and 25 feet in diameter. The sidewalk, a telephone pole, a concrete pad, and a fence had to be replaced after the hole was filled. Fortunately, a gas line exposed by subsidence did not rupture. The property owner backfilled the hole, acknowledging the site had previously subsided and had been filled. An inclined shaft to an old coal mine underlies the site. The workings were abandoned more than 50 years ago.

**El Paso County – April 1979:** On Friday, April 13, 1979, a group of Colorado Highway Department (now the Department of Transportation) maintenance crews found a 500-foot-deep airshaft to the abandoned Klondike coal mine had been reopened by surface subsidence into the mine. A crater about 20 to 25 feet across opened like a funnel into the shaft just off the pavement on the northeast corner of the Interstate 25 Woodmen Road interchange in Colorado Springs. The shaft had previously been capped, but the slow deterioration of the surface plug finally caused this reopening.

**San Juan County – 1979:** In an especially rare event, AML subsidence caused a dam failure flood of sorts. In the San Juan Mountains above Silverton, a natural lake (Lake Emma) was completely drained on June 4, 1979 by a series of abandoned mine tunnels beneath the lake.

**Weld County - Ongoing:** Interstate 25 crosses several abandoned coal mines in Weld County. Current roadway settlement of more than two feet near Erie has taken place in patterns that can be closely correlated to subsidence over coal mine workings 350 to 400 feet below the surface. Much of the severely damaged road is now below original grade, resulting in a mild roller coaster-like ride. Estimates for repair of the three-quarter mile section damaged by subsidence are about \$1 million.

In addition to these events, CGS has recorded several subsidence case studies related to AMLs in Colorado, as described below (<http://coloradogeologicalsurvey.org/geologic-hazards/subsidence-mine/case-histories/>).

**CGS Case Study - Marshall Area (Boulder County) - May 2007:** In May 2007, a consultant reported mine-related subsidence features in a property near Marshall being considered for

residential development. Upon investigation, a number of subsidence holes and mine-related features were found on the property. An abandoned building showed significant damage possibly related to the old mine. No records of the mine were found, but several old foundations around the property indicate a mine entry exists west of the site. Due to the unknown mine, lack of records, and the presence of subsidence features, the property owner elected not to pursue development.

**CGS Case Study - Town of Erie (Boulder/Weld Counties) - December 2008:** In December of 2008, a report of a large subsidence hole in a field west of Erie was reported. The hole was about 50 feet in diameter and 35 feet deep before being filled with water. The field where the hole appeared was under consideration for annexation by the town for future residential development. A geophysical investigation conducted three months prior did not show any evidence of voids in the area. The hole was located outside of the mined area shown on the mine map, indicating that the mine map was inaccurate. During the mitigation process, a secondary subsidence pit of smaller dimensions was found directly west of the original hole. Both holes were backfilled by the Abandoned Mine Lands program.

**CGS Case Study - Town of Erie (Boulder/Weld Counties) - January 2009:** A large subsidence hole was reported in January 2009 at a residence near the corner of a horse barn. The property owners reported the hole opened up overnight and a fence and gate had been destroyed by the event. The hole measured roughly 25 feet by 25 feet by 15 feet deep and was filled with water. Because of the nature of the opening and the proximity to livestock and human activities, the event was considered a subsidence emergency and was backfilled by the Abandoned Mine Lands program.

**CGS Case Study - City of Colorado Springs (El Paso County) – Ongoing:** The Country Club Circle area of Colorado Springs has a long history of mine subsidence from multiple mines that were active during the early 1900's. The mining in the area was very shallow, and there is little bedrock between the mine roof and the ground surface. The area is developed with residential neighborhoods, and residents in the area have been living with subsidence for decades. Starting in 2005, the Abandoned Mine Lands program has been working to try to grout the homes in the area to prevent further damage. The money for this effort was made available by the Office of Surface Mining, based on the history of ongoing damage and the age of the residential structures involved. Many of the residents are enrolled in the Mine Subsidence Protection Program. Structures built after 1989 would generally not qualify for assistance and would have to rely on the developer to adequately address potential subsidence hazards.

**CGS Case Study - Colorado School of Mines (Jefferson County) – Ongoing:** The Colorado School of Mines (CSM) has had ongoing subsidence issues related to the old clay mines west of the main campus for decades. At one point, one of the married student housing units was so badly damaged that it was uninhabitable. In recent years, the school has made the subsidence-prone area into an athletic field; however, ongoing subsidence-related issues are still being

reported. Sidewalks, streets, and two-story buildings have sustained substantial damage from settlement. The problem continues despite repeated repairs and some corrective work.

During the construction of the fields in 2004, depressions started occurring. In the spring of 2005 the area reactivated from the snowmelt runoff. Several open holes in the field were visible, and the street near the sorority houses was damaged. The structures themselves were not, as they sit on deep piers on the sandstone that was not mined.

A grouting program was implemented to try to stabilize the area in 2005; however, in 2006 additional street damage occurred and several new depressions were found in the field. In 2008, the DRMS conducted a geophysical survey to try to establish areas where voids still existed so that a mitigation strategy could be developed to avoid future damage.

### **5.3 COLLAPSIBLE SOILS**

The first settlers of the Plateau Region of western Colorado along the Colorado River, and the Uncompahgre and Paonia river basins, looked to fruit crops for their livelihood. The semi-arid but moderate climate was well suited for fruit orchards once irrigation canal systems could be constructed. But serious problems occurred when certain lands were first broken out for agriculture and wetted by irrigation. They sank, so much in places (up to four feet) that irrigation-canal flow directions were reversed, ponding occurred, and whole orchards, newly planted with fruit trees imported by rail and wagon at considerable expense, were lost. While not understood, fruit growers and agriculturists began to recognize the hazards of “sinking ground.” (Source: CGS)

**Garfield County:** A rancher’s stock-watering pond excavated in a pasture collapsed because of hydro-compaction. A bowl-shaped depression 60 feet across and eight feet deep resulted when he attempted to pond water in his field. The soils were so permeable that the pond would not hold water, and the wetted soils under the pond collapsed. Many roads and other improvements in the vicinity have been destroyed or damaged by soaking of collapsible, low density soils.

**Garfield County - 2003:** The town of Glenwood Springs lies within the valley confluence of the Roaring Fork and Colorado Rivers. Almost the entire town lies on coalesced alluvial fan and colluvial soils that were derived from sediments shed from the steep valley sides. These soil deposits are highly susceptible to hydrocompaction. The Terrace development included 13 two-story structures with basement-level garage drive-outs. Thick collapsible soils were previously mapped and identified at the site. These units were built from 2001 to 2003 and within six months of the first units completed and sold, collapse of the soil was causing settlement of the back concrete retaining-wall foundations, which caused deflection of interior beams, a host of interior cracks and structural offsets, and distortion of windows and doors. The homeowner’s association settled a lawsuit against the developer, the engineering consultants, and builder for \$12 million in 2005. Compaction grouting was used to structurally lift the settled areas of the buildings.

**Garfield County:** The Colorado Highway Department, recognizing that severe hydro-compaction along a highway alignment could totally destroy a road, investigated the potential for hydro-compaction along the alignment of Interstate 70 from Rifle to DeBeque. Water was impounded in a small pond and a road fill was placed beside the pond as a model of probable future conditions. The result of the test was that the ground surface sank three feet in one month. The test provided design information to prevent the possible future total failure of a portion of the highway. The engineering geologic investigation may have saved taxpayers millions of dollars.

## 6. IMPACT ANALYSIS

The consequences of improper utilization of land subject to ground subsidence will generally consist of excessive economic losses. This includes high repair and maintenance costs for buildings, irrigation works, highways, utilities, and other structures. At times, structures are condemned because of the damage. This results in direct economic losses to citizens, and indirect losses through increased taxes and decreased property values. Spontaneous ground openings can be dangerous if a sinkhole were to open below an occupied structure.

Subsidence can 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. Surface depressions created by subsidence may be filled in, only to sink further because the underground void has not been completely closed. Areas may appear to be free of subsidence for many years, and then undergo renewed gradual or even drastic subsidence.

The large ground displacements caused by collapsing soils can totally destroy roads and structures and alter surface drainage. Minor cracking and distress may result as the improvements respond to small adjustments in the ground beneath them.

FEMA estimates annual losses in the US at over \$125 million. Most homeowner's insurance policies specifically exclude subsidence events. Over 1,000 participants are currently enrolled in the Mine Subsidence Protection Program in Colorado. This program was set up to pay for damage to homes resulting from subsidence due to coal mining.

In 2009 the DRMS estimated that AML subsidence could potentially impact 25,000 people and 7,500 houses along the Front Range Urban Corridor ([http://mining.state.co.us/SiteCollectionDocuments/DRMS-044\\_subsidence\\_guide\\_FINAL-screenres.pdf](http://mining.state.co.us/SiteCollectionDocuments/DRMS-044_subsidence_guide_FINAL-screenres.pdf)). These numbers may be much higher now after several years of population and development growth in Colorado. AML subsidence can be extremely costly in damages to existing structures and interruption or abandonment of new development projects.

Subsidence events can occur, in most cases, without warning. Its impact can potentially have major consequences on all critical infrastructure/key resource sectors. A brief sampling of this impact is shown in Table 3-186.

TABLE 3-186 SUBSIDENCE EMAP IMPACT SUMMARY

Consideration	Description
<b>General Public</b>	Homeowners, developers, and owners of public and private facilities and infrastructure.
<b>First Responders</b>	Some exposure exists to personnel performing routine duties after a specific site is impacted and unstable.
<b>Property</b>	Subsidence can result in serious structural damage to buildings, roads, irrigation ditches, underground utilities, and pipelines. Instances of infrastructure damage due to compressing soil can cause major or long-term structural damage.
<b>Facilities and Infrastructure</b>	Subsidence can result in serious structural damage to buildings, roads, irrigation ditches, underground utilities, and pipelines.
<b>Economic</b>	None, or limited loss of facilities or infrastructure function or accessibility, and limited uninsured damages.
<b>Environment</b>	Subsidence events can alter the morphology and hydrology of an impacted area.
<b>Continuity of Government and Services</b>	None, or limited loss of facilities or infrastructure function or accessibility, or ability to provide services. May have limited power interruption if not adequately equipped with backup generation.
<b>Confidence in Government</b>	Characteristics of expansive soils such as duration and speed of onset result in limited response functions for government beyond building inspection and repair.
<b>Critical Assets</b>	Risk to any critical asset that does not have adequate mitigation actions taken during construction.

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

Based on previous occurrences and severity, impacts to population, property, and the economy are minimal for subsidence, or at least isolated to areas with specific solid or mining characteristics. There is a slight potential for environmental impacts, but only in a very limited scale. There is little potential for economic impact beyond a localized area.

There are a handful of counties in Colorado most at risk for subsidence related events. Figure 3-109 shows that Lake County has the most subsidence area compared to the total area of the county. Lake County is followed by Garfield, Routt, and El Paso Counties as having a relatively high amount of subsidence areas compared to total county area. Undermined areas are most prevalent in Las Animas, Huerfano, Fremont, Boulder, and Weld Counties, as shown in Figure 3-110. Collapsible soil risk is concentrated to just over a handful of Colorado counties as shown in Figure 3-111. El Paso, Larimer, Eagle, and Garfield Counties have the highest amount of

collapsible soil areas compared to total acres in the county. Montrose, Dolores, Montezuma, and San Juan Counties also show a higher risk for collapsible soil than other counties.

Subsidence was ranked as a high hazard by Lake County and the City of Colorado Springs in their local hazard mitigation plans. Only one county, Lake, listed subsidence as one of their top four hazards. Lake County identified 890 structures or parcels and 53 critical facilities in subsidence hazard areas. The potential loss from subsidence is estimated at \$39,435,904, based on GIS mapping of total exposure. Lake County did not identify any mitigation actions specifically related to subsidence.

The subsidence hazard rank by county based on local mitigation plans is shown in Figure 3-112.

FIGURE 3-109 SUBSIDENCE AREA RANK BY COUNTY

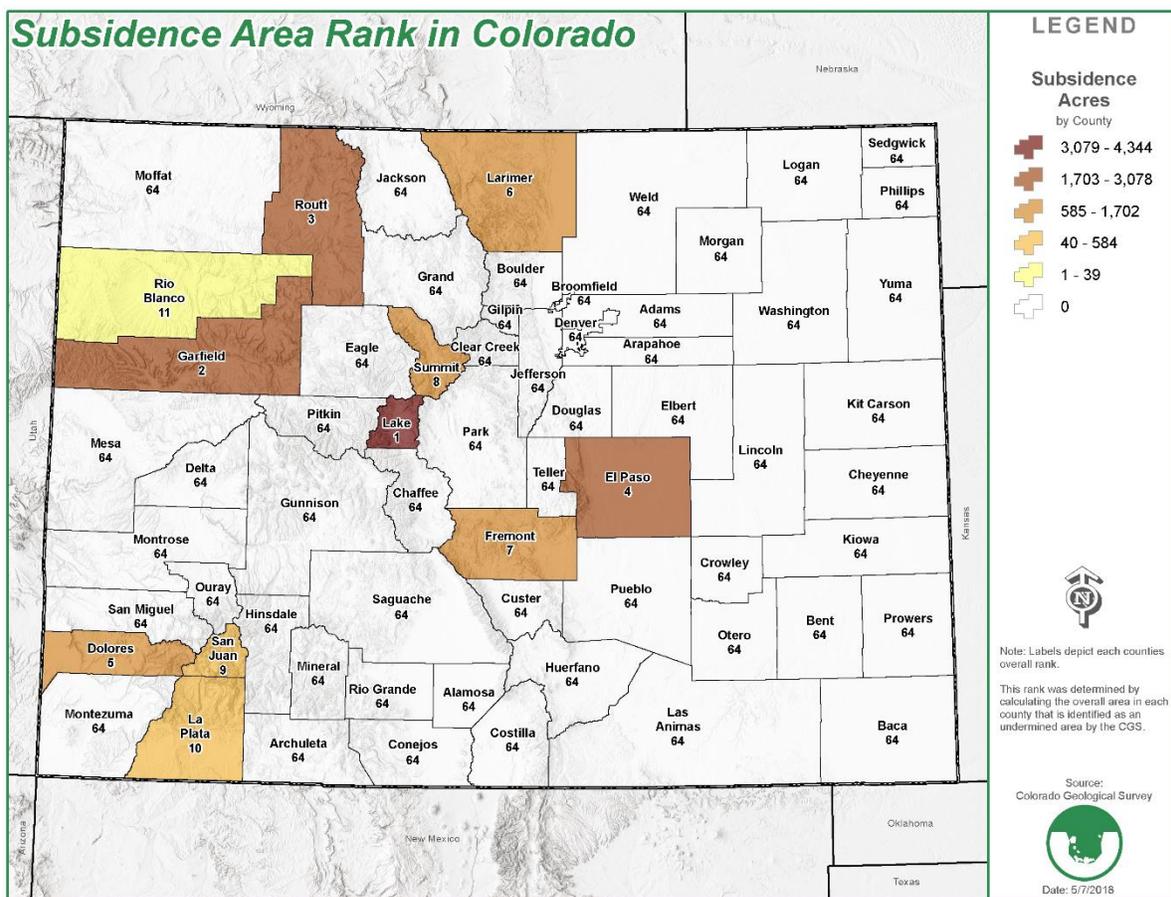




FIGURE 3-111 COLLAPSABLE SOIL RANK BY COUNTY

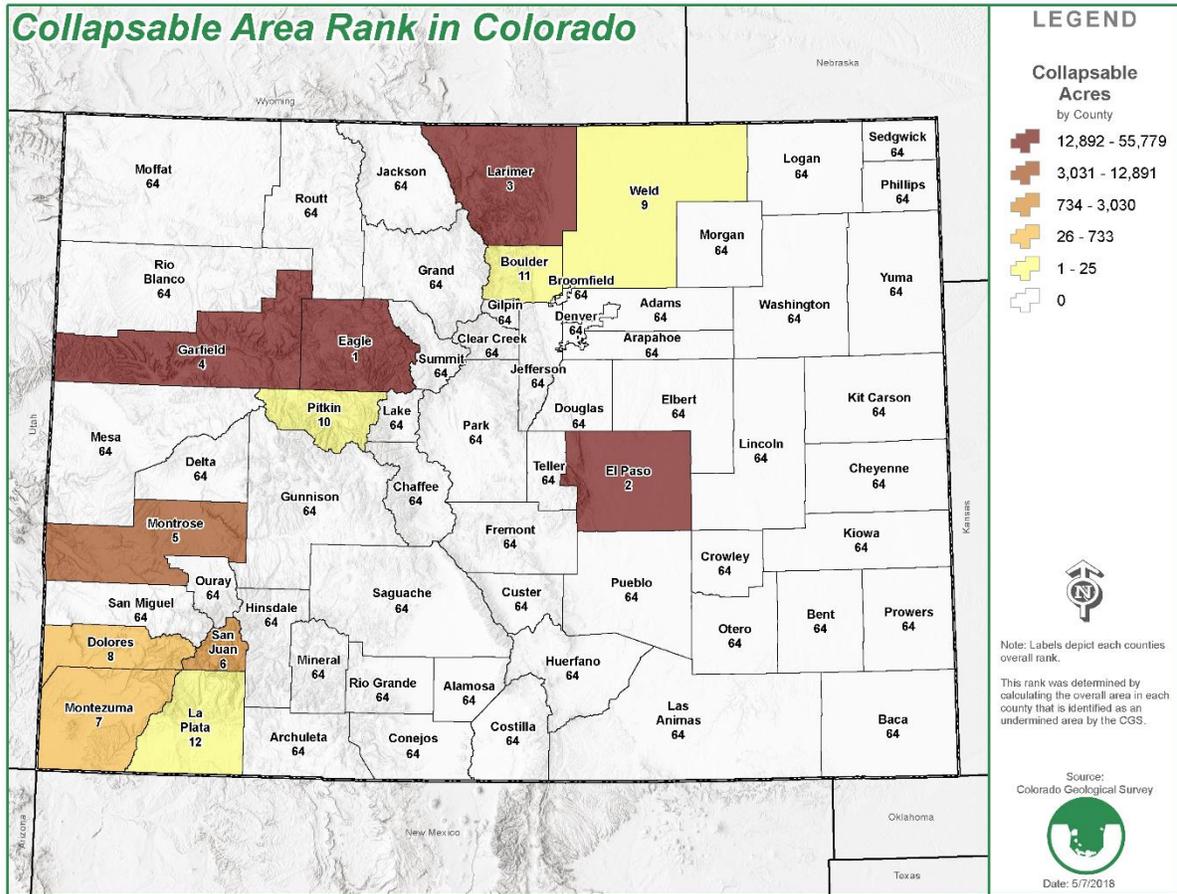
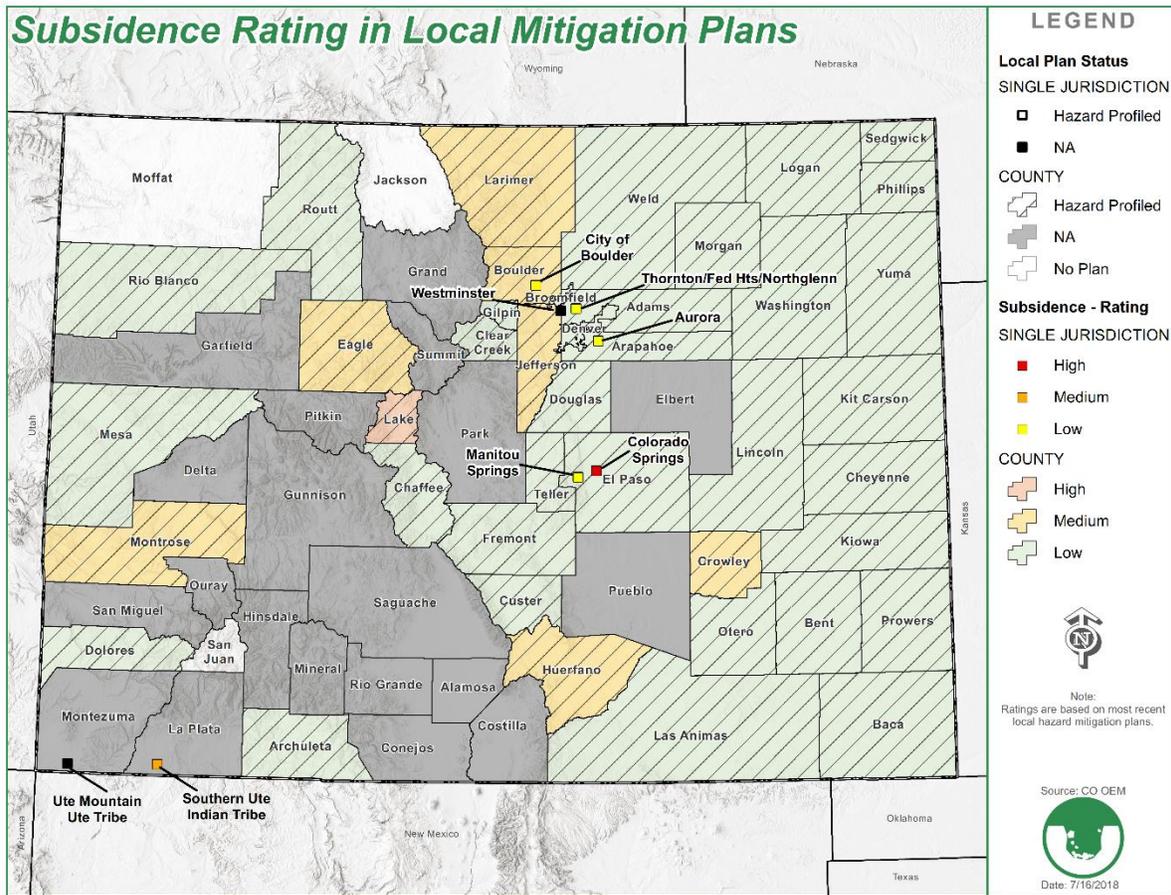


FIGURE 3-112 SUBSIDENCE HAZARD IN LOCAL MITIGATION PLANS



Another indication of vulnerability by jurisdiction is the prioritization of planned abandoned mine reclamation projects. The USFS has prioritized AMLs for reclamation to reduce the public safety risk.

## 8. FUTURE DEVELOPMENT

Future development will potentially intersect subsidence hazard areas. As Colorado's population continues to grow and the need for additional housing increases, more people and property may be affected by subsidence. Local land use planning agencies should consult federal and state sources including CGS, the US Forest Service, the Bureau of Land Management, and the Colorado Division of Reclamation, Mining, and Safety (DRMS) to identify known abandoned mine lands and other subsidence hazards before beginning development projects. Engineering geology and geotechnical investigations can help in identification of hazards and mitigation strategies.

Avoidance is generally the best mitigation solution where subsidence features are properly identified. Many older sinkholes may be hidden. Only subsurface inspections, either by

investigative trenching, a series of investigative borings, geophysical means, and/or observations made during overlot grading or utility installation, can ascertain whether sinkholes exist within a development area. Ground-modification and structural solutions can help mitigate the threat of localized subsidence. Drainage issues and proper water management are also important. In Colorado’s semi-arid climate, additional increases of fresh water may accelerate dissolution and further destabilize certain subsidence areas.

## 9. CLIMATE CHANGE

According to the best data available at the time of this plan update, the future impacts of climate change are not expected to influence future subsidence or abandoned mine land hazard events.

## 10. RISK TO STATE ASSETS

Subsidence includes sinkholes, undermined areas, and collapsible soils. Subsidence is an issue along the Front Range, Western Slope, the Colorado River Valley, and a few other isolated areas throughout the state. Because there is a significant amount of collapsible soils around the Denver metro area, there are a large number of state assets exposed to this risk.

Potentially collapsible soils account for the greatest subsidence risk to state assets. Throughout the state, 169 total assets with a value of \$320 million are at risk to these collapsible soils. The highest risk assets are educational uses, including higher education and school uses, with total combined value of \$266 million. Note that risk to state assets is significantly lower than reported risk in the previous version of this plan, particularly for subsidence areas. This discrepancy is likely due to using a more accurate set of data for state asset locations and better-defined hazard areas.

TABLE 3-187 STATE ASSETS AT RISK TO SUBSIDENCE BY USE TYPE

Type of Use	Undermined		Collapsible Soils		Subsidence	
	#	Value	#	Value	#	Value
Dining facility	-	-	1	\$664,760	-	-
Employee Housing	-	-	1	\$5,279	-	-
Garage Operations	-	-	2	\$2,842,846	-	-
Higher Education	78	\$340,861,960	41	\$183,395,402	-	-
Hotel/Residency	-	-	12	\$13,173,723	-	-
Lab	-	-	1	\$192,319	-	-
Maintenance/Repair	-	-	5	\$2,971,158	-	-
None	2	\$23,608	15	\$1,976,331	-	-
Office	-	-	5	\$9,863,678	-	-
Office type contents	3	\$13,358,098	11	\$6,398,158	-	-

Type of Use	Undermined		Collapsible Soils		Subsidence	
	#	Value	#	Value	#	Value
Other	10	\$4,618,664	35	\$10,799,241	-	-
Sand Shed	-	-	4	\$726,945	-	-
School	-	-	13	\$83,101,995	-	-
Shop/Metalworking	1	\$963,657	6	\$2,258,628	-	-
Storage	-	-	9	\$2,120,939	-	-
Storage Shed	-	-	6	\$274,693	-	-
Storage Tank	1	\$40,750	2	\$81,500	-	-
<b>Total</b>	<b>95</b>	<b>\$359,866,737</b>	<b>169</b>	<b>\$320,847,597</b>	<b>-</b>	<b>-</b>

Source: Colorado Geological Survey, Colorado Office of Risk Management

Distribution of state assets at risk to subsidence and associated value across Colorado is shown in Table 3-188. Counties not represented in the table did not intersect with the hazard data layers used for analysis. El Paso County has the highest number and value of state assets at risk, with 99 assets valued at over \$441 million in areas with undermined or collapsible soils. Larimer County has the second highest state asset value at risk to subsidence along the Front Range with over \$186 million at risk. Garfield County is a Western Slope example of an area with a high value of state assets exposed to subsidence. In Garfield, 17 state assets with a total of \$6.5 million at risk are potentially at risk to collapsible soils.

**TABLE 3-188 STATE ASSETS AT RISK TO SUBSIDENCE BY COUNTY**

County	Undermined		Collapsible Soils		Subsidence	
	Total Assets	Asset Value	Total Assets	Asset Value	Total Assets	Asset Value
Boulder	1	\$13,180,000	-	-	-	-
Dolores	-	-	4	\$2,184,887	-	-
Eagle	-	-	31	\$7,750,745	-	-
El Paso	74	\$335,902,17	25	\$105,797,818	-	-
Fremont	3	\$633,531	-	-	-	-
Garfield	-	-	17	\$6,564,979	-	-
Huerfano	9	\$4,232,873	-	-	-	-
Jefferson	5	\$4,527,958	-	-	-	-
Larimer	-	-	50	\$186,695,958	-	-
Las Animas	2	\$1,349,448	-	-	-	-
Montrose	-	-	42	\$11,853,211	-	-
Weld	1	\$40,750	-	-	-	-
<b>Total</b>	<b>95</b>	<b>\$359,866,73</b>	<b>169</b>	<b>\$320,847,597</b>	<b>-</b>	<b>-</b>

## 11. RESOURCES

- Colorado Geological Survey (CGS)
- Colorado Division of Reclamation, Mining, and Safety (DRMS)
- Federal Emergency Management Agency (FEMA)
- U.S. Forest Service (USFS)

# ANIMAL DISEASE



## 1. DEFINITION

Animal disease outbreak, as defined by FEMA, is the introduction of a highly contagious, infectious, or economically devastating animal disease or agent. The introduction of a new strain of virus not previously seen in the animal population, the accidental or intentional introduction of a foreign animal disease, or the reintroduction of a previously eliminated disease are all included in this definition.

According to the World Health Organization (WHO), a disease epidemic occurs when there are more cases of that disease than normal. A pandemic is defined as a disease affecting or attacking the population of an extensive region which may include several countries and/or continents. A pandemic is a worldwide epidemic of a disease and may occur when a new virus appears against which the human population has no immunity. Colorado State law requires the Colorado Department of Public Health and Environment (CDPHE) to monitor, investigate and control the causes of epidemic and communicable diseases affecting public health in Colorado.

Zoonotic diseases are a significant hazard to the state's population and livestock. Zoonotic diseases are those which can be transmitted between animals and humans. The CDHPE indicates that the most common of these diseases in Colorado are hantavirus, plague, rabies, tularemia, West Nile virus (WNV) (and other mosquito-borne diseases), and various tick-borne diseases. It is important to realize that this Plan does not examine pandemic contingency plans, but instead focuses on examining the risk of a normal hazard occurrence. Colorado's food and agriculture industry ranks among the state's most important economic drivers, generating \$41 billion to the state's economy and supporting more than 173,000 jobs.

### Reportable Diseases in Colorado

Below is a list of reportable diseases to the Colorado Area Office of the USDA or to the Colorado State Veterinarian's Office and includes diseases of interest to small animal practitioners and diseases reportable to the Colorado Department of Public Health and Environment. This list of diseases was compiled by the Colorado Department of Agriculture.

- Anaplasmosis (clinical disease only)
- Anthrax
- Avian Influenza (both high or low pathogenic)
- Bluetongue (clinical disease only)
- Brucellosis (bovine, porcine, ovine, or canine)
- Bovine Babesiosis
- Bovine Spongiform Encephalopathy (BSE)
- Chronic Wasting Disease (CWD)
- Contagious Equine Metritis (CEM)

- Epizootic Hemorrhagic Disease (EHD) in livestock
- Equine Encephalomyelitis
- Equine Infectious Anemia (EIA) (positive Coggins/ELISA)
- Equine Piroplasmiasis
- Equine Viral Arteritis
- Equine Herpes Myeloencephalopathy (EHM)
- Exotic Newcastle Disease
- Johne's Disease
- Malignant Catarrhal Fever
- Plague
- Psittacosis
- Pseudorabies
- Rabies
- Salmonella (pullorum or enteritidis)
- Scabies (cattle or sheep)
- Scrapie
- Screwworm
- Senecavirus A or Seneca Valley Virus (SVV)
- Swine Enteric Coronavirus Diseases (new) – porcine epidemic diarrhea virus (PEDV) or porcine delta coronavirus (PDCoV)
- Trichomoniasis
- Tuberculosis
- Tularemia<sup>1,2</sup>
- Vesicular Stomatitis (all species)
- Vesicular Diseases (all species)
- West Nile virus

(1) Diseases of interest to small animal practitioners

(2) Diseases reportable to the Colorado Department of Health and Environment

Table 3-189 presents a summary of animal disease's impacts to the state:

**TABLE 3-189 HAZARD PROFILE SUMMARY**

<b>Consideration</b>	<b>Impact</b>	<b>Description</b>
<b>Location</b>	Statewide	Farms are dispersed throughout the state, meaning impacts of an outbreak could have statewide impacts.
<b>Previous Occurrence</b>	Perennial	Between 2010 and 2015 there were a consistent recording of outbreaks for recorded diseases.
<b>Probability</b>	Likely	Previous local outbreaks of disease such as plague, tularemia, and West Nile virus, as well as the evident increase in global trade are all indicators of this possibility.

Consideration	Impact	Description
<b>Extent</b>	Extensive	Epidemics result in mass mortality of animals, resulting in the devastation of economic impacts on industries and communities.

## 2. LOCATION

The State of Colorado comprises over 33,800 farms, with over 31,700,000 acres zoned as farmland maintaining a livestock inventory of over 8,800,000 (USDA 2012; State Agricultural Overview 2012). The geographical makeup of the state has lent itself to a widespread mixture of farm properties statewide.

## 3. EXTENT (MAGNITUDE/STRENGTH)

Epidemics result in mass mortality of animals, resulting in devastating economic impacts on industries and communities. Some animal diseases, such as Salmonella, influenza, and Equine Encephalitis, can also infect humans. Animal disease costs are due to loss of production, loss of animals, human morbidity and mortality, days of lost work, and legal actions (FEMA 2011).

## 4. PROBABILITY

Predicting the likelihood of future occurrences of animal disease outbreak is difficult. However, the likelihood of an animal disease outbreak affecting the State of Colorado is possible. Previous local outbreaks of disease such as plague, tularemia, and West Nile virus, as well as the evident increase in global trade are all indicators of this possibility. The high concentration of farms located throughout Colorado makes the state susceptible to livestock outbreaks. Outbreaks in the domesticated animal population is also possible, and could be very influential due to population density and the saturation of pets within households.

## 5. PREVIOUS OCCURRENCES

While the availability of historical data is somewhat limited for this hazard, there is a basis for considering animal disease as a major hazard. Table 3-190 shows the outbreaks between 2010 and 2015.

TABLE 3-190 2015 COLORADO ZOOSES REPORT

Disease	Report Year					5-Year Average (2010-2014)	Report Year
	2010	2011	2012	2013	2014		2015
<b>Anthrax</b>	0	0	0	0	0	0	0
<b>Brucellosis</b>	1	0	2	1	3	1.4	0

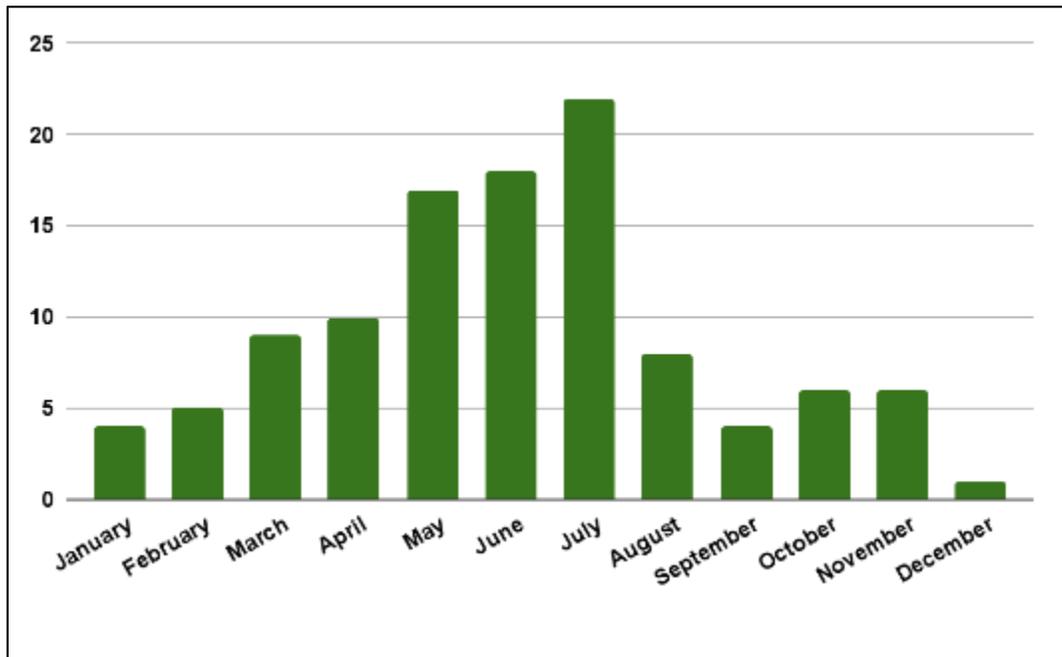
Disease	Report Year					5-Year Average (2010-2014)	Report Year
	2010	2011	2012	2013	2014		2015
<b>Chikungunya</b>	No data	No data	No data	No data	14	N/A	8
<b>Dengue</b>	No data	No data	No data	No data	10	N/A	13
<b>Hantavirus</b>	5	4	3	2	6	4.4	6
<b>Malaria</b>	31	27	30	31	30	29.8	21
<b>Plague</b>	0	0	1	0	8	1.8	4
<b>Psittacosis</b>	0	0	0	0	0	0	0
<b>Q-Fever, Acute</b>	4	2	9	5	4	4.8	7
<b>Q-Fever, Chronic</b>	0	2	1	3	2	1.4	1
<b>Rabies, Human</b>	0	0	0	0	0	0	0
<b>Rabies, Animal</b>	136	104	183	187	130	148	119
<b>Rocky Mountain Spotted Fever</b>	2	3	7	5	5	4.4	7
<b>Tick-borne Relapsing Fever</b>	1	7	7	6	2	4.6	3
<b>Tularemia</b>	3	3	0	2	16	4.8	52
<b>West Nile virus</b>	79	7	134	321	118	131.8	101

Source: CDPHE

### 5.1 HANTAVIRUS

Hantavirus Pulmonary Syndrome (HPS) is an infectious respiratory disease endemic to North and South America. It is caused by a virus generally known as the hantavirus. Hantavirus is spread through the saliva, urine, and feces of the deer mouse and is caused by the Sin Nombre virus. Contamination is only possible when humans come into direct contact with the rodents or dust and feces contaminated by the mice. Hantavirus was initially identified in the Four Corners region of the United States in 1985. The CDPHE reports that mitigation of the disease includes adequate sanitation and use of respiratory and eye protection when working in areas where exposure may occur, including barns, hay lots, basements, and attics. Figure 3-113 shows that hantavirus cases occur year-round, though they peak from May-July of each year.

FIGURE 3-113 HANTAVIRUS CASES, COLORADO 1955-2017

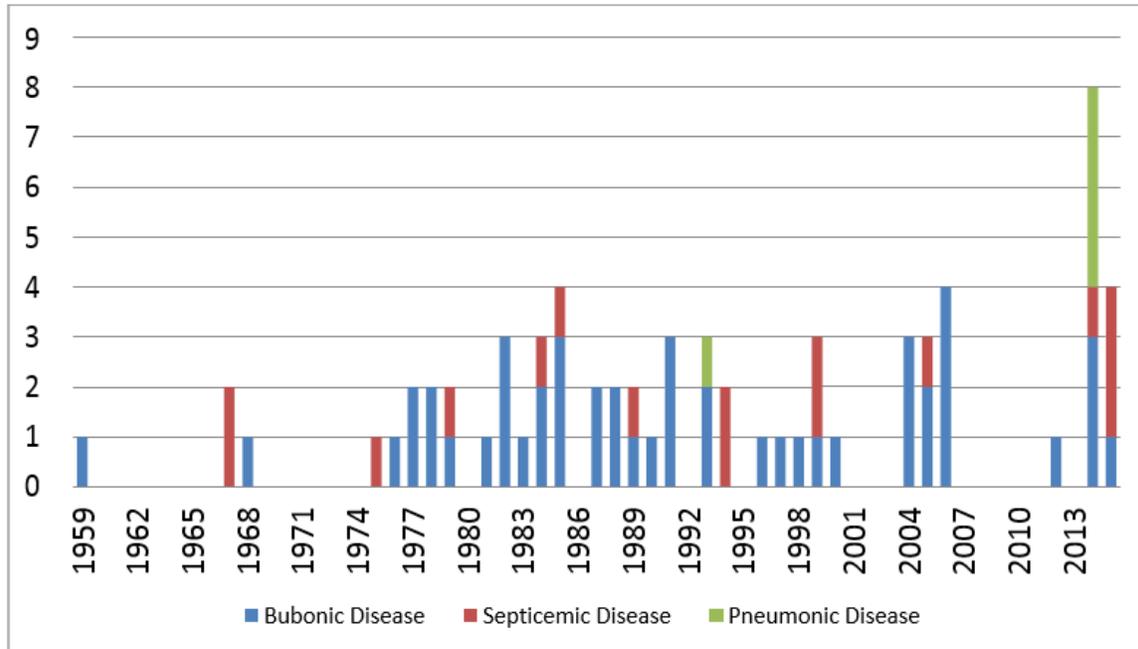


Source: CDPHE

## 5.2 PLAGUE

Plague is a disease caused by a bacterium known as *Yersinia pestis*. It is reported in the Zoonotic Disease in Colorado 2015 Annual Report that there are many syndromes that occur and have been given their own sub-name. These sub-names include: bubonic, septicemic, and pneumonic. Bubonic plague causes painful, swollen lymph nodes, fever, headache, and chills; septicemic plague is a blood infection that results in high fever, chills, abdominal pain, and shock. Septicemic plague may cause tissues such as fingers, toes, and nose to turn black and die; pneumonic plague causes a fever, headache, weakness, and a rapidly developing pneumonia, and if left untreated can lead to respiratory failure and shock. The plague bacterium spreads through the transfer of flea bites or direct contact from animals to humans and can be treated with antibiotics. Colorado reported four human cases of plague in 2015, unfortunately two of the affected individuals did not survive. The etiological agent of plague, *Yersinia pestis*, was also active in the animal kingdom. Figure 3-114 presents historical plague cases per year. Table 3-191 show which counties currently test wildlife for plague and Table 3-192 detail those species types being tested.

FIGURE 3-114 HUMAN PLAGUE BY YEAR AND DISEASE TYPE, COLORADO 1975-2015



Source: CDPHE

TABLE 3-191 COUNTIES TESTING WILDLIFE FOR PLAGUE

County	Negative	Positive	Total
Adams	1	0	1
Archuleta	1	0	1
Boulder	2	0	2
Broomfield	5	0	5
Clear Creek	0	1	1
Denver	1	0	1
El Paso	1	2	3
Jefferson	10	2	12
La Plata	1	0	1
Larimer	4	2	6
Las Animas	1	0	1
Lincoln	1	0	1
Mesa	3	0	3
Pueblo	11	0	11
Weld	1	1	2
<b>Total</b>	<b>43</b>	<b>8</b>	<b>51</b>

Source: CDPHE

\*Counties not listed did not test animals for plague

\*Data from January 1- December 8, 2017

TABLE 3-192 SPECIES OF WILDLIFE TESTED

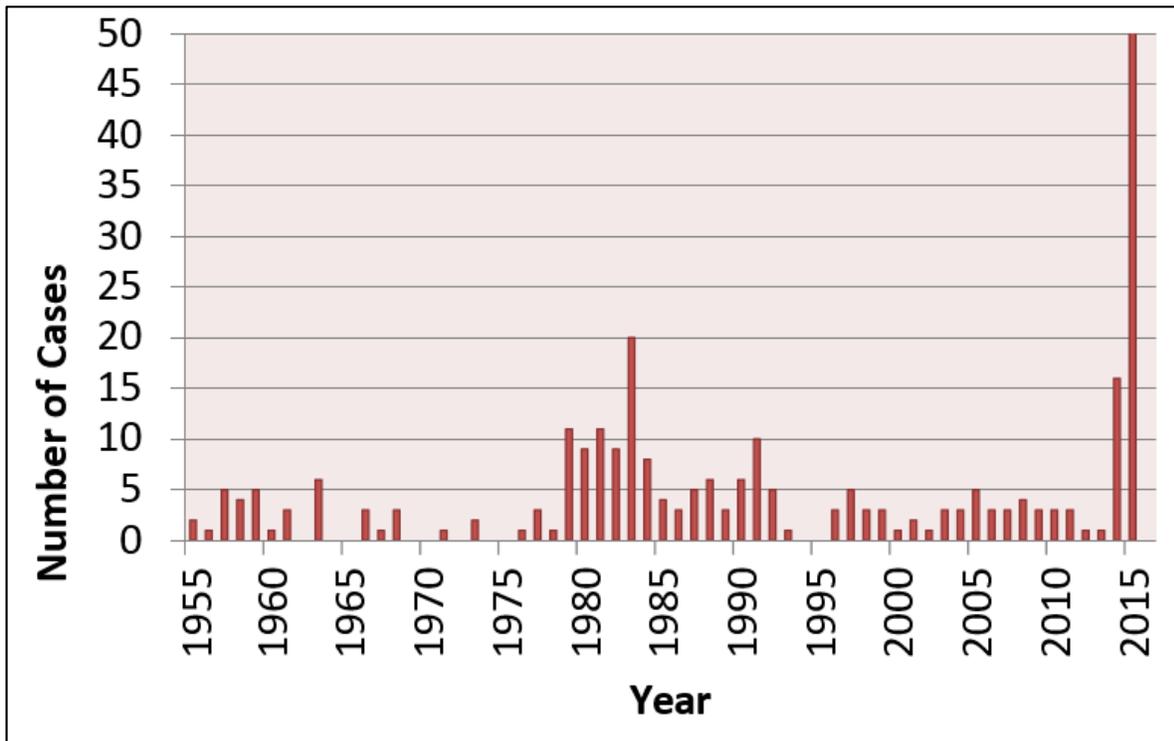
Wildlife	Negative	Positive	Total
Flea pools	6	1	7
<b>Rodent</b>			
Prairie dog	3	4	7
Tree squirrel	8	0	8
Other rodent	2	0	2
<b>Wildlife</b>			
Fox	3	2	5
Rabbit	19	0	19
Raccoon	1	0	1
Mountain Lion	1	1	2
<b>Total</b>	<b>43</b>	<b>8</b>	<b>51</b>

Source: CDPHE

### 5.3 TULAREMIA

Tularemia is a disease caused by the bacterium *Francisella tularensis*. This disease is often referred to as rabbit fever, due to the transfer of bacterium *Francisella tularensis* from rabbits or other wild rodents to humans by contact with infected animal tissues or ticks. Symptoms of this disease primarily are ulceroglandular (a skin ulcer and swollen lymph nodes), glandular (swollen lymph nodes and no ulcer), typhoidal (blood infection or septicemia), and pneumonic (cough, chest pain, and difficulty breathing). It is reported in the Zoonotic Disease in Colorado 2015 Annual Report that 52 people in Colorado were diagnosed as having a clinical illness from infection with *Francisella tularensis* in 2015, the etiological agent of tularemia. These cases presented with a diverse range of symptoms including glandular/ulceroglandular, pneumonic, gastrointestinal, and typhoidal. In 2015, 37 animals tested positive for tularemia in Colorado. Twenty-three of these animals were rabbits and 10 were rodents. A total of 62 dogs and cats were tested for tularemia; two cats and two dogs were positive. Figure 3-115 shows historical tularemia cases across the state since 1955.

FIGURE 3-115 HUMAN TULAREMIA CASES, COLORADO 1955 TO 2015



Source: CDPHE

#### 5.4 WEST NILE VIRUS

According to the Zoonotic Disease in Colorado 2015 Annual Report, West Nile virus is the most common arboviral disease in Colorado. West Nile occurs most often by the bite of an infected mosquito. Other ways of transferring West Nile Disease may be infrequent but can include: organ transplant, receipt of blood products, breastfeeding, and intrauterine transmission.

The reservoir animal for West Nile virus is birds. Other animals, particularly horses, are susceptible to infection but do not serve as reservoirs. In Colorado, West Nile virus human cases can be identified as early as May and as late as December of each year, with the vast majority of cases identified in August and September. During the most common transmission months of June-August, surveillance of mosquitoes is conducted throughout the state to determine the commonness of virus in the mosquito population and guide decisions on when to conduct mosquito control activities.

In 2015, a total of 101 cases of human West Nile virus infection were identified in Colorado. In addition to the human cases of West Nile virus, a total of 15 horses and 15 birds from Colorado were also identified by laboratory testing.

## 6. IMPACT ANALYSIS

Both animal and human health issues could be adversely impacted from any form of animal disease outbreak. Public health could be significantly threatened by the exposure and transfer

of foreign strains of animal disease. The lack of immunity to these diseases creates a higher risk of susceptibility to both the animal and human population.

Furthermore, there is potential for significant economic impact. The livestock industry, as a whole, could be detrimentally impacted. Use of the state’s animal production for products, food, or any combination of the two could be halted if there were an outbreak occurrence. This would not only impact the livestock industry, but industries that rely on the state’s animal production as well. Response actions to an outbreak are costly. Having to take actions such as quarantine, dispatch, and disposal could have the potential to bring about financial vulnerability of the livestock industry. Taking these actions would likely meet with some public resistance and could lead to a loss of the public’s confidence.

There is also the potential for environmental impacts. Animal disease could have long term impacts on the wildlife in Colorado. A serious event could have the potential to entirely deplete a species of its population. A variety of environmental factors could also influence the spread of disease. Disease could potentially be spread through the water supply, sanitation facilities, food, and more.

Disease outbreaks have many adverse impacts and consequences. Table 3-119 summarizes some of the adverse impacts and consequences that can come from animal disease outbreaks.

**TABLE 3-193 ANIMAL DISEASE EMAP IMPACT SUMMARY**

<b>Consideration</b>	<b>Description</b>
<b>General Public</b>	Public health is at risk. If an outbreak occurs, measures to protect the public from exposure should be taken.
<b>First Responders</b>	Exposure to the disease could impact first responders
<b>Property</b>	No Impact.
<b>Facilities and Infrastructure</b>	No Impact.
<b>Economic</b>	Colorado’s livestock industry, as well as related industries are at risk during an outbreak.
<b>Environment</b>	Entire species are at risk. Environmental factors can also be influential in spreading the disease.
<b>Continuity of Government and Services</b>	None or limited impact.
<b>Confidence in Government</b>	An occurrence could lead to lack of confidence in global trade initiatives.
<b>Critical Assets</b>	Increased risk impacted facilities including animal shipping and receiving facilities, livestock meat processing centers, and dairy processing centers.

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

It is difficult to estimate the impact that animal disease outbreak could have on the State of Colorado. This is due to the fact that each occurrence would require a different form of response. The livestock industry in Colorado functions as a system, and the impact of disease on any portion of the industry would provide a trickle-down impact on the state's economy, making the overall loss significant. The agriculture industry is a critical driver of Colorado's economy, contributing \$41 billion. The losses associated with an animal disease outbreak would not only directly impact the livestock value, but also the farming, transportation, processing, and animal medical industry that directly supports Colorado's farmers.

Based on a recent (2017) review of local hazard mitigation plans, no jurisdictions profiled an animal disease outbreak in local plans.

## 8. FUTURE DEVELOPMENT

Future development has a limited relationship to animal disease risk. If an occurrence of animal disease outbreak were to impact and diminish the livestock industry, land currently used for livestock production could be converted for other uses.

Based on review of local hazard mitigation plans, no jurisdiction provided information regarding future development and animal disease outbreak.

## 9. CLIMATE CHANGE

According to the best data available at the time of this plan update, the future impacts of climate change are expected to influence future animal disease events. Table 3-194 presents a breakdown of these projected changes in terms of hazard: location, extent/intensity, frequency, and duration. However, ongoing efforts to reduce Colorado's greenhouse gas emissions and adapt to a changing climate, such as the Colorado Climate Plan and the Climate Change in Colorado Report, will help to reduce the impacts of climate change on animal disease.

TABLE 3-194 CLIMATE CHANGE IMPACTS

Impact	Projected Change
<b>Location</b>	Warmer stream temperatures could have direct and indirect effects on aquatic ecosystems, including the spread of non-native species and diseases to higher elevations.
<b>Extent/Intensity</b>	The extent is projected to increase with climate change. Climate change may increase the prevalence of parasites and diseases that affect livestock (i.e., the earlier onset of spring and warmer winters could allow some parasites and pathogens to survive more easily).
<b>Frequency</b>	Under warmer winter temperatures, new pests and diseases may become established.

Impact	Projected Change
<b>Duration</b>	Under warmer winter temperatures, some existing agricultural pests can persist year-round.

Source: FEMA 2017

## 10. RISK TO STATE ASSETS

There is no direct risk to state assets from animal disease. Usually, disease does not directly cause property damages or losses. Some zoonotic diseases may impact livestock, which may have a significant impact on the economics of the planning area. Other diseases impact the human population, which may have secondary impacts on the production of materials, goods, and services while the population is ill. The most common method of evaluating the magnitude and severity of a disease, however, is to examine how many people are likely to fall ill, and of those, how many are likely to die. Since 2008, there have been no state asset property losses reported due to animal disease outbreak.

## 11. RESOURCES

- Colorado Department of Agriculture (CDA), Animal Health Division
- Colorado Department of Public Health and Environment (CDPHE)
- Colorado Office of Economic Development and International Trade (OEDIT)
- Federal Emergency Management Agency (FEMA). (2017). Assessing Future Conditions, Colorado.
- Southeast Colorado Regional Hazard Mitigation Plan
- The Center for Food Security and Public Health, Animal Disease Emergencies – Local Preparedness and Response
- Zoonotic Disease in Colorado: Annual Report 2015, Colorado Department of Public Health and Environment (CDPHE)

# PANDEMIC



## 1. DEFINITION

Pandemic is defined as a disease affecting or attacking the population of an extensive region which may include several countries and/or continents. It is further described as extensively epidemic. Generally, pandemic events cause sudden, pervasive illness in all age groups on a global scale. The exact size and extent of the infected population is dependent upon how easily the illness is spread, the mode of transmission, and the amount of contact between infected and non-infected persons. Table 3-195 describes the hazard summary for pandemics.

TABLE 3-195 HAZARD SUMMARY TABLE

Consideration	Impact	Description
<b>Location</b>	Statewide	A pandemic has the potential to affect every county within the state.
<b>Previous Occurrence</b>	Sporadic	There is no particular pattern for when pandemics can occur. There have been four in the past century in the United States.
<b>Probability</b>	Occasional	They arise typically when new variations of existing viruses emerge, to which there is no active immunity.
<b>Extent</b>	Extensive	Depending on the disease, many people could die as a result of illness. For many varieties of flu, those who die have existing health complications that compound with the virus, leading to death.

## 2. LOCATION

Pandemics occur not only on a state or regional level, but on a national and global scale. It is likely that most counties in Colorado would be affected, either directly or by secondary impacts. The last pandemic, the 2009 H1N1 flu, saw 54 counties affected. All communities in the state are likely to be impacted, either directly or indirectly. Some indirect consequences may be the diversion of resources that may be otherwise available.

## 3. EXTENT (MAGNITUDE/STRENGTH)

The magnitude of a health-related emergency will range significantly depending on the aggressiveness of the virus in question and the ease of transmission. Pandemic influenza is more easily transmitted from person-to-person and is more easily transmitted than West Nile virus, but advances in medical technologies have greatly reduced the number of deaths caused by influenza over time. In terms of lives lost, the impact various pandemic influenza outbreaks have had globally over the last century has declined.

There are three conditions that must be met before a pandemic influenza begins:

- 1) A new virus subtype must emerge that has not previously circulated in humans (and therefore there is no pre-existing immunity),
- 2) This new subtype must be able to cause disease in humans, and,
- 3) The virus must be easily transmissible from human to human.

Table 3-196 describes the World Health Organization’s six main phases to a pandemic flu as part of their planning guidance.

**TABLE 3-196 WORLD HEALTH ORGANIZATION'S PANDEMIC FLU PHASES**

Phase	Description
1	No animal influenza virus circulating among animals have been reported to cause infection in humans.
2	An animal influenza virus circulating in domesticated or wild animals is known to have caused infection in humans and is therefore considered a specific potential pandemic threat.
3	An animal or human-animal influenza reassortant virus has caused sporadic cases or small clusters of disease in people, but has not resulted in human-to-human transmission sufficient to sustain community-level breakouts.
4	Human-to-human transmission of an animal or human-animal influenza reassortant virus able to sustain community-level breakouts has been verified.
5	The same identified virus has caused sustained community-level outbreaks in two or more countries in one WHO region.
6	In addition to the criteria defined in Phase 5, the same virus has caused sustained community-level outbreaks in at least one other country in another WHO region.
<b>Post-Peak Period</b>	Levels of pandemic influenza in most countries with adequate surveillance have dropped below peak levels.
<b>Post-Pandemic Period</b>	Levels of influenza activity have returned to levels seen for seasonal influenza in most countries with adequate surveillance.

Source: World Health Organization

## 4. PROBABILITY

The Colorado Department of Public Health and Environment (CDPHE) considers a pandemic to be inevitable. However, there is no definite way to predict when a pandemic might happen. Some indicators will be present, but not every new virus turns into a pandemic.

Based on historical incidents throughout the United States, another pandemic would cause 1.4 million Coloradans to become seriously ill. It is estimated that between 3,000 and 30,000 people from Colorado would die from the virus itself or from resulting complications.

## 5. PREVIOUS OCCURRENCES

Pandemics have occurred throughout history, but it has only been in the last century that proper records have been kept regarding their cause and origins. The four most serious pandemics that the Centers for Disease Control and Prevention (CDC) has recorded are the result of influenza viruses. These occurred in 1918, 1957, 1968, and 2009.

**1918 Spanish Flu:** In 1918, a powerful strain of the flu, colloquially known as “Spanish Flu,” spread throughout the world. The virus was extremely deadly, bringing on pneumonia that filled its victim’s lungs with fluid. Worldwide, an estimated 21-50 million people died between 1918 and 1919 as a result of the flu. In Colorado, an estimated 8,000 people were killed by the flu and by complications. The state had one of the highest mortality rates in the country, possibly because of the large population with compromised lung function, including miners and tubercular patients. It would not be uncommon for terminal patients to request their caretakers to end their life. The 1918 Spanish flu pandemic remains the worst-case pandemic event on record.

The Denver Library website provided an excerpt from the autobiography of Nova Eisner Rose, detailing the effects of the Spanish Flu on her family:

*“Father caught it. Mother took a leave of absence [from teaching at Denver’s Whittier School] and went up to nurse him, but she herself became so tired she then sent for me to come from my college freshman year and relieve her. The second day after I arrived, Father died of a massive hemorrhage. His body was taken to Denver for burial, but the day of the funeral I couldn’t raise my head from the pillow. People avoided gatherings in those days, so Mother alone saw my Father buried (Denver’s Influenza Pandemic of 1918, Denver Public Library, 2018).”*

**1957 Asian Flu:** In February 1957, a new influenza A (H2N2) virus emerged in East Asia, triggering a pandemic (“Asian Flu”). This H2N2 virus was comprised of three different genes from an H2N2 virus that originated from an avian influenza A virus, including the H2 hemagglutinin and the N2 neuraminidase genes. It was first reported in Singapore in February 1957, Hong Kong in April 1957, and in coastal cities in the United States in summer 1957. The estimated number of deaths was 1.1 million worldwide and 116,000 in the United States.

**1968 Flu:** The 1968 pandemic was caused by an Influenza A (H3N2) virus comprised of two genes from an avian Influenza A virus, including a new H3 hemagglutinin, but also contained the N2 neuraminidase from the 1957 H2N2 virus. It was first noted in the United States in September 1968. The estimated number of deaths was one million worldwide and about 100,000 in the United States. Most excess deaths were in people 65 years and older. The H3N2 virus continues to circulate worldwide as a seasonal Influenza A virus. Seasonal H3N2 viruses, which are associated with severe illness in older people, undergo regular antigenic drift.

**2009 Swine Flu:** In the spring of 2009, a new version of the H1N1 virus emerged. This version, due to its genetic lineage, became known as Swine Flu. By June, the Centers for Disease Control and Prevention (CDC) had stopped counting cases and declared it a pandemic. The CDC estimated that there were 60.8 million cases, 274,304 hospitalizations, and 12,469 deaths throughout the United States.

In Colorado, there had been 2,041 hospitalizations across 54 counties by May of 2010. A total of 69 people died. Unlike most other pandemics, deaths were fairly spread out amongst all age groups, with younger generations taking more of the brunt. This is likely because older generations had been exposed to another version of H1N1 at some point in their lives, giving them some immunity, while those who were younger had no existing immunity. Deaths by age group are shown in Table 3-197.

Of those who were hospitalized, the CDC estimated that about 70 percent of them belonged to a high-risk group, meaning they likely had existing complications that only compounded the illness.

**TABLE 3-197 DEATHS BY AGE GROUP CAUSED BY H1N1**

Age	Deaths	Percent Total	Death Rate per 100,000
<b>0-18</b>	12	17.4%	0.91
<b>19-24</b>	4	5.8%	0.86
<b>25-49</b>	23	33.3%	1.27
<b>50-64</b>	19	27.5%	2.05
<b>65+</b>	11	15.9%	2.25
<b>Total</b>	<b>69</b>	<b>100.0%</b>	<b>1.38</b>

Source: Colorado Legislative Council Staff

## 6. IMPACT ANALYSIS

Pandemics have the ability to shut down large segments of the population for long periods of time. Unscheduled sick leave from a large portion of the workforce could result in millions, even billions, of dollars lost in productivity. As previously discussed, an estimated 3,000 to 30,000 people could die as a result of a widespread, deadly pandemic. This is the equivalent population of small towns or counties.

In the event of a pandemic, medical personnel would be incredibly overtaxed. Help from the federal government and from other states would likely be limited, as all personnel would be deployed throughout the country already. While the federal government would do what they can, communities would have to rely on their own resources for a much longer period of time as compared to other disasters.

Medications may be limited to help prevent or treat the disease. It takes five to six months to manufacture a vaccine, but it would likely become available in small quantities at first. It may

become necessary to ration limited amounts of medications, vaccinations, and other health care supplies.

Social and economic disruptions could be temporary but may be amplified in today's closely interrelated and interdependent systems of trade and commerce. Social disruption may be greatest when rates of absenteeism impair essential services, such as power, transportation, and communications.

In planning for a pandemic, there is no way to be 100 percent prepared for every scenario, so assumptions have to be made in order to help as many people as possible in a timely and efficient manner. These are guidelines and should be used for planning only:

- A. Susceptibility to the virus will be universal.
- B. The clinical disease attack rate will be about 30 percent of the overall population. The highest rates will be among school-aged children, at around 40 percent. About 20 percent of working adults will become ill.
- C. Of those who become ill with the new strain, 50 percent will seek outpatient medical care.
- D. In an infected community, a pandemic outbreak will last about six to eight weeks, with at least two waves likely. The seasonality cannot be predicted with certainty.
- E. The number of hospitalizations and death will depend on the virulence of the virus.
- F. Based on an extrapolation for a severe pandemic, Colorado deaths are estimated to exceed 30,000. It is assumed that the pandemic will occur in two waves, lasting six to eight weeks each. Colorado can expect to see approximately 350 deaths per day. This factors in the 80 deaths per day that Colorado typically has per day.
- G. Risk groups for severe and fatal infections cannot be predicted with certainty. During annual fall and winter influenza season, infants and the elderly, persons with chronic illnesses, and pregnant women are usually at higher risk of complications from influenza infections.
- H. In a severe pandemic, it is expected that absenteeism may reach 40 percent due to illness, the need to care for ill family members, and fear of infection during the peak weeks of a community outbreak. Certain public health measures (closing schools, quarantining household contacts of infected individuals, "snow days") are likely to increase rate of absenteeism.
- I. The typical incubation period is two days. It is assumed this would be the same for a novel strain that is transmitted between people by respiratory secretions.
- J. Persons who become ill may shed the virus, and can transmit infection for up to one day before the onset of symptoms. Viral shedding and the risk of transmission will be greatest during the first two days of illness. Children shed the greatest amount of virus and are therefore the most likely to pose a risk for transmission.

- K. On average, infected persons will transmit the infection to approximately two other people. Some estimates from past pandemics have been higher.
- L. Outbreaks can be expected to occur simultaneously throughout much of the United States, preventing shifts in human and material resources that usually occur in response to other disasters.
- M. Localities must be prepared to rely on their own resources to respond. The effect of influenza on individual communities will be relatively prolonged (weeks to months) in comparison to other types of disasters.
- N. Healthcare workers, public health workers, and other responders (i.e., law enforcement and firefighters) may be at higher risk of exposure and illness than the general population, further straining the pandemic response.
- O. Effective prevention and therapeutic measures, including vaccine and antiviral agents, may be delayed and, initially, in short supply or not available.
- P. Substantial public education regarding the need to target priority groups for vaccination and possibly for antiviral medication, and rationing of limited supplies, is paramount to controlling public panic.
- Q. Adequate security measures must be in place while distributing limited supplies of vaccine or antiviral medication.
- R. All plans must account for the uncertainty of the situation.

Table 3-198 describes the impact summary for pandemics.

**TABLE 3-198 PANDEMIC EMAP IMPACT SUMMARY TABLE**

<b>Consideration</b>	<b>Description</b>
<b>General Public</b>	Approximately 30 percent of the general public would become seriously ill. Half of those may require medical care, and 10 percent may need to be hospitalized.
<b>First Responders</b>	Medical staff would be overburdened with hundreds of additional cases on top of their normal workload. All other responders will be impacted in similar proportions to the general public, thereby reducing available responders.
<b>Property</b>	Property would not be directly affected by a pandemic.
<b>Facilities and Infrastructure</b>	Facilities and infrastructure would not be directly affected by a pandemic.
<b>Economic</b>	In the event of a pandemic, upwards of 50 percent of the working population may be out sick. Fear of public gatherings would eliminate most in-person commerce.

Consideration	Description
<b>Environment</b>	There are not likely to be any environmental effects from a pandemic.
<b>Continuity of Government and Services</b>	With an estimated 30 percent of the workforce absent, the continuity of government may be severely affected. The state has Continuity of Operations Plans (COOPs) for pandemics that seek to minimize the amount of time and efficiency lost to a pandemic flu.
<b>Confidence in Government</b>	It is expected that the government will work towards a solution that will end the pandemic, typically by helping to distribute vaccines and antiviral agents. Continual public messaging and outreach is vital.
<b>Critical Assets</b>	Schools and hospitals will take the brunt of a pandemic. Nearly 40 percent of children may contract a pandemic flu, which can result in schools needing to close to halt the spread of the disease. Hospitals will be greatly overburdened during this period because of the influx of new patients.

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

It is possible for anyone to contract a pandemic disease. With many diseases, the oldest and youngest members of society tend to be the most vulnerable. The more rural counties typically have an older population. These can be seen in Table 3-199. For example, Mineral County has the highest percent of individuals aged 65 or over, making up 37.6 percent of the total population. In contrast, this county also only has one percent of its population being five years or younger.

The county with the highest rate of their population being five years and younger is Cheyenne County with 8.2 percent. El Paso County has the highest number of young children, with an estimated 46,562. Denver County is a close second at 44,441. Densely populated areas such as these have the greatest risk of spreading infection because of shared resources and close contacts. El Paso and Denver Counties have the highest base populations in the state. It is likely that any pandemic would hit these areas particularly hard.

TABLE 3-199 YOUNGEST AND OLDEST POPULATIONS BY COUNTY, 2016

County	Total Population	Percent 5 and Under	Number 5 and Under	Percent 65 and Over	Number 65 and Over
<b>Adams</b>	479,977	7.7%	36,958	9.5%	45,598
<b>Alamosa</b>	16,353	6.9%	1,128	12.7%	2,077
<b>Arapahoe</b>	617,668	6.5%	40,148	11.8%	72,885
<b>Archuleta</b>	12,355	5.1%	630	22.2%	2,743
<b>Baca</b>	3,648	6.4%	233	25.5%	930
<b>Bent</b>	5,816	3.8%	221	16.1%	936

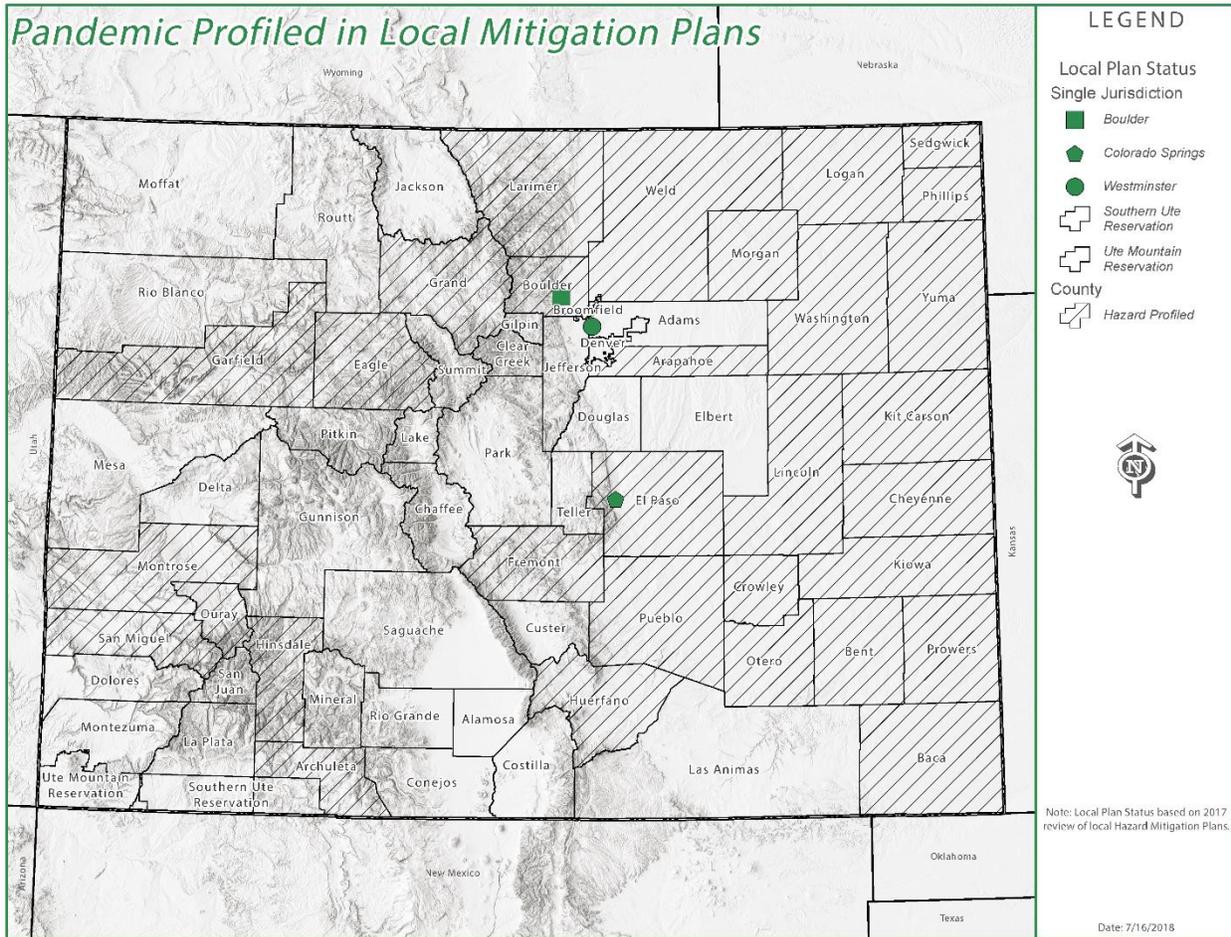
County	Total Population	Percent 5 and Under	Number 5 and Under	Percent 65 and Over	Number 65 and Over
Boulder	313,961	5.0%	15,698	12.1%	37,989
Broomfield	62,449	5.9%	3,684	11.9%	7,431
Chaffee	18,507	4.0%	740	22.8%	4,220
Cheyenne	2,071	8.2%	170	11.6%	240
Clear Creek	9,238	4.1%	379	18.2%	1,681
Conejos	8,213	7.0%	575	17.4%	1,429
Costilla	3,590	5.0%	180	25.5%	915
Crowley	5,537	3.4%	188	13.3%	736
Custer	4,375	3.2%	140	28.9%	1,264
Delta	30,221	5.1%	1,541	23.3%	7,041
Denver	663,303	6.7%	44,441	10.9%	72,300
Dolores	1,789	4.6%	82	27.0%	483
Douglas	314,238	6.4%	20,111	9.9%	31,110
Eagle	52,894	6.2%	3,279	8.2%	4,337
Elbert	24,225	4.0%	969	13.7%	3,319
El Paso	665,171	7.0%	46,562	11.5%	76,495
Fremont	46,835	3.8%	1,780	20.0%	9,367
Garfield	57,495	7.2%	4,140	10.6%	6,094
Gilpin	5,708	5.0%	285	11.7%	668
Grand	14,490	4.0%	580	14.5%	2,101
Gunnison	15,889	4.9%	779	10.7%	1,700
Hinsdale	856	4.4%	38	30.4%	260
Huerfano	6,521	1.7%	111	29.8%	1,943
Jackson	1,306	4.8%	63	22.5%	294
Jefferson	558,810	5.3%	29,617	14.6%	81,586
Kiowa	1,465	7.6%	111	19.8%	290
Kit Carson	8,174	6.1%	499	17.2%	1,406
Lake	7,401	5.9%	437	11.5%	851
La Plata	53,994	5.2%	2,808	14.1%	7,613
Larimer	325,228	5.4%	17,562	13.8%	44,881
Las Animas	14,322	4.6%	659	21.7%	3,108
Lincoln	5,515	5.6%	309	17.3%	954
Logan	21,862	5.4%	1,181	16.3%	3,564
Mesa	148,166	6.1%	9,038	16.8%	24,892
Mineral	793	1.0%	8	37.6%	298
Moffat	13,034	5.9%	769	12.8%	1,668
Montezuma	26,006	6.0%	1,560	18.9%	4,915
Montrose	40,866	5.6%	2,288	21.4%	8,745
Morgan	28,288	7.3%	2,065	15.6%	4,413
Otero	18,440	6.1%	1,125	19.2%	3,540
Ouray	4,651	2.8%	130	26.6%	1,237

County	Total Population	Percent 5 and Under	Number 5 and Under	Percent 65 and Over	Number 65 and Over
Park	16,440	3.7%	608	16.5%	2,713
Phillips	4,347	6.5%	283	19.3%	839
Pitkin	17,543	4.4%	772	15.6%	2,737
Prowers	12,121	6.8%	824	16.0%	1,939
Pueblo	162,158	6.0%	9,729	16.9%	27,405
Rio Blanco	6,658	6.1%	406	13.6%	905
Rio Grande	11,623	6.2%	721	18.3%	2,127
Routt	23,980	4.5%	1,079	11.9%	2,854
Saguache	6,255	5.7%	357	18.3%	1,145
San Juan	552	4.9%	27	17.0%	94
San Miguel	7,767	4.5%	350	10.5%	816
Sedgwick	2,367	5.4%	128	25.8%	611
Summit	29,269	4.6%	1,346	10.4%	3,044
Teller	23,472	3.9%	915	17.8%	4,178
Washington	4,814	4.9%	236	20.2%	972
Weld	278,065	7.4%	20,577	11.2%	31,143
Yuma	10,150	8.0%	812	17.9%	1,817

Source: U.S. Census Bureau

Based upon an updated (2017) review of local mitigation plans, Figure 3-116 illustrates which local jurisdictions profiled pandemic as a hazard. Due to not having spatial data for historical pandemic occurrences in Colorado, the map does not show which jurisdictions profiled pandemic as a hazard against historical pandemic events. Many counties and three single jurisdictions profile pandemics as a hazard in their local mitigation plans. However, some counties along the Front Range with high populations and population density, such as Denver and Jefferson counties, do not profile pandemics.

FIGURE 3-116 PANDEMIC PROFILED IN LOCAL MITIGATION PLANS



Based on review of local hazard mitigation plans, four jurisdictions profiled pandemics as one of their top four hazards. None of these jurisdictions listed parcels/structures or critical facilities impacted by a pandemic. Table 3-200 shows this information in further detail.

TABLE 3-200 LOCAL HAZARD MITIGATION PLANS

Jurisdiction	# of Structures/ Parcels in Hazard Area	# Critical Facilities in Hazard Area
City and County of Broomfield		
University of Colorado Boulder		
Eagle County		
Pueblo County		
<b>Total</b>		

## 8. FUTURE DEVELOPMENT

Population growth and development contribute the greatest to pandemic exposure. Unlike many other hazards, there is not a direct impact on infrastructure due to diseases. It is possible that infrastructure may not be able to be maintained as necessary during a pandemic because of a significantly decreased workforce.

Denver County currently has the highest projected population change between 2010 and 2030. By 2030, the County is projected to grow by an additional 256,831 people. This drastically increases the County's risk to pandemics, as there will be far more people who can potentially become ill, and can also pass on the disease.

With the exception of El Paso County, the first ten counties in Table 3-201 are all a part of the greater Denver area. By 2030, this area is expected to have nearly 1.3 million more people. If a severe pandemic were to occur, of this new population, 390,000 people could be absent from their jobs or from school.

TABLE 3-201 POPULATION CHANGE BY COUNTY, 2010 - 2030

County	2010 Population	2030 Population Projection	Population Change	Population Percent Change
Denver	604,875	861,706	256,831	42%
El Paso	627,238	855,170	227,932	36%
Adams	443,709	658,865	215,156	48%
Weld	254,240	459,772	205,532	81%
Arapahoe	574,808	779,283	204,475	36%
Douglas	287,119	413,162	126,043	44%
Larimer	300,545	426,293	125,748	42%
Jefferson	535,648	647,959	112,311	21%
Boulder	295,610	377,107	81,497	28%
Broomfield	56,098	96,097	39,999	71%
Mesa	146,587	181,209	34,622	24%
Pueblo	159,464	191,163	31,699	20%
La Plata	51,443	73,266	21,823	42%
Garfield	56,153	77,404	21,251	38%
Elbert	23,140	43,695	20,555	89%
Eagle	52,064	69,748	17,684	34%
Montrose	41,179	53,355	12,176	30%
Summit	28,078	39,540	11,462	41%
Montezuma	25,515	35,043	9,528	37%
Routt	23,451	32,916	9,465	40%
Teller	23,402	29,228	5,826	25%
Park	16,277	21,834	5,557	34%
Chaffee	17,835	23,040	5,205	29%

County	2010 Population	2030 Population Projection	Population Change	Population Percent Change
Archuleta	12,082	16,942	4,860	40%
Grand	14,790	19,487	4,697	32%
Morgan	28,213	32,631	4,418	16%
San Miguel	7,393	11,742	4,349	59%
Gunnison	15,314	19,282	3,968	26%
Alamosa	15,454	18,894	3,440	22%
Logan	22,291	25,438	3,147	14%
Pitkin	17,147	20,218	3,071	18%
Delta	30,897	33,417	2,520	8%
Fremont	46,856	49,354	2,498	5%
Lake	7,288	8,536	1,248	17%
Clear Creek	9,083	10,319	1,236	14%
Lincoln	5,502	6,673	1,171	21%
Custer	4,248	5,079	831	20%
Ouray	4,471	5,210	739	17%
Gilpin	5,461	6,178	717	13%
Yuma	10,030	10,721	691	7%
Saguache	6,101	6,672	571	9%
Crowley	5,850	6,128	278	5%
Washington	4,851	5,104	253	5%
Costilla	3,549	3,795	246	7%
Hinsdale	825	1,067	242	29%
Rio Blanco	6,634	6,763	129	2%
Mineral	728	846	118	16%
Dolores	2,084	2,191	107	5%
Conejos	8,293	8,374	81	1%
Cheyenne	1,811	1,848	37	2%
San Juan	713	746	33	5%
Sedgwick	2,403	2,340	-63	-3%
Huerfano	6,639	6,560	-79	-1%
Kit Carson	8,259	8,169	-90	-1%
Jackson	1,417	1,316	-101	-7%
Kiowa	1,410	1,298	-112	-8%
Phillips	4,467	4,336	-131	-3%
Bent	6,523	6,206	-317	-5%
Moffat	13,812	13,389	-423	-3%
Baca	3,765	3,262	-503	-13%
Rio Grande	12,018	11,440	-578	-5%
Prowers	12,527	11,865	-662	-5%
Otero	18,875	17,566	-1,309	-7%

County	2010 Population	2030 Population Projection	Population Change	Population Percent Change
Las Animas	15,383	13,937	-1,446	-9%

Source: Colorado Department of Local Affairs

In review of local hazard mitigation plans, no information on future development trends were profiled for pandemics.

## 9. CLIMATE CHANGE

According to the best data available at the time of this plan update, the future impacts of climate change are expected to influence future pandemic events. The following Table 3-202 presents a breakdown of these projected changes in terms of hazard: location, extent/intensity, frequency, and duration. However, ongoing efforts to reduce Colorado’s greenhouse gas emissions and adapt to a changing climate, such as the Colorado Climate Plan, will help to reduce the impacts of climate change on pandemics.

TABLE 3-202 CLIMATE CHANGE IMPACTS

Impact	Projected Change
Location	Climate change will influence vector-borne disease prevalence, but the direction of the effects (increased or decreased incidence) will be location- and disease specific.
Extent/Intensity	Intensity is projected to increase. Disadvantaged populations are expected to bear a greater burden from climate change as a result of their current reduced access to medical care and limited resources for adaptation strategies. Extent of certain diseases is expected to increase.
Frequency	Additional research is needed to determine the effects of climate change on the frequency of epidemics and pandemics.
Duration	Additional research is needed to determine the effects of climate change on the duration of epidemics and pandemics.

Source: FEMA 2017

## 10. RISK TO STATE ASSETS

A catastrophic and widespread pandemic event would overwhelm large segments of the workforce. Hospitals throughout the state would largely have to rely on the equipment, medicines, and expertise at their disposal, as federal and state resources would be stretched thin throughout the country. However, since 2008, no state asset property losses were reported due to a pandemic.

## 11. RESOURCES

- Colorado Department of Public Health and Environment (CDPHE), Developing Continuity of Operations Plans, 2006

- Colorado Department of Public Health and Environment (CDPHE), Guidelines for Pandemic Readiness, 2007
- Colorado Legislative Council Staff
- Denver Library
- Federal Emergency Management Agency (FEMA). (2017). Assessing Future Conditions, Colorado.
- Northeast Colorado Threat and Hazard Identification and Risk Assessment (THIRA)
- United States Census Bureau

# WILDLIFE-VEHICLE COLLISIONS



## 1. DEFINITION

Wildlife-Vehicle Collisions (WVCs) occur thousands of times each year in Colorado. Affected species include bear, beaver, bighorn sheep, bobcat, cow, coyote, deer, dog, elk, fox, moose, pronghorn, raccoon, skunk, and unknown. Most reported WVCs involve deer and elk. These incidents are not only common but also extremely costly to life safety and property. Table 3-203 describes the hazard profile summary for WVCs.

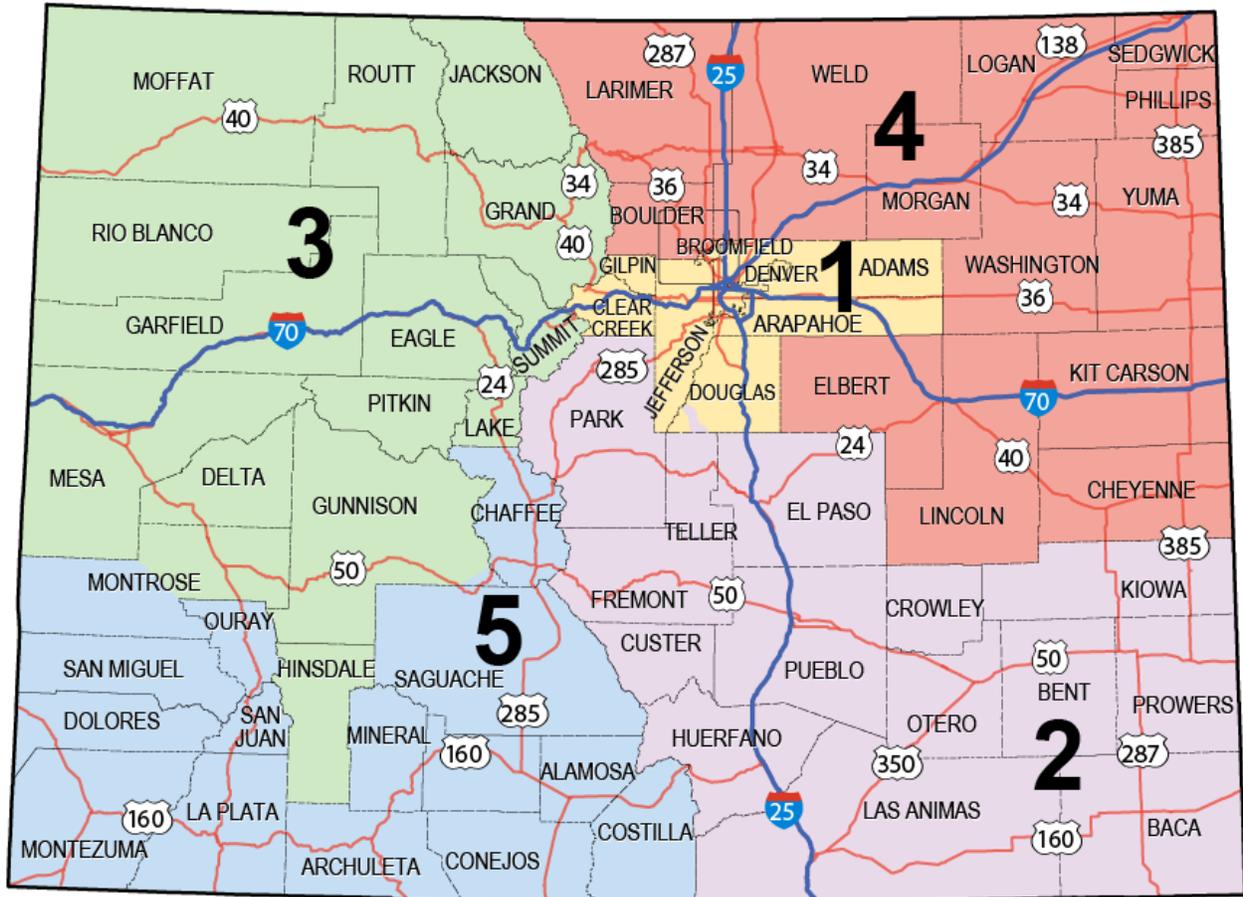
TABLE 3-203 HAZARD PROFILE SUMMARY

Consideration	Impact	Description
<b>Location</b>	Local	Occurs across the state, but especially likely along the Front Range and the Western Slope.
<b>Previous Occurrence</b>	Perennial	Regular occurrences throughout the year. Especially likely between fall and winter and between winter and spring.
<b>Probability</b>	Expected	Expected to happen thousands of times each year.
<b>Extent</b>	Moderate	Isolated injuries and fatalities. Personal property damage likely from each isolated incident. Minimal interruption to critical services.

## 2. LOCATION

WVCs can happen nearly anywhere in Colorado, but Colorado Parks and Wildlife (CPW) cautions drivers to be especially wary when driving through the following areas: Interstate 70 (Floyd Hill, Mt. Vernon, and Eagle), Highway 285 (Morrison), Highway 160 (Durango to Pagosa Springs and Durango to Mancos), Highway 550 (north of Durango and from Montrose to Ouray), Interstate 25 (Castle Rock to Larkspur), Highway 82 (Glenwood Springs to Aspen), Highway 36 (Boulder to Lyons), and Highway 93 (Golden to Boulder) (<http://cpw.state.co.us/learn/Pages/AvoidWildlifeCollisions.aspx>). CDOT’s Annual Roadkill Reports can also be used to identify the most dangerous stretches of highway. Data from the 2016 Annual Roadkill Report is summarized in Table 3-204. A total of 5,833 WVCs were recorded across the state in 2016. The greatest number of WVCs occurred in Region 3 and Region 5 (Figure 3-117) with 1,852 and 1,654 incidents, respectively. Over 860 incidents were recorded on Highway 160 between mileposts 10 through 290 alone. This is over twice as many WVCs as the area with the second highest number of incidents, Interstate 70 between mileposts 10-220 with 416 reports.

FIGURE 3-117 CDOT REGIONS



Source: CDOT

TABLE 3-204 ROADKILL INCIDENTS BY HIGHWAY AND MILEPOST (2016)

CDOT Region	Highway	Milepost Range	Roadkill Incidents
1	Interstate 25	160-240	12
1	Interstate 70	210-340	174
1	Highway 83	30-80	23
1	Highway 285	230-270	111
		SUBTOTAL	320
2	Highway 9	0-50	47
2	Highway 24A	240-310	135
2	Highway 24G	310-360	35
2	Interstate 25	10-170	109
2	Highway 50A	240-300	47

CDOT Region	Highway	Milepost Range	Roadkill Incidents
2	Highway 50B	210-220, 310-360, 400-480	54
2	Highway 69A	1-90	28
2	Highway 94A	1-50	87
2	Highway 96A	0-60	49
2	Highway 115A	0-60	99
2	Highway 285D	160-240	69
		SUBTOTAL	759
3	Highway 9D	110-150	80
3	Highway 13A	0-100	125
3	Highway 13B	10-30, 90-140	220
3	Highway 24A	140-200	19
3	Highway 40A	0-230	277
3	Highway 50A	40-180	218
3	Highway 64A	20-80	17
3	Highway 65A	0-70	69
3	Interstate 70A	10-220	416
3	Highway 82A	0-90	125
3	Highway 92A	10-50	47
3	Highway 131B	0-80	60
3	Highway 133A	0-80	58
3	Highway 135A	0-40	18
3	Highway 550B	120-140	103
		SUBTOTAL	1,852
4	Highway 6J	370-460	26
4	Highway 14B	60-130	12
4	Highway 14C	140-240	45
4	Highway 24G	350-390	15
4	Interstate 25A	240-310	33
4	Highway 34A	80-160	79
4	Highway 34B	130-270	103
4	Highway 36B	0-50	65
4	Highway 36D	20-30, 110-230	130

CDOT Region	Highway	Milepost Range	Roadkill Incidents
4	Highway 40H	240-250, 350-360, 390-500	73
4	Highway 52A	0-80	13
4	Highway 59A	10-40, 60-80	47
4	Highway 59B	60-150	24
4	Highway 63A	0-70	29
4	Highway 66B	20-60	57
4	Interstate 70	190-200, 330-350, 390-430	22
4	Highway 71D	140-180	12
4	Interstate 76	0-190	91
4	Highway 85C	240-300	34
4	Highway 85L	280-320	15
4	Highway 138A	0-30, 50-60	32
4	Highway 257A	0-30	56
4	Highway 287C	320-390	161
4	Highway 385C	20-30, 150-180, 210-230	55
4	Highway 385D	220-280, 310-320	19
		SUBTOTAL	1,248
5	Highway 24A	200-270	145
5	Highway 50A	190-250	53
5	Highway 114A	10-20, 40-70	10
5	Highway 145A	0-80, 110-120	79
5	Highway 149A	0-50	17
5	Highway 151A	0-40	43
5	Highway 160A	10-290, 580-590	864
5	Highway 491B	20-80	147
5	Highway 550A	0-30	119
5	Highway 550B	20-130	177
5		SUBTOTAL	1,654
		<b>GRAND TOTAL</b>	<b>5,833</b>

Source: CDOT

### 3. EXTENT (MAGNITUDE/STRENGTH)

Individual WVCs typically only directly impact a small geographic area and only few people at once. Collisions can lead to serious injury or death and can cause extensive vehicle damage. A larger area and number of people may be indirectly impacted by traffic jams caused by WVCs.

### 4. PROBABILITY

Thousands of WVCs are certain to happen every year in Colorado. Data from Colorado Parks and Wildlife indicates that 4,600 deer were killed on Colorado highways in 2016, up from 3,000 in 2013 (<http://www.9news.com/traffic/more-people-are-getting-into-crashes-with-wildlife-in-colorado/486671209>). WVCs are most likely to occur during migration season, particularly between dusk and dawn. Deer and elk will move from higher elevations to lower elevations as fall shifts to winter, and then move back to higher elevations as winter gives way to spring. Because the days are shorter at these times of year motorists may be commuting around dawn and dusk, putting people and animals at greater risk of a collision. This risk is even higher along the stretches of highway listed in Table 3-204. November in particular is the peak time for WVCs in Colorado (<http://www.iihs.org/iihs/sr/statusreport/article/49/9/3>). A 2016 State Farm study found that Colorado drivers had a one in 263 chance of hitting a deer between 2015 and 2016 (<https://newsroom.statefarm.com/state-farm-releases-2016-deer-collision-data/#Xy6TvIOAjFyzdssK.97>). This study did not evaluate the chances of hitting other wildlife species.

### 5. PREVIOUS OCCURRENCES

WVCs are, unfortunately, difficult to avoid throughout Colorado. As the state's population has grown over the past several years, the incidence of WVCs has increased accordingly. Table 3-205 shows the number of Property Damage Only (PDO) events (refers to events in which no injuries or fatalities occurred), injuries, and fatalities from WVCs in Colorado between 2005 and 2014. Fortunately, the number of fatalities from this hazard has been relatively small considering the total number of WVCs. However, many crashes go undocumented, so the number of incidents is likely higher than shown in Table 3-205. Figure 3-118 depicts the total reported WVCs by county, and Figure 3-119 depicts the total PDOs by county.

TABLE 3-205 WILD ANIMAL CRASHES BY COUNTY (2005-2014)

County	PDOs	Injuries	Fatalities
Adams	290	31	0
Alamosa	355	18	0
Arapahoe	426	43	1
Archuleta	577	67	0
Baca	46	4	0
Bent	155	10	1

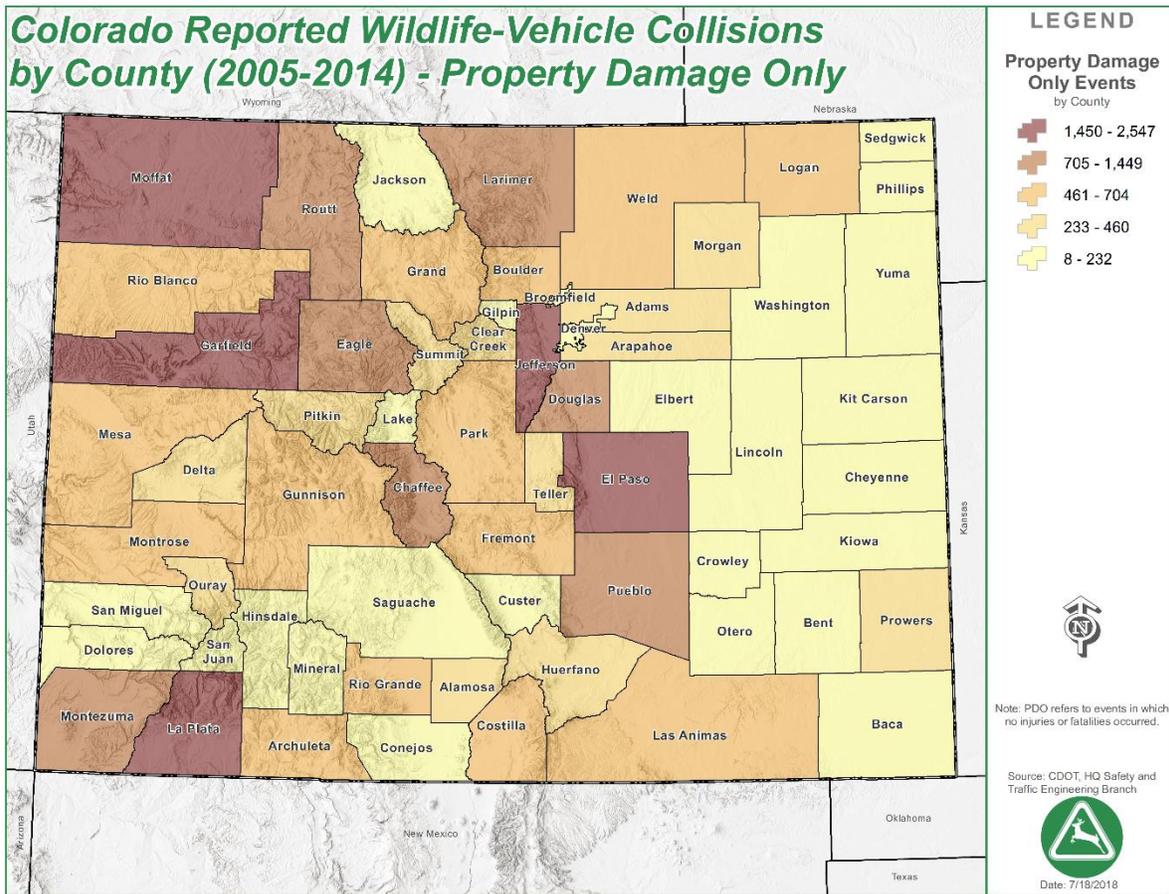
<b>County</b>	<b>PDOs</b>	<b>Injuries</b>	<b>Fatalities</b>
<b>Boulder</b>	624	49	1
<b>Broomfield</b>	16	3	0
<b>Chaffee</b>	1,116	61	0
<b>Cheyenne</b>	87	1	0
<b>Clear Creek</b>	311	31	0
<b>Conejos</b>	160	16	1
<b>Costilla</b>	587	48	0
<b>Crowley</b>	40	1	0
<b>Custer</b>	144	16	1
<b>Delta</b>	450	50	2
<b>Denver</b>	62	5	0
<b>Dolores</b>	88	14	0
<b>Douglas</b>	1,449	135	2
<b>Eagle</b>	1,135	72	2
<b>El Paso</b>	1,807	176	1
<b>Elbert</b>	232	13	0
<b>Fremont</b>	690	66	0
<b>Garfield</b>	1,707	131	1
<b>Gilpin</b>	69	8	0
<b>Grand</b>	684	33	0
<b>Gunnison</b>	600	26	1
<b>Hinsdale</b>	8	3	0
<b>Huerfano</b>	459	39	2
<b>Jackson</b>	75	15	0
<b>Jefferson</b>	2,547	225	1
<b>Kiowa</b>	54	2	0
<b>Kit Carson</b>	145	8	0
<b>La Plata</b>	2,245	232	3
<b>Lake</b>	74	9	0
<b>Larimer</b>	949	110	0
<b>Las Animas</b>	561	45	0
<b>Lincoln</b>	89	4	1
<b>Logan</b>	534	23	0
<b>Mesa</b>	598	66	1
<b>Mineral</b>	105	7	1
<b>Moffat</b>	1,606	80	1
<b>Montezuma</b>	970	98	2
<b>Montrose</b>	704	37	1
<b>Morgan</b>	321	20	0
<b>Otero</b>	218	18	0
<b>Ouray</b>	283	25	1
<b>Park</b>	616	45	0

<b>County</b>	<b>PDOs</b>	<b>Injuries</b>	<b>Fatalities</b>
<b>Phillips</b>	31	2	0
<b>Pitkin</b>	417	29	0
<b>Prowers</b>	330	10	0
<b>Pueblo</b>	914	67	0
<b>Rio Blanco</b>	620	30	0
<b>Rio Grande</b>	676	38	0
<b>Routt</b>	950	52	1
<b>Saguache</b>	199	15	0
<b>San Juan</b>	8	4	0
<b>San Miguel</b>	87	16	2
<b>Sedgwick</b>	102	6	0
<b>Summit</b>	386	30	1
<b>Teller</b>	460	41	0
<b>Washington</b>	120	9	0
<b>Weld</b>	698	60	0
<b>Yuma</b>	149	13	1
<b>TOTAL</b>	33,215	2,661	33

Source: CDOT



FIGURE 3-119 TOTAL PROPERTY-DAMAGE ONLY WILDLIFE-VEHICLE COLLISIONS (2005-2014)



## 6. IMPACT ANALYSIS

Thousands of WVCs occur in Colorado each year. Table 3-206 summarizes CDOT’s data on PDO incidents, injuries, and fatalities caused by wild animal crashes in Colorado between 2005 and 2014. During this time, 35,909 PDOs, injuries, and fatalities from WVCs were recorded, or roughly 3,200 to 4,000 total incidents each year. The total number of injuries (2,661) and fatalities (33) averages to roughly 266 injuries and three fatalities per year.

TABLE 3-206 WILD ANIMAL CRASHES STATEWIDE (2005-2014)

Year	PDOs	Injuries	Fatalities	Total
2005	3,533	263	3	3,799
2006	3,318	279	2	3,599
2007	3,045	232	2	3,279
2008	3,177	281	5	3,463
2009	3,313	243	3	3,559

Year	PDOS	Injuries	Fatalities	Total
2010	3,116	215	5	3,336
2011	3,204	258	2	3,464
2012	3,659	353	1	4,013
2013	3,183	250	4	3,437
2014	3,667	287	6	3,960
<b>TOTAL</b>	<b>33,215</b>	<b>2,661</b>	<b>33</b>	<b>35,909</b>

Source: CDOT

The impact of WVCs on most critical infrastructure/key resource sectors is fairly limited. WVCs primarily impact public safety and personal property. Impacts to critical infrastructure/key resource sectors are briefly summarized in Table 3-207.

TABLE 3-207 WVC EMAP IMPACT SUMMARY

Consideration	Description
<b>General Public</b>	There are roughly three fatalities and 266 injuries annually.
<b>First Responders</b>	First responders may face the same level of exposure as the general public. They may also face additional risk from traffic when responding to WVCs.
<b>Property</b>	Thousands of personal vehicles will be damaged in any given year.
<b>Facilities and Infrastructure</b>	Buildings are generally not impacted. WVCs may damage road infrastructure if vehicles or animals collide with guardrails, barriers, etc. These impacts are typically short-term.
<b>Economic</b>	Possible short-term blockage of roadways that prevent travel and access to local businesses by residents, recreationists, and tourists.
<b>Environment</b>	Environmental damage may occur when vehicles leave the roadways. Engine fluids may also leak onto the ground, though likely not in large enough quantities to cause extensive or long-term environmental damage.
<b>Continuity of Government and Services</b>	Loss of facilities or infrastructure for the provision of government services is expected to be non-existent or negligible.
<b>Confidence in Government</b>	WVCs are not expected to impact confidence in government. However, installation of additional wildlife crossings, underpasses, and overpasses may improve the public's sense that the government is working to address the hazard.

Consideration	Description
<b>Critical Assets</b>	Impacts to critical assets are highly unlikely.

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

Motorists across Colorado regularly face the potential for vehicle collisions with wildlife. However, CDOT data on WVCs between 2005 and 2014 indicates that the risk is especially high in 10 counties in particular: La Plata, Jefferson, Douglas, El Paso, Montezuma, Garfield, Eagle, Moffat, Pueblo, and Routt. This order is not necessarily the same from year to year, though La Plata and Jefferson Counties consistently have the most incidents. Both counties can expect roughly 250-300 incidents and 20-30 injuries per year. Fortunately, fatalities are much rarer. The other eight counties can expect approximately 120-200 incidents and 5-20 injuries per year. Data on damages in dollar values was not available by county for the 2018 Colorado E-SHMP update.

Two counties identified WVCs as a hazard in their local hazard mitigation plans: Archuleta County and Grand County. Archuleta County ranked the hazard as low. Grand County ranked WVCs as medium. Neither county ranked WVCs as one of their top four hazards.

Several federal, state, and local agencies have been working with communities to reduce losses from WVCs over several decades. Wildlife crossings were first installed in Colorado in the 1970s and 1980s at Interstate 70 near West Vail, Highway 160 west of Durango, and Interstate 70 at Vail Pass. Since then, over 50 wildlife crossing structures have been built across the state. The majority of these structures are in CDOT Regions 3 and 5, as shown in Figure 3-120.

La Plata County has the most wildlife crossings at 14, followed by Summit County with nine crossings. Douglas and Eagle Counties follow with eight crossings each, and Garfield and Grand Counties have seven structures. Additional crossings are planned at Highway 24 in Chaffee County, Highway 160 in La Plata County, Highway 160 in Archuleta County, and Highway 550 in Ouray County. Most of these planned structures are underpasses for large mammals.



put more people at risk of experiencing a collision with wildlife, either as residents of the most at-risk counties or as tourists who are passing through the area.

Table 3-208 summarizes the total number of WVCs between 2005 and 2014, as well as the expected housing percent change between 2010 and 2030. Those counties that have a large expected housing percent change, as well as a high number of historical WVCs between 2005 and 2014 are most at risk for future exposure.

Jefferson County has the highest number of historical WVCs between 2005 and 2014, as well as an expected housing percent increase of 30 percent. Additionally, La Plata County follows closely, with 2,480 WVCs during this time period, and a projected 50 percent increase in housing. El Paso, Garfield, and Douglas Counties also have some of the highest historical WVC counts along with housing percent change projections among the highest in the state, at 40 percent or higher.

**TABLE 3-208 HOUSING PERCENT CHANGE (2010 TO 2030) AND HISTORICAL WVCs (2005 TO 2014)**

County	Number of Events	Housing Percent Change	Growth Rating
Elbert	245	120%	Highest
Weld	758	93%	Highest
Broomfield	19	78%	Highest
Douglas	1,586	67%	Highest
Park	661	65%	Highest
San Miguel	105	64%	Highest
Archuleta	644	61%	Highest
Montrose	742	61%	Highest
Adams	321	60%	Highest
Eagle	1,209	56%	Highest
Arapahoe	470	52%	Highest
Garfield	1,839	51%	Highest
La Plata	2,480	50%	Highest
Summit	417	49%	Highest
Larimer	1,059	47%	Highest
Routt	1,003	46%	High
Grand	717	44%	High
Custer	161	41%	High
El Paso	1,984	40%	High
Chaffee	1,177	38%	High
Mesa	665	38%	High
Boulder	674	37%	High
Denver	67	37%	High
Montezuma	1,070	37%	High
Delta	502	35%	High

County	Number of Events	Housing Percent Change	Growth Rating
Pitkin	446	34%	High
Jefferson	2,773	30%	High
Fremont	756	28%	High
Gunnison	627	28%	High
Crowley	41	26%	High
Lincoln	94	26%	High
Morgan	341	26%	Moderate
Pueblo	981	26%	Moderate
Alamosa	373	25%	Moderate
Las Animas	606	23%	Moderate
Teller	501	23%	Moderate
Lake	83	21%	Moderate
Logan	557	21%	Moderate
Clear Creek	342	20%	Moderate
Kit Carson	153	20%	Moderate
Hinsdale	11	19%	Moderate
Saguache	214	17%	Moderate
Yuma	163	17%	Moderate
Conejos	177	14%	Moderate
Huerfano	500	13%	Moderate
Ouray	309	13%	Moderate
Gilpin	77	12%	Moderate
Kiowa	56	12%	Low
Cheyenne	88	11%	Low
Costilla	635	10%	Low
Mineral	113	10%	Low
Rio Blanco	650	10%	Low
San Juan	12	10%	Low
Jackson	90	9%	Low
Washington	129	8%	Low
Bent	166	7%	Low
Moffat	1,687	7%	Low
Rio Grande	714	7%	Low
Otero	236	6%	Low
Dolores	102	4%	Low
Prowers	340	3%	Low
Phillips	33	1%	Low
Sedgwick	108	1%	Low
Baca	50	-6%	Low

Source: Colorado State Demography Office, 2017

The following section provides county-scale WVC exposure projections by comparing WVC risk based on total incidents and total combined injuries and fatalities with projected population data. The combination of a growing population and high WVC threat results in increasing exposure over that of today. The counties of La Plata, El Paso, Douglas, Garfield Jefferson, Larimer, Montezuma, and Routt are projected to experience the highest exposure to WVCs through 2030.

**TABLE 3-209 WVC EXPOSURE PROJECTIONS**

Future WVC Exposure Projections					
		County Population Percent Change Projections, 2010 to 2030			
Combined Risk (WVC)		-13% to 2%	3% to 17%	18% to 34%	35% to 89%
<b>High</b>  <b>Moderate</b>	5-6	Moderate	High	Severe	Extreme
	3-4	Slight	Moderate	High	Severe
	0-2	Negligible	Slight	Moderate	High

The Combined Risk calculations in Table 3-209 are based on the methodology outlined in Table 3-210. Values (between 0 and 3) have been assigned to total deaths and total number of WVC events per county. The Jenks Natural Breaks algorithm was used to classify these historical data sets. The sum of these values then arrives at the Combined Risk value for each county.

**TABLE 3-210 COMBINED RISK METHODOLOGY**

Total Events (2005 – 2014)	Value	# of Injuries and Fatalities (2005-2014)	Value
1,850 – 2,773	3	158 – 235	3
925 – 1,849	2	79 – 157	2
1 – 924	1	1 – 78	1
0	0	0	0

Colorado continues to experience some of the largest population growth in the country and future projections seem to indicate a similar trend should be expected. Exposure to WVCs is expected to intensify across the State of Colorado between 2010 and 2030 as population increases. The darker, more red colors in Table 3-209 illustrate relative rates of increase in exposure between counties. Exposure ratings for each county are shown in Table 3-211 and Figure 3-121. As Colorado's population increases, infrastructure and businesses will follow

these population centers. This further adds to the potential future exposure that counties face from WVCs.

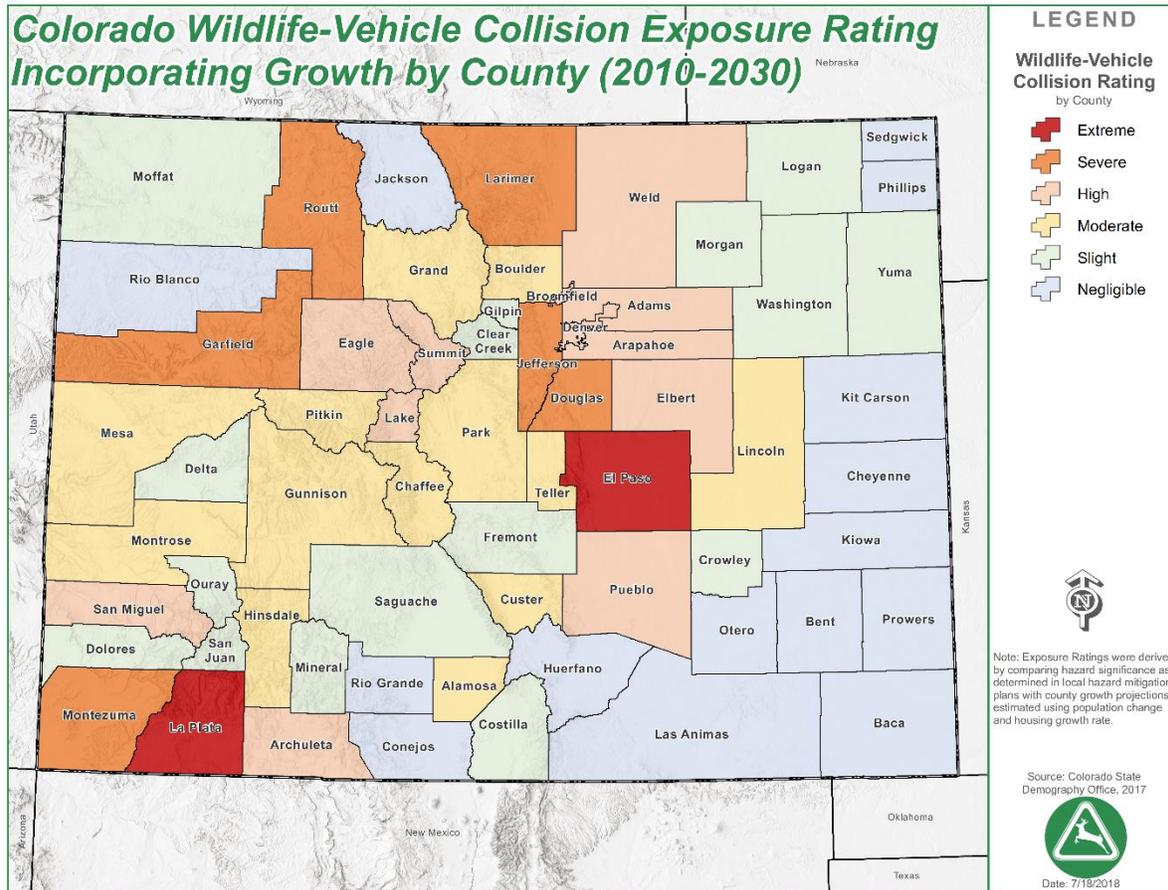
TABLE 3-211 WVC EXPOSURE PROJECTIONS, 2010 TO 2030

County	Combined Risk	Population Percent Change	Exposure Rating
La Plata	6	42%	Extreme
El Paso	6	36%	Extreme
Douglas	4	44%	Severe
Garfield	4	38%	Severe
Jefferson	6	21%	Severe
Larimer	4	42%	Severe
Montezuma	4	37%	Severe
Routt	3	40%	Severe
Adams	2	48%	High
Arapahoe	2	36%	High
Archuleta	2	40%	High
Broomfield	2	71%	High
Denver	2	42%	High
Eagle	3	34%	High
Elbert	2	89%	High
Pueblo	3	20%	High
San Miguel	2	59%	High
Summit	2	41%	High
Weld	2	81%	High
Alamosa	2	22%	Moderate
Boulder	2	28%	Moderate
Chaffee	3	29%	Moderate
Custer	2	20%	Moderate
Grand	2	32%	Moderate
Gunnison	2	26%	Moderate
Hinsdale	2	29%	Moderate
Lincoln	2	21%	Moderate
Mesa	2	24%	Moderate
Montrose	2	30%	Moderate
Park	2	34%	Moderate
Pitkin	2	18%	Moderate
Teller	2	25%	Moderate
Clear Creek	2	14%	Slight
Costilla	2	7%	Slight
Crowley	2	5%	Slight
Delta	2	8%	Slight
Dolores	2	5%	Slight

County	Combined Risk	Population Percent Change	Exposure Rating
Fremont	2	5%	Slight
Gilpin	2	13%	Slight
Lake	2	17%	Slight
Logan	2	14%	Slight
Mineral	2	16%	Slight
Moffat	4	-3%	Slight
Morgan	2	16%	Slight
Ouray	2	17%	Slight
Saguache	2	9%	Slight
San Juan	2	5%	Slight
Washington	2	5%	Slight
Yuma	2	7%	Slight
Baca	2	-13%	Negligible
Bent	2	-5%	Negligible
Cheyenne	2	2%	Negligible
Conejos	2	1%	Negligible
Huerfano	2	-1%	Negligible
Jackson	2	-7%	Negligible
Kiowa	2	-8%	Negligible
Kit Carson	2	-1%	Negligible
Las Animas	2	-9%	Negligible
Otero	2	-7%	Negligible
Phillips	2	-3%	Negligible
Prowers	2	-5%	Negligible
Rio Blanco	2	2%	Negligible
Rio Grande	2	-5%	Negligible
Sedgwick	2	-3%	Negligible

Source: Colorado State Demography Office, 2017

FIGURE 3-121 WILDLIFE-VEHICLE COLLISION EXPOSURE RATING INCORPORATING GROWTH



Land-use planning for future development needs to consider the location of wildlife habitat to minimize disruption to wildlife migration corridors. Federal, state, and local government should continue working with communities to identify priority areas for mitigation based on crash data, wildlife migration patterns, wildlife action plans, and crossing structure feasibility. Adjacent counties will also need to work together to identify landscape connectivity opportunities. Wildlife may migrate back and forth across jurisdictional boundaries each year. Multi-jurisdictional land use planning efforts focused on safely linking wildlife habitats across transportation corridors will be vital to managing wildlife migration, property damage, and life safety as Colorado’s population continues to grow.

## 9. CLIMATE CHANGE

According to the best data available at the time of this plan update, the future impacts of climate change are expected to influence future WVC events, but the extent of these impacts is as yet unknown. Additional research is needed to determine the effects of climate change on the location, extent/intensity, frequency, and high-season duration of WVCs.

## 10. RISK TO STATE ASSETS

State assets and critical facilities are at little to no risk from WVCs. Risk to state assets primarily includes traffic issues on transportation corridors, but is unlikely that road infrastructure would be damaged. Highway personnel, including CDOT and CSP staff may have greater risk to a WVC, particularly those in southwestern Colorado.

## 11. RESOURCES

- Colorado Department of Transportation (CDOT)
- Colorado Parks and Wildlife (CPW)
- Rocky Mountain Insurance Information Association (RMIIA)
- The Denver Post
- The Vail Daily
- 9news.com

# PEST INFESTATION



## 1. DEFINITION

An infestation is defined as a state of being invaded or overrun by parasites that attack plants, animals and humans. Insect, fungi, and parasitic infestations can result in destruction of various natural habitats and cropland, impact human health, and cause disease and death among native plants, wildlife, and livestock. The pest infestation hazard largely focuses on two pests - grasshopper and the Emerald Ash Borer (EAB).

An infestation is the presence of a large number of pest organisms in an area or field, on the surface of a host, or in soil. They result from when an area is inhabited or overrun by these pest organisms, in numbers or quantities large enough to be harmful, threatening, or obnoxious to native plants, animals, and humans. Pests are any organism (insects, mammals, birds, parasite/pathogen, fungi, non-native species) that are a threat to other living species in its surrounding environment. Pests compete for natural resources or they can transmit diseases to humans, crops, and livestock. Table 3-212 describes the hazard profile summary for pests.

TABLE 3-212 HAZARD PROFILE SUMMARY

Consideration	Impact	Description
<b>Location</b>	Regional	Grasshopper - Eastern Plains are the most impacted area coinciding with rangeland. Portions of western Colorado are also impacted but to a lesser extent. Higher elevations are largely void of significant grasshopper populations. Emerald Ash Borer – Localized in Boulder, Longmont, Lafayette, and Lyons with potential to spread.
<b>Previous Occurrences</b>	Cyclical	Grasshopper - Outbreaks occur cyclically and may be encouraged by drought conditions. In addition, populations may increase as grazing rates increase. In 2009, the northeast portions of the state experienced the highest grasshopper infestation since 2002-2003. Emerald Ash Borer – Found in Boulder in 2013. No previous occurrences.
<b>Probability</b>	Expected	Grasshopper - Natural and human-induced conditions responsible for past outbreaks are expected to continue. Weather conditions have high impact on outbreak potential. Emerald Ash Borer - Ongoing and expected to continue.
<b>Extent</b>	Extensive	Grasshopper - Damage to rangeland and crops may be severe enough to warrant USDA disaster or emergency declarations across multiple counties. Damage depends on where grasshopper outbreaks originate and where they migrate. Emerald Ash Borer – Extensive damage to Colorado’s urban forests.

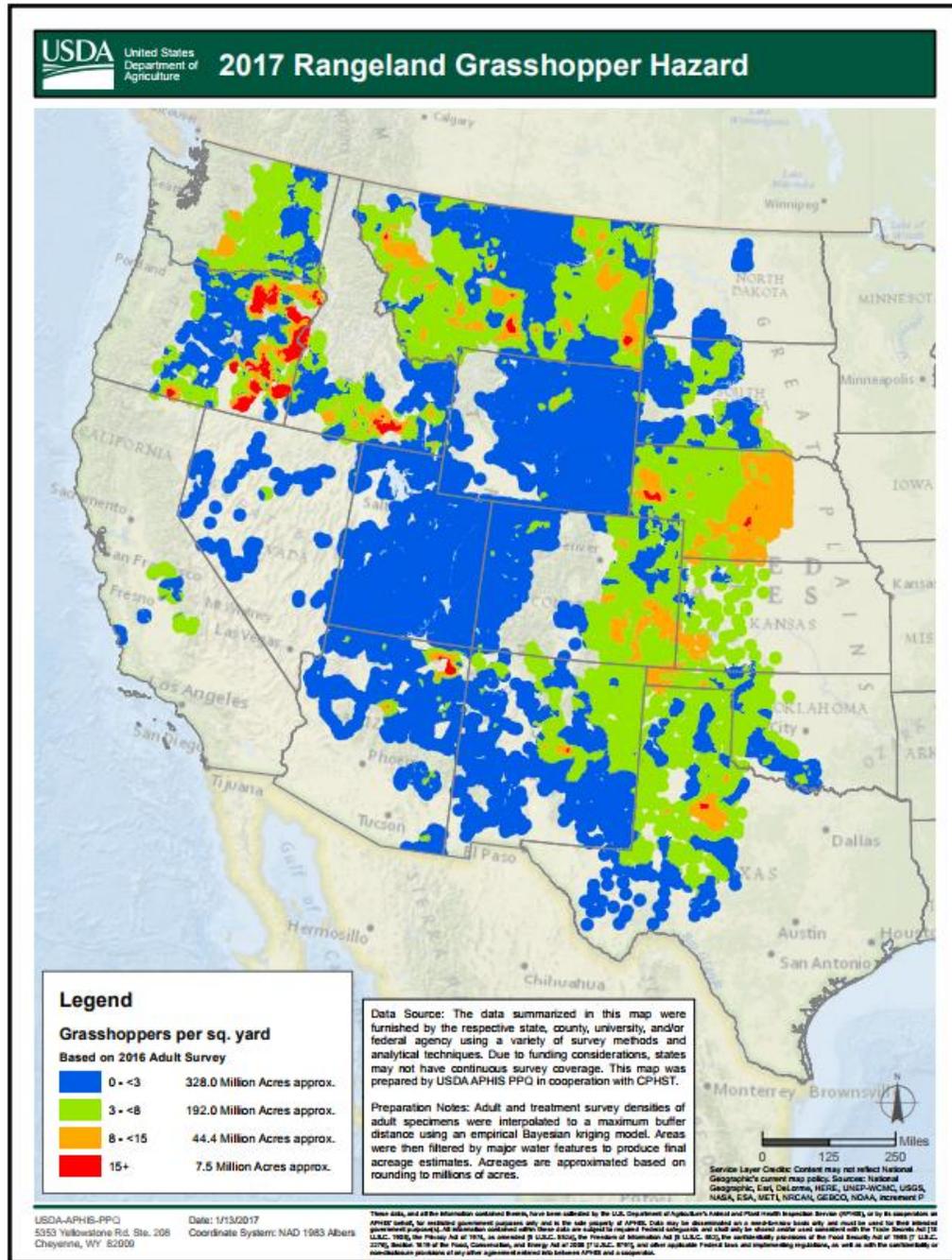
## 2. LOCATION

Pest infestations are statewide with regional propensity depending on the specific rodent or insect. The 2013 Southeast Colorado Regional Hazard Mitigation Plan identifies agricultural infestation as a hazard for the Region, which includes Baca, Bent, Crowley, Kiowa, Otero, and Prowers Counties. Rodent and insect infestations are summarized under the agricultural infestation hazard as they threaten crops, which is one of the primary industries in the planning region.

The Eastern Plains of Colorado are most typically impacted by grasshopper infestations as the area coincides with rangeland. Western Colorado is also impacted but to a lesser extent. Higher elevations are largely void of significant grasshopper populations.

Figure 3-122 shows the results from a 2016 survey of adult grasshoppers in the western United States. High adult counts in one year will typically suggest a perpetuation of high numbers the following year. Generally, the Eastern Plains and northwest Colorado show the highest numbers of adults, largely in the three to eight adults per square yard. Some isolated areas in Colorado have showed more than 15 adult grasshoppers per square yard.

FIGURE 3-122 RANGELAND GRASSHOPPER HAZARD IN THE WESTERN UNITED STATES

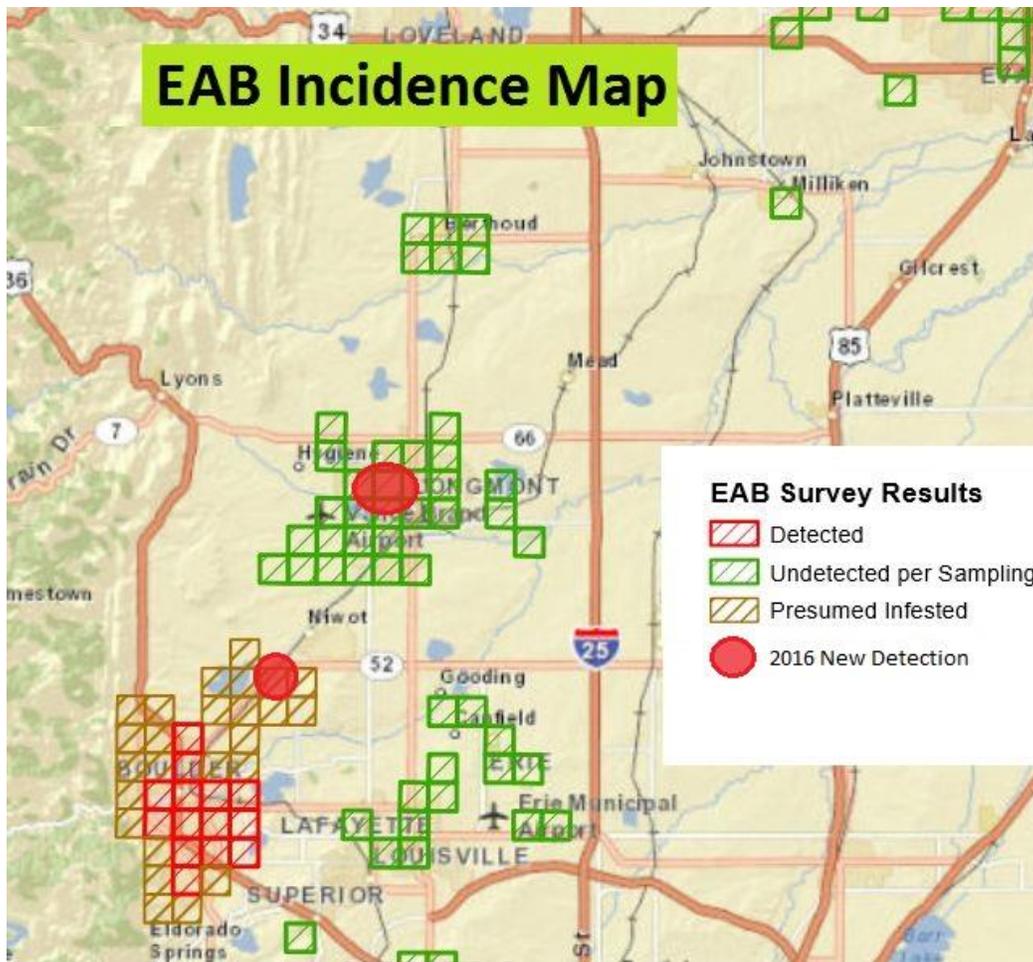


Source: USDA

The emerald ash borer (EAB) is a non-native species that was first detected in Colorado in the City of Boulder in September 2013. The EAB attacks and kills all true native North American ash trees, including green, white, black and blue ash, and their cultivars (including “autumn purple ash,” a popular white ash varietal in Colorado). Although rare in Colorado, white fringetree (*Chionanthus virginicus*) also has now been documented as susceptible to EAB (CSFS, n.d.).

To date, the EAB has only been detected in Boulder County, in the cities of Boulder, Longmont, Lafayette, and Lyons. However, it is very likely the EAB will spread to other Front Range and northeast plains urban forests, where ash trees comprise an estimated 15 percent or more of all trees. On their own, the EAB can only move approximately a half-mile per year. Human-assisted spread, such as through firewood or raw ash material, is the only way the EAB can move over long distances. Figure 3-123 shows the extent of the EAB in Boulder County as of 2016.

FIGURE 3-123 EMERALD ASH BORER IN BOULDER COUNTY



Source: Arbor-x, 2016

### 3. EXTENT (MAGNITUDE/STRENGTH)

Pest infestations are statewide with regional propensity depending on the specific pest. Grasshopper infestation tends to follow appropriate rangeland habitat which includes two-thirds of Colorado, generally outside of the high mountains. Depending on climate conditions and rangeland health, infestations can impact most counties in the Eastern Plains and Western Slope or be more localized, for instance to higher drought impacted counties.

The EAB has the potential to spread across Colorado’s urban forests. The City of Boulder alone has 98,000 ash trees, and the Denver metro area has an estimated 1.45 million ash trees (Colorado Department of Agriculture, n.d.).

Rodents such as mice, rats, and rabbits, are found across the entire statewide area. When the density of these populations exceeds the capacity of the ecosystem, agricultural industries such as crops and the health of livestock are threatened. The ability to model these trends is difficult and inconsistent.

## 4. PROBABILITY

Pest infestation and related disease is actively occurring in Colorado and is a continual process of nature. As more adaptable and generalized species are introduced to environments already impacted adversely by human activities, native species are often at a disadvantage to survive in what was previously a balanced ecosystem. There are many examples of decreased biodiversity in such areas. One of the primary threats to biodiversity is the spread of humanity into what were once isolated areas, with land clearance and habitation putting significant pressure on local species. Agriculture, livestock, and fishing can also introduce changes to local populations of indigenous species and may result in a previously innocuous native species becoming a pest, due to a reduction of natural predators. This threat intensifies the need for scientists, managers, and stakeholders to cooperate to build better systems to prevent invasion, improve early detection of invaders, track established invaders, and to coordinate containment, control, and effective habitat restoration.

Although invasive species, in most cases, primarily cause environmental damage and degradation, there are situations in which serious threats to public health, safety, and well-being can occur due to animal disease or plant/animal infestations. For example, certain diseases could wipe out large segments of an animal population, creating a potentially serious public health emergency and the need to properly (and rapidly) dispose of the dead animal carcasses.

Similarly, a widespread insect infestation, such as that of the emerald ash borer, can create serious public safety threats (especially in densely populated urban areas) due to partial/total collapse due to high winds or ice/snow accumulation. The falling trees or limbs can also bring down power lines, cause damage to public and private structures, and cause injuries or even death.

## 5. PREVIOUS OCCURRENCES

While historical data is somewhat limited for this hazard, there is a basis for considering pest infestations as a major hazard. Table 3-213 shows that since 1980 the state has twice declared disasters due to pest infestations.

TABLE 3-213 STATE DISASTERS IN COLORADO, 1980 TO 2017

Year	Hazard	Location
1980	Grasshopper Infestation	Logan, Morgan, Sedgwick, Phillips, Washington, and Weld Counties
1981	Grasshopper Infestation	Eastern Colorado Counties

Source: Colorado.gov

Colorado also regularly receives United States Department of Agriculture (USDA) Secretarial Disasters related to pest infestations. Table 3-214 shows Secretarial Disasters since 2003, however, years prior produced many additional declarations.

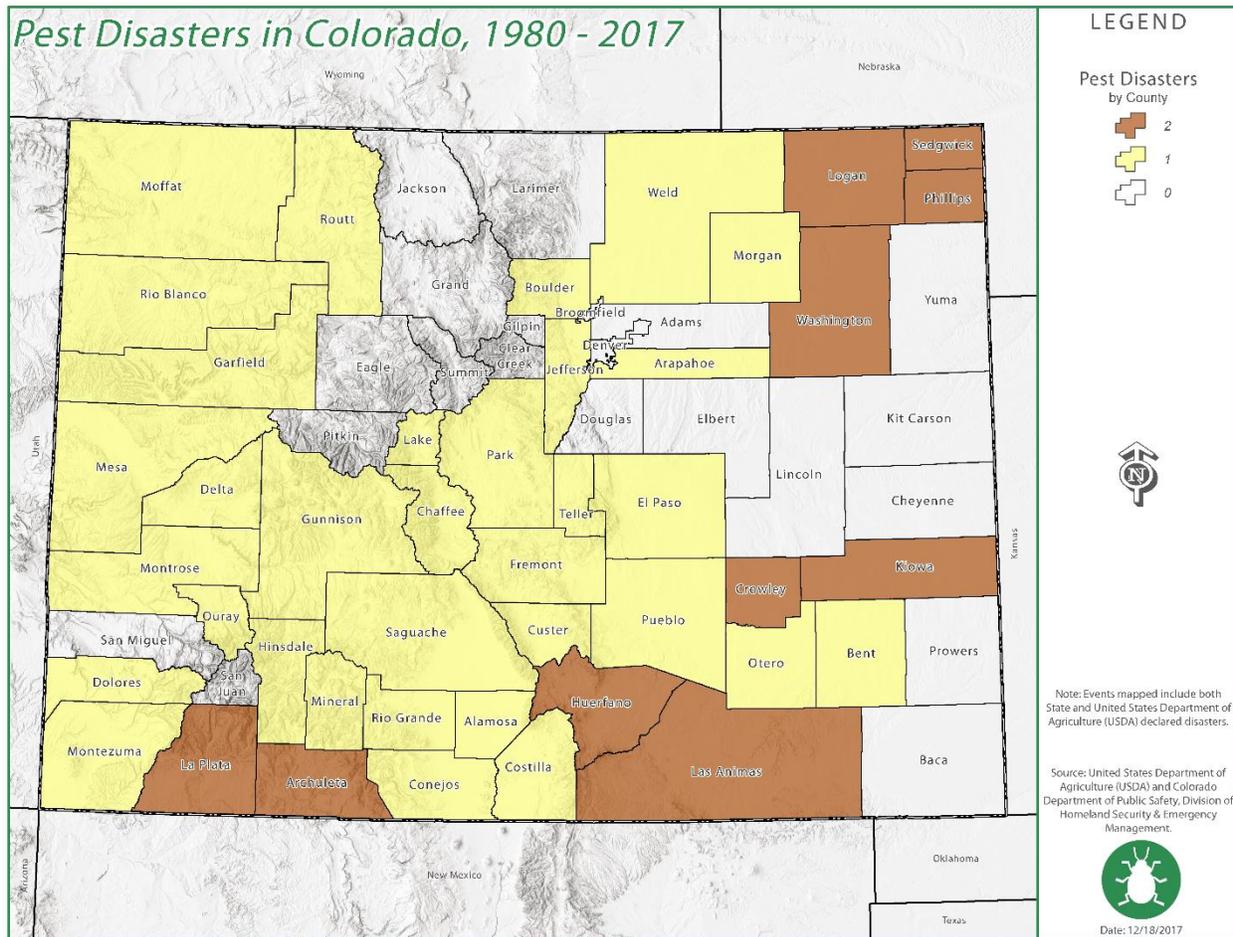
TABLE 3-214 USDA SECRETARIAL DISASTERS IN COLORADO, 2003 TO 2017

Year	Type	Declaration Number	Affected Counties
2003	Drought, Insects	S1843	Alamosa, Archuleta, Chaffee, Conejos, Costilla, Crowley, Custer, Dolores, Fremont, Garfield, Hinsdale, Huerfano, La Plata, Lake, Las Animas, Mesa, Mineral, Moffat, Montezuma, Otero, Pueblo, Rio Blanco, Rio Grande, Routt, and Saguache
2005	Drought, Crop Diseases, Insect Infestation	S2217	Logan
2005-06	Drought, Crop Diseases, Insect Infestation	S2287	Huerfano, Kiowa, Las Animas, and Sedgwick
2006	Heat, high winds, insect pests, late freeze, drought	S2329	Arapahoe, Archuleta, Bent, Boulder, Crowley, Delta, El Paso, Gunnison, Jefferson, Kiowa, La Plata, Montrose, Ouray, Park, Phillips, Teller, and Washington

Source: USDA

Figure 3-124 shows all pest-related disasters declared in Colorado from 1980 to 2017.

FIGURE 3-124 PEST DISASTERS IN COLORADO, 1980 TO 2017



### **Emerald Ash Borer (EAB)**

Emerald Ash Borer (EAB) is an insect native to Asia that was inadvertently introduced into North America sometime during the 1990s. Since its initial discovery in Michigan in 2002, this insect has killed millions of ash (*Fraxinus* spp.) trees throughout the central and northeastern United States and Canada. It is now considered the most destructive tree pest ever to be introduced into North America.

Infestations were first detected in Colorado in the City of Boulder, in September 2013. It is reported in the 2016 Health of Colorado’s Forests Report that approximately 15 percent of the trees in Colorado’s urban and community forests are ash, making this insect a major threat to these forests statewide. EAB was presumed to have infested the entire City of Boulder more than a year ago. Surveys in 2015 and 2016 in communities surrounding Boulder targeted ash trees exhibiting EAB symptoms, such as branch dieback and thinning crowns. New detections in the City of Longmont and community of Gunbarrel were confirmed in 2016. In August 2017, a the EAB was confirmed in the City of Lafayette, and as recent as March 2018, the EAB was confirmed in the City of Lyons.

A collaborative Colorado EAB Response Team has been organized to coordinate surveys and pest management activities designed to slow the spread and reduce the impacts of this extremely destructive insect. Agencies and organizations represented on this team include: Colorado State Forest Service, Colorado Department of Agriculture, Boulder County, City of Boulder, Colorado State University Extension, Colorado Tree Coalition, Green Industries of Colorado, University of Colorado, United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) and various municipalities. Representatives of this team have been instrumental in evaluating traps designed to attract flying adult beetles for early detection of infestations; the release of four species of parasitic wasps that target EAB; maintenance of an ash/hardwood quarantine zone in Boulder County and nearby areas to restrict movement of plant materials; and providing up-to-date information on the insect's status and the most effective ways to protect ash trees.

## 6. IMPACT ANALYSIS

The USDA APHIS estimates that introduced plant pests result in an approximate annual loss of over \$140 billion dollars to American agriculture and cost taxpayers millions more dollars in control expenditures. For Colorado, a conservative loss estimate of five to 10 percent due to plant pests could cost Colorado producers \$50 to \$100 million annually. Colorado's natural and cultivated plant resources are an important component of the state's economy.

The 2016 market value of Colorado crops, including nursery and greenhouse crops, totaled over \$2.1 billion. Colorado's top crops are wheat, corn, hay, and potatoes. With over 2.4 million acres dedicated to growing wheat, Colorado ranks fifth nationally in producing winter wheat and seventh for overall wheat production. There are approximately 1.3 million acres dedicated to corn production in the state generating \$462 million in cash receipts.

Colorado's largest vegetable crop is potatoes; the state produces over two billion pounds of potatoes annually and is consistently one of the top three shippers of fresh potatoes every year. Colorado's 2016 potato crop was valued at over \$175 million. The state's top fruit crops in 2016 were peaches and apples with a combined value of \$27 million.

The EAB specifically impacts Colorado's urban forests which provide many benefits to communities, including mitigating the urban heat island effect, stormwater services, improved air quality, and increased property values. It is estimated that metro Denver's approximately 1.45 million ash trees provide \$82 million annually in services including stormwater mitigation, energy savings and increased property values. This estimate does not include larger potential costs for tree removals (\$300/tree, or \$432 million), tree replacements (\$400/tree, or \$576 million) and additional costs of insecticidal treatments to indefinitely preserve valuable ash trees (CSFS, 2015). Additionally, the impact of EAB may spread beyond metro Denver. Costs for EAB management will impact communities from the Eastern Plains to the Western Slope. Colorado Springs ash tree treatment and removal costs are estimated to be approximately \$3 million and \$10.5 million, respectively, and the City of Brighton's recent tree inventory data suggest that

EAB could lead to nearly a half-million dollars in removal costs. Also, City of Grand Junction inventory data indicate that ash trees make up 28 percent of the canopy, which could equate to approximately \$144,000 in treatment costs or over \$500,000 in removal costs (CSFS, 2015). Table 3-215 provides an overview of additional impacts of pest infestation.

**TABLE 3-215 PEST INFESTATION EMAP IMPACT SUMMARY**

Consideration	Description
<b>General Public</b>	Persons in agriculture and livestock industry. Mental health issues such as stress, anxiety, depression, and addiction recurrence may arise with loss of income in agricultural areas.
<b>First Responders</b>	No impact.
<b>Property</b>	Property impacts are likely limited to vegetation loss with cascading effects of erosion and deposition. Property values may decrease with trees impacted by the EAB.
<b>Facilities and Infrastructure</b>	No impact.
<b>Economic</b>	Crop and rangeland damage occur on an annual basis and in outbreak years, large amounts of rangeland and crops may be destroyed. Cost of damage to farmers and ranchers can reach into the millions of dollars in outbreak years. Economic impact to communities may be extensive for EAB. Potential economic impact of \$82 billion in metro Denver alone due to the EAB.
<b>Environment</b>	During a severe outbreak, grasshoppers may remove more vegetation than cattle in a given pasture and perpetuate erosion through the degradation of vegetation. Decline in urban forests from EAB may impair air quality and water quality in communities.
<b>Continuity of Government and Services</b>	None or limited loss of facilities, infrastructure function, accessibility, or ability to provide services.
<b>Confidence in Government</b>	Expectations of farmers and ranchers are largely related to the provision of financial resources for insecticides and the availability of financial assistance through disaster declarations.
<b>Critical Assets</b>	Increased risk to overhead utilities due to fall hazard from dead trees.

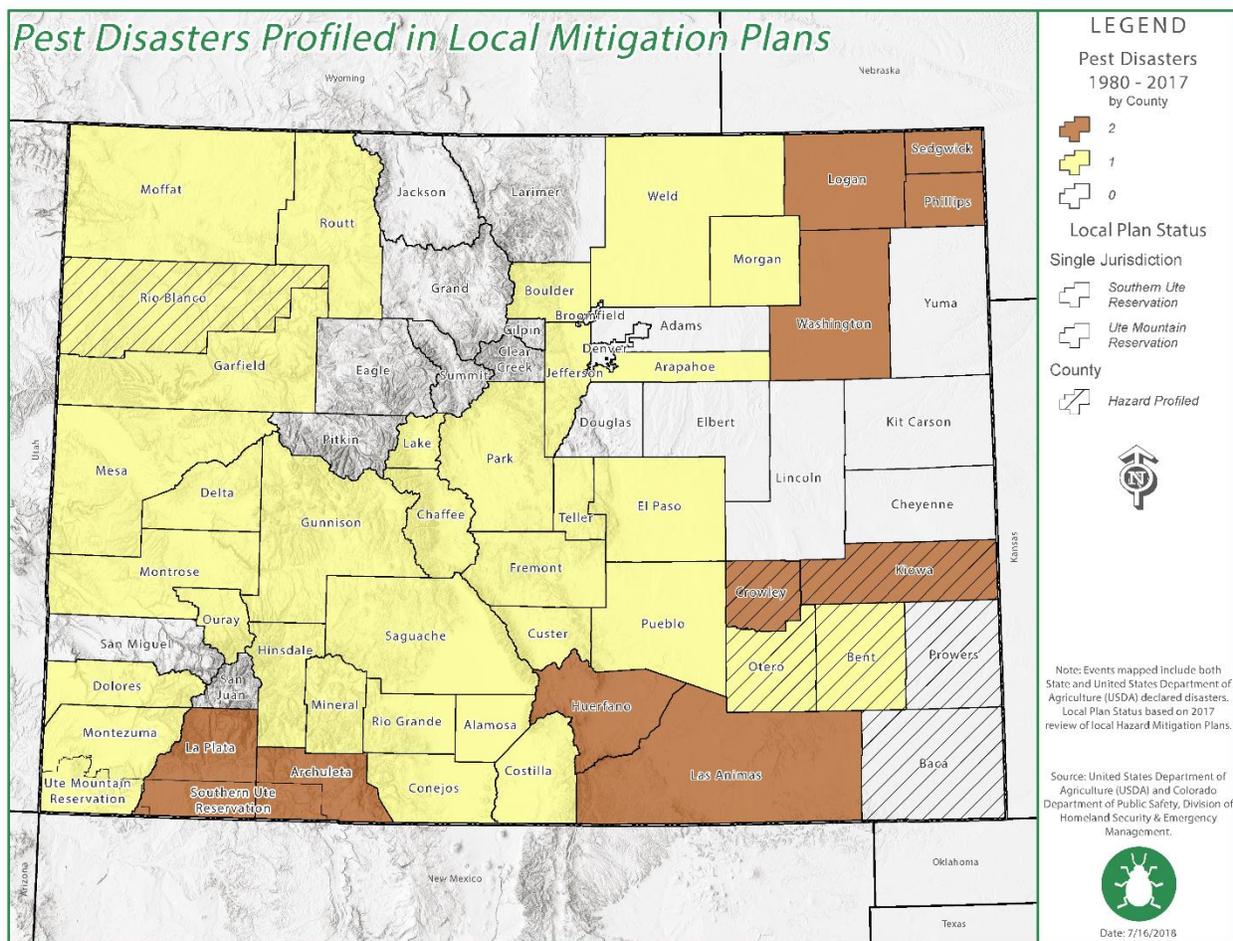
## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

It is difficult to estimate the impact that pest infestations could have on the State of Colorado. This is due to the fact that each occurrence requires a different form of response. A grasshopper infestation would largely impact the agricultural sector and counties with larger agricultural outputs. An EAB infestation is more localized, impacting individual communities'

urban forest. The higher percent of the urban forest that is comprised of ash trees, the larger the impact would be to the community.

Based upon an updated (2017) review of local mitigation plans, Figure 3-125 illustrates which local jurisdictions profiled pest infestations as a hazard, compared with historical disaster declarations. Only six counties have profiled pests as a hazard in local hazard mitigation plans, all located in the southeast corner of the state. This may be attributed to the low number of pest disasters, however, there are several counties that have had two pest disasters declared from 1980 to 2017, and many with one declared, that do not have pests profiled in local hazard mitigation plans.

**FIGURE 3-125 PEST DISASTERS PROFILED IN LOCAL MITIGATION PLANS**



Based on review of local hazard mitigation plans, one jurisdiction, Bent County, profiles pest infestation, specifically grasshoppers, as one of their top four hazards. Bent County estimated \$659,553 in average annual insurance losses due to grasshoppers.

## 8. FUTURE DEVELOPMENT

Future development has a limited relationship to pest infestation risk. If grassland or rangeland is converted to cropland, additional agricultural land may be exposed to grasshoppers during outbreaks.

In review of local hazard mitigation plans, no information on future development trends were profiled for pest infestations.

## 9. CLIMATE CHANGE

According to the best data available at the time of this plan update, the future impacts of climate change are expected to influence future pest infestation events. The following Table 3-216 presents a breakdown of these projected changes in terms of hazard: location, extent/intensity, frequency, and duration. However, ongoing efforts to reduce Colorado’s greenhouse gas emissions and adapt to a changing climate, such as the Colorado Climate Plan, will help to reduce the impacts of climate change on pest infestations.

TABLE 3-216 CLIMATE CHANGE IMPACTS

Impact	Projected Change
Location	Pests are projected to expand into more northern and higher elevation regions as average temperatures increase.
Extent/Intensity	Pest infestations are projected to increase in intensity as average temperatures increase. Extent may also increase.
Frequency	Pest infestations are projected to increase in frequency due to increased temperatures.
Duration	Crops are vulnerable to increased weeds and pests due to a longer growing season.

Source: FEMA 2017

## 10. RISK TO STATE ASSETS

No structures are anticipated to be directly affected by infestation, and since 2008, no state asset property losses have been reported due to a pest infestation.

## 11. RESOURCES

- Arbor-x, July 2016, Emerald Ash Borer, <http://www.arbor-x.net/tree-spraying/emerald-ash-borer/>
- Centers for Disease Control and Prevention (CDC)
- Colorado Climate Plan
- Colorado Department of Agriculture (CDA)
- Colorado Department of Public Health and Environment (CDPHE)

- Colorado Hazard and Incident Response and Recovery Plan (CHIRRP)
- Colorado Parks and Wildlife (CPW), Forest Management Program
- Colorado State Forest Service (CSFS)
- Colorado State Forest Service (CSFS), 2015. Report on the Health of Colorado's Forests. <https://csfs.colostate.edu/media/sites/22/2016/02/ForestHealthReport-2015.pdf>
- Federal Emergency Management Agency (FEMA). (2017). Assessing Future Conditions, Colorado.
- Southeast Colorado Regional Hazard Mitigation Plan
- U.S. Department of Agriculture (USDA)

# INFRASTRUCTURE FAILURE



## 1. DEFINITION

The National Infrastructure Protection Plan 2013 (NIPP) opens by stating, “Our national well-being relies upon secure and resilient critical infrastructure.” The NIPP goes on to define critical infrastructure as “systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters.”

For purposes of this Plan, Critical Infrastructure (CI) failure refers to any significant disruption to critical infrastructure that could have cascading effects that negatively impact Colorado’s security, public health and safety, and economic vitality. More broadly, critical infrastructure (CI) refers to the assets, systems, and networks, whether physical or virtual, so vital that their incapacitation or destruction would have a debilitating effect on Colorado’s way of life. The majority of the state’s critical infrastructure is owned and operated by the private sector, but significant components are owned or operated by the public sector, to include the State of Colorado as well as federal, local, and tribal governments.

Critical infrastructure failure is most often thought of as the consequence of another hazard or disaster, and the effects of other hazards on critical infrastructure are examined in those hazard profiles. This section examines CI failure separately as its own hazard with its own set of consequences.

Of the sixteen critical infrastructure sectors identified in Presidential Policy Directive (PPD) 21, *Critical Infrastructure Security and Resilience*, this profile focuses specifically on the following ten Commercial Facilities:

- Communications
- Critical Manufacturing
- Emergency Services
- Financial Services
- Food and Agriculture
- Government Facilities
- Healthcare and Public Health
- Transportation Systems
- Water and Wastewater Systems

The following CI sectors are not addressed in this profile:

- Chemical: see Hazardous Materials Release Hazard Profile
- Dams: see Dam/Levee Failure Hazard Profile
- Defense Industrial Base: a thorough assessment of this sector is beyond the scope of this Plan
- Energy: see Power Failure Hazard Profile
- Information Technology: see Cyber Attack Hazard Profile
- Nuclear Reactors, Materials, & Waste: see Radiological Release Hazard Profile

TABLE 3-217 HAZARD PROFILE SUMMARY

Consideration	Impact	Description
<b>Location</b>	Statewide	CI failures can occur in any part of Colorado. More vital CI tends to be concentrated in major population centers.
<b>Previous Occurrence</b>	Year-Round	CI failures can occur at all times of the year.
<b>Probability</b>	Increasing	Multiple factors point to the likelihood of more frequent and more severe CI failures in the future.
<b>Extent</b>	Moderate (Varies)	Small CI failures are typically handled locally with little or no assistance. A major, cascading CI failure could have significant statewide impacts and possibly require federal assistance.

## 2. LOCATION

Critical infrastructure can be found in every part of Colorado.

Commercial Facilities: Retail stores, hotels, theaters, and public venues are found in every county and municipality. Larger facilities, such as shopping malls, wholesale centers, media outlets, and major sports stadiums tend to be concentrated in population centers.

Communications: Communications systems utilized by government, emergency responders, businesses, and the public are located in every county and municipality.

Critical Manufacturing: Manufacturing facilities are located throughout the state.

Emergency Services: Every county and municipality has some emergency service resources, with larger and more-specialized resources being concentrated in the major population centers.

Financial Services: Nearly every populated area of Colorado contains banks, insurance agents, and the like. Larger financial institutions tend to be concentrated in population centers.

Food and Agriculture: Food and agriculture resources are located throughout the state, particularly in rural areas.

Government Facilities: Every county and municipality has their own local government facilities, in addition to state assets being distributed throughout the state. The bulk of major state and federal facilities are concentrated in the Denver metro area.

Healthcare and Public Health: Healthcare and public health facilities are distributed throughout the state, and generally increase along with population levels.

Transportation Systems: Roads and bridges, rail lines, small airstrips, postal and shipping facilities, and pipelines can be found throughout the state. Larger transportation hubs, commercial airports, and mass transit systems are more common in the larger population centers.

Water and Wastewater Systems: Water and wastewater systems are found in every county and municipality, to include many unincorporated areas.

Predicting the precise location of the next infrastructure failure is often difficult and generally dependent on the quality, upkeep, and maintenance of each piece of infrastructure, as well as protective actions that have been taken to mitigate or prevent damage.

See 7. *Vulnerability and Potential Losses by Jurisdiction*, for a more thorough discussion of the locations of Colorado's critical infrastructure.

### **3. EXTENT (MAGNITUDE/STRENGTH)**

The significance of any critical infrastructure failure will vary depending on the location and nature of the infrastructure itself. The loss of major CI systems could have potentially devastating impacts throughout the state, including significant disruption to essential life, and economic and financial impacts, as well as the possibility of causing damage to additional infrastructure. The September 2013 Colorado Floods were an example of a severe infrastructure disruption affecting 17 counties.

Conversely, the loss of a local road or a small commercial facility may have only minor impacts limited to the immediate area. However, small jurisdictions often have fewer resources to respond to infrastructure failure, as well as fewer available alternatives; as a result, the loss of relatively "minor" infrastructure can still have a significant impact on those jurisdictions, sometimes leading to a need for state assistance.

The interconnected nature of critical infrastructure means that a failure in one jurisdiction can often lead to impacts in neighboring areas. For example, the loss of a hospital in one jurisdiction

can result in increased patient load on surrounding hospitals. An interruption of emergency services in one jurisdiction may lead to a need for response resources from other jurisdictions. In many sectors, such as Communications and the Financial Sector, local operations can be interrupted by the failure of virtual/cyber infrastructure located in another state, or even in another country.

Interdependencies between CI sectors can frequently lead to cascading impacts on other CI sectors; see Impact Analysis section.

## 4. PROBABILITY

Small, localized failures of individual infrastructure elements are a relatively common occurrence, and will likely continue to be so. It is more difficult to state the probability of a large-scale failure of critical infrastructure in Colorado, let alone to predict where and when it will happen. However, the convergence of multiple trends leads many experts to conclude that the probably is rising.

Extreme Weather: More severe storms, extreme and prolonged drought conditions, and severe flooding all combine to increase the risk of major infrastructure failure. See the other Hazard Profiles in this Plan for more discussion of how those hazards could in turn impact the state's critical infrastructure.

Aging Infrastructure: While America's infrastructure continues to age and deteriorate, public investment in maintaining our infrastructure as a portion of gross domestic product has declined substantially for the past 50 years. The American Society of Civil Engineers (ASCE) has estimated that \$2.2 trillion would be needed to bring the nation's infrastructure up to a condition that meets the needs of the current population. The Congressional Budget Office (CBO) has similarly estimated that an average annual investment of \$24 billion to \$41 billion is needed to maintain, repair and modernize America's drinking water and wastewater systems. The potential for accidents and failures from infrastructure operating beyond its intended lifespan or with insufficient maintenance thus continues to increase.

Colorado is not immune to these challenges. According to the Federal Highway Administration (FHA), Colorado ranks 18<sup>th</sup> among the 50 states in having the most roads in poor condition (10.5 percent) and 36<sup>th</sup> in terms of number of bridges rated as structurally deficient (5.7 percent). The National Inventory of Dams (NID), a database maintained by the U.S. Army Corps of Engineers (USACE) and the Association of State Dam Safety Officials (ASDSO), lists 24.5 percent of Colorado's dams as being high hazard risk, ranking Colorado 20<sup>th</sup> among states. Lastly, the U.S. Census Bureau's 2015 Annual Survey of State Government Finances found that 4.9 percent of Colorado's public spending was devoted to highways, the 15<sup>th</sup> lowest of all states, and well below the National average of 5.5 percent. These rankings are summarized in Table 3-218.

TABLE 3-218 COLORADO INFRASTRUCTURE RANKINGS

Area	CO Score	State Ranking	Source
Roads in Poor Condition	10.5%	18 <sup>th</sup> worst	Federal Highway Administration
Structurally-Deficient Bridges	5.7%	36 <sup>th</sup> worst	Federal Highway Administration
High Hazard Risk Dams	24.5%	20 <sup>th</sup> worst	National Inventory of Dams
Highway Spending	4.9%	15 <sup>th</sup> worst	US Census Bureau

Growing Interdependencies: Infrastructure systems are becoming more interconnected, both within and between sectors. While this has many operational and financial advantages, the extent of sector interdependencies greatly increases the likelihood of one failure leading to cascading failures through other systems. In an increasingly interconnected world, where critical infrastructure crosses national borders and global supply chains, the potential impacts increase with these interdependencies and the ability of a diverse set of threats to exploit them.

Cyber Vulnerabilities: Cyber-attacks against critical infrastructure systems have increased significantly and have the potential to cause major disruptions. See the Cyber-Attacks Hazard Profile for further discussion.

The breakdown of communications systems is a common theme in most disasters. Whether partial or complete, the failure of communications infrastructure exacerbates any emergency and can lead to additional loss of life and damage to property. Despite the increasing reliability and resiliency of modern telecommunications networks to withstand physical damage, the risk associated with communications failures remains serious due to growing dependence upon these tools by both responders and the public.

## 5. PREVIOUS OCCURRENCES

Colorado routinely experiences minor infrastructure disruptions, such as road closures, minor utility failures, or damage to government buildings from severe weather. The majority of such incidents are handled by the utilities, local government, or individual state agencies with no need for additional resources or coordination. More significant infrastructure failures are less common, but do happen:

1997 Blizzard: In October of 1997, a severe blizzard dumped as much as two to three feet of snow across much of southern and eastern Colorado. Power outages were widespread. Transportation throughout the area was severely disrupted; hundreds of people had to be rescued from stranded vehicles, and several people died. Closed

businesses resulted in economic loss of millions of dollars, and an estimated 20,000 cattle froze or starved to death.

2008 Salmonella Outbreak: In March 2008, the water supply for the City of Alamosa was found to be contaminated with salmonella. Multiple state agencies assisted in the response, to include providing bulk water distribution.

2008 Tornadoes: On May 22, 2008, six tornadoes touched down in Weld and Larimer Counties. In addition to killing one individual, destroying 102 homes and damaging another 154 structures, the tornadoes disrupted gas, electric, telephone, and water systems in the Town of Windsor, and damaged two wastewater treatment facilities.

September 2013 Floods: Historic rainfall and flooding damaged numerous roads and bridges, multiple sewer lines, and one wastewater treatment facility, as well as numerous businesses and government facilities. Many schools, businesses, and government offices remained closed for days or longer. Colorado's highway infrastructure was heavily impacted, with 486 miles of state roadway and 120 bridges damaged or unusable; the damage took months, and in some cases years, to repair.

Other notable recent infrastructure failures outside of Colorado include:

September 2001 Terrorist Attack: Communications failures in New York City on September 11, 2001 contributed directly to the loss of at least 300 firefighters.

2007 Minneapolis Bridge Collapse: The collapse of the Interstate 35W bridge in Minneapolis, Minnesota, in 2007, resulted in 13 deaths, numerous injuries, the disruption of commerce for more than a year, and the need for a new bridge at a cost of \$233 million.

2011 Joplin Tornado: On May 22, 2011, an EF5 tornado caused massive damage to the town of Joplin, Missouri. The regional medical center was destroyed, killing 6 patients and forcing the evacuation of 177 patients. Overall, the tornado killed 158 people and injured another 1150.

2012 Superstorm Sandy: Superstorm Sandy hit the New York metropolitan area on October 29, 2012. Mass transit throughout the region was shut down or disrupted, and the New York City subway system sustained significant damage. At least 37 health care facilities had to be evacuated due to flooding and loss of power and water; only a single hospital remained open on the island of Manhattan. Six hundred dialysis patients had to be displaced due to the closure of dialysis centers. The New York Stock Exchange closed for two days, it's longest closure since 1888.

## 6. IMPACT ANALYSIS

A 2009 National Academy of Sciences report “Sustainable Critical Infrastructure Systems: A Framework for Meeting 21st Century Imperatives” found that the efficiency, reliability, and resiliency of critical infrastructure systems affects many aspects of our society, including the following:

- The costs of food, durable goods, and consumer goods
- The competitiveness of U.S. services and goods in the global market
- The health, safety, and well-being of citizens
- The quality of life in communities
- The availability and reliability of power and the maintenance of life-support systems
- The travel time required for people to go from home to work or other destinations, and for the efficient transport of goods and services
- The reliability and speed of telecommunications
- The speed and effectiveness of communications about actions to be taken during natural and human-made disasters (e.g., regarding evacuation and safe harbors)
- The time, cost, and extent of recovery for communities following such disasters
- The quality of the environment and the availability of natural resources for other uses

Failures in one infrastructure sector can cascade into other sectors, and can even make the state more vulnerable to other hazards. Some of these interdependencies and cascading effects are discussed below, but this should in no way be considered a definitive list.

Commercial Facilities: Disruption in commercial operations can have major economic impacts, and affect the ability of other CI sectors to purchase needed supplies, parts, etc. A supply chain disruption could severely limit the state’s ability to recover from any disaster or emergency.

Communications: Most critical infrastructure sectors rely heavily on communications systems to control and monitor their operations; for many businesses, losing communications is as serious an interruption as losing power. Emergency Services in particular rely heavily on communications systems, both internally-owned and commercial, to coordinate their operations, as well as to send information to and from the public. According to Ernst & Young's Global Information Security Survey 2002, the top causes of business interruption failures are hardware or software failure (56%) and telecommunications failure (49%). The information technology sector is almost entirely reliant on communications systems; indeed, as more communications systems transition

to digital and Internet-based services, the line between “communications” and “data” has become increasingly blurred. Additionally, cell phones and Voice Over Internet Protocol (VOIP) services are more vulnerable to power outages than traditional “landline” phones.

Critical Manufacturing: A major failure or disruption in critical manufacturing facilities could result in significant national economic impact and lengthy disruptions that cascade across multiple critical infrastructure sectors or regions. Many critical manufacturing sector facilities also produce key elements or products for defense and are a part of the defense industrial base sector.

Emergency Services: As its operations provide the first line of defense for nearly all critical infrastructure sectors, a failure or disruption in emergency services can result in significant harm or loss of life, major public health issues, long term economic loss, and cascading disruptions to other critical infrastructure. Reduced emergency services could put the state at increased risk of several human-made hazards, as well as limiting the state’s ability to respond to and recover from natural and technological hazards.

Financial Services: The unique, complex, broad-based, globally distributed, and highly integrated nature of the financial services sector makes it more interdependent and prone to cascading impacts that could have major effects on the commercial and manufacturing sectors, as well as government and healthcare sectors.

Food and Agriculture: Interruption in any stage of the farm-to-table chain can lead to severe disruptions throughout the sector. Widespread disruptions to the food supply could have severe impacts on all CI sectors, the economy, and the general public; severe food shortages could also degrade the public’s ability to withstand other hazards such as prolonged winter storms.

Government Facilities: Loss of facilities can disrupt the ability of state and local governments to provide essential services to the public, to include emergency services, the maintenance and repair of transportation systems, and other public sector services. While loss of government facilities may not increase the likelihood of natural or technological disasters, a lack of government coordination and response could greatly magnify the impacts of most hazards.

Healthcare and Public Health (HPH): For many Americans, even a brief disruption in healthcare services could be catastrophic. At any one time, almost 50 percent of Americans require one or more prescription medications to mitigate health issues. Nearly 468,000 Americans require regular dialysis services. In 2012, America’s 15,673 certified nursing homes operated at over 80 percent capacity, and, at any one time, over 60 percent of the beds in America’s 4,973 community healthcare facilities were occupied. With such high demand, even minor interruptions to local or regional HPH infrastructure can have widespread impacts on the public, and to employees in all

sectors. Long-term or widespread interruptions could put the public at increased risk of a pandemic or other biological hazards.

Transportation Systems: Interruptions to commerce can affect the commercial, manufacturing, and agriculture sectors, to include potential critical supply chain disruptions. Interrupting the movement of the public affects all sectors if employees are not able to reach their worksites. Disruption of transportation systems can limit the ability of emergency services to reach affected areas. Utility work crews may be delayed in restoring services. Conversely, transportation interruptions can put some members of the public at severe risk if they are unable to reach needed medical services, such as dialysis patients.

Water and Wastewater Systems: A drinking water contamination incident or the denial of drinking water services could severely impact manufacturing facilities, food and agricultural operations, healthcare services, and the operation of government and emergency services. A major, prolonged loss of clean water could have far-reaching public health, economic, environmental, and psychological impacts. Disruption of wastewater treatment facilities or services can cause loss of life, economic impacts, and severe public health and environmental impacts. If wastewater infrastructure were to be severely damaged or destroyed, the lack of redundancy in the sector might cause a loss of service potentially affecting the habitability of homes and work spaces in all sectors.

The importance of continuity planning for all infrastructure sectors, public and private, cannot be overstated. Organizations and facilities should determine what infrastructure systems are necessary for them to continue to provide mission-essential services, what mitigation measures can be taken to protect those systems, and what alternate systems they could use in the event of an interruption.

## **7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION**

The following maps approximate the distribution of various Critical Infrastructure Sectors across the state. Figure 3-126 uses retail sales figures as a proxy for Commercial Facilities. Figure 3-127 uses manufacturing production as a proxy for Critical Manufacturing Facilities. Figure 3-128 uses the number of people employed in the financial and insurance industry as a proxy for Financial Services. Figure 3-129 uses healthcare and social assistance receipts and revenues as a proxy for Healthcare and Public Health Services (these figures all use 2012 Economic Census data). Figure 3-130 shows key Transportation Sector assets across Colorado. Figure 3-131 shows the value of state-owned assets as an indicator of Government Facilities Sector locations. Figure 3-131 does not include federal and local government assets; major federal assets are concentrated in the Denver-Lakewood area, while local government facilities tend to track generally with population.

FIGURE 3-126 COLORADO COMMERCIAL/RETAIL SALES BY COUNTY

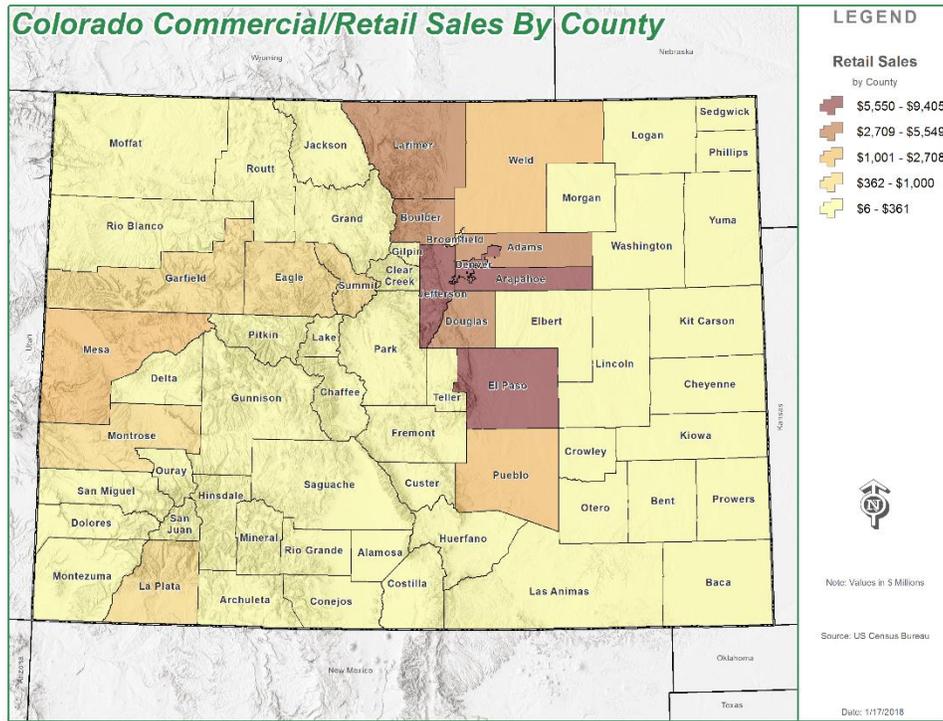


FIGURE 3-127 COLORADO MANUFACTURING PRODUCTION BY COUNTY

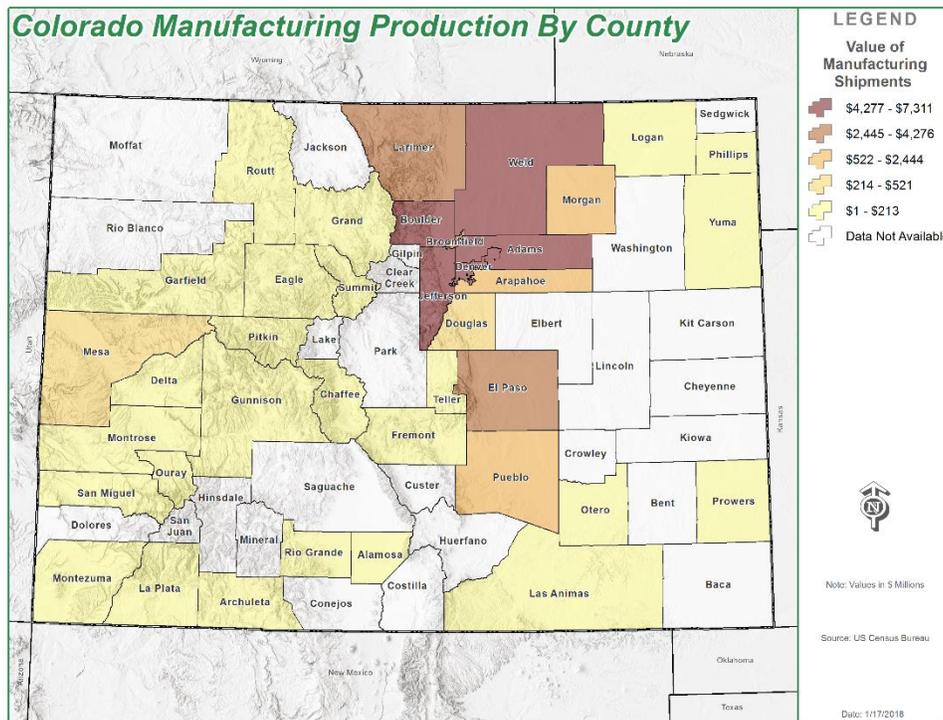


FIGURE 3-128 COLORADO FINANCIAL SECTOR EMPLOYEMNT BY COUNTY

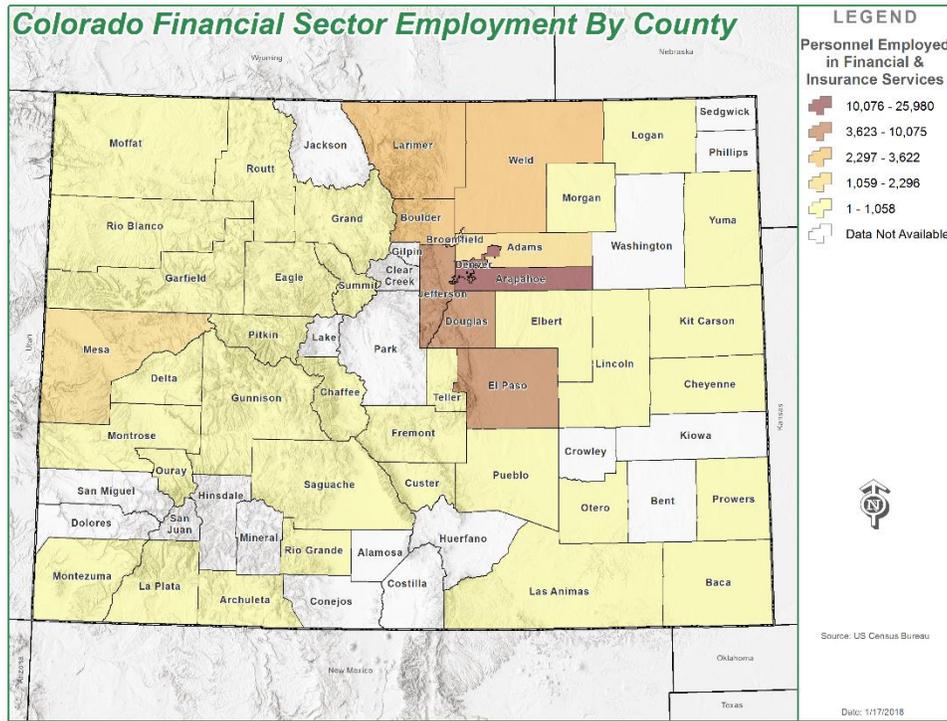


FIGURE 3-129 COLORADO HEALTHCARE SERVICES BY COUNTY

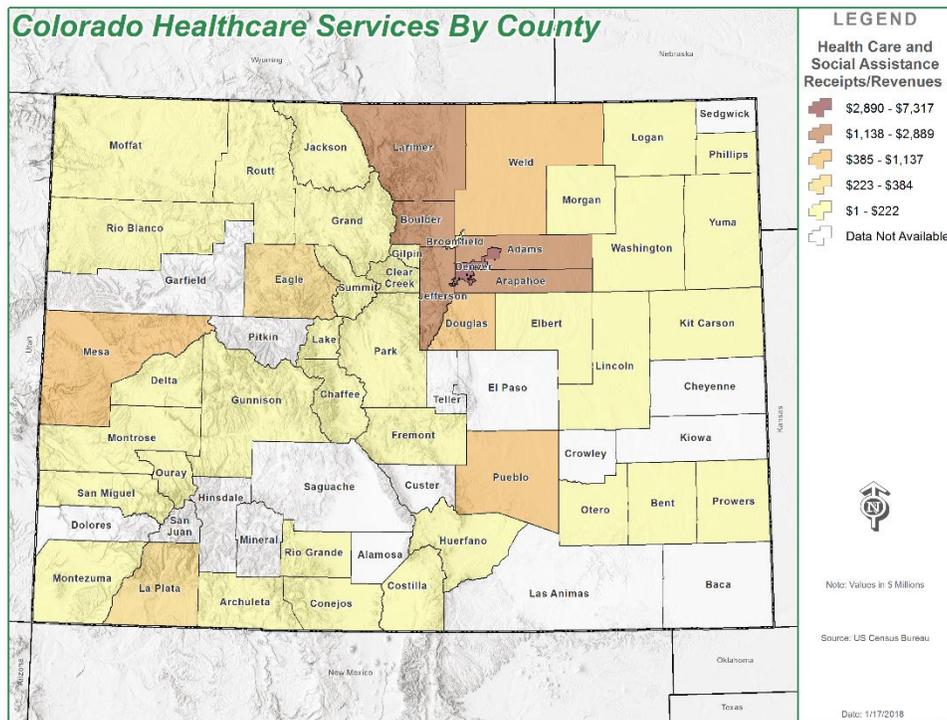


FIGURE 3-130 COLORADO TRANSPORTATION INFRASTRUCTURE

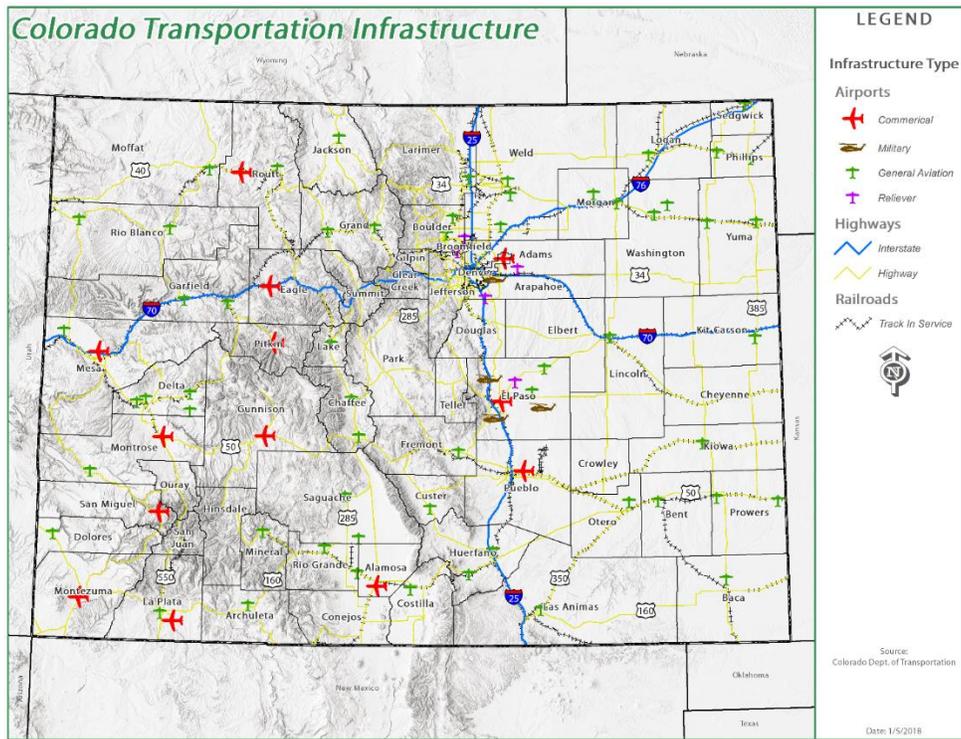
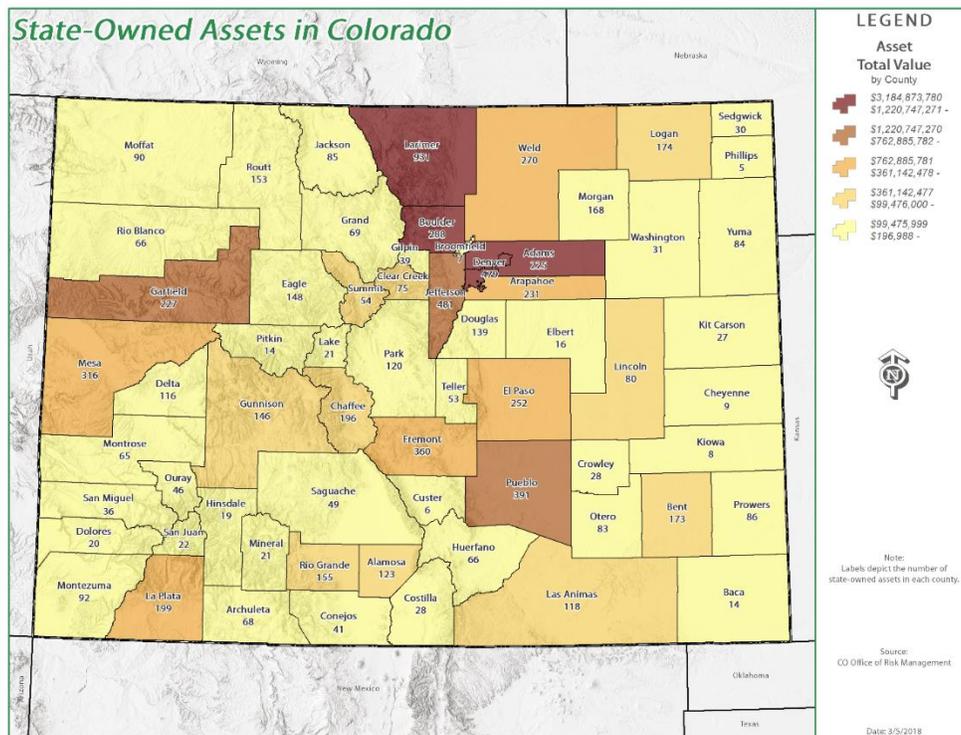


FIGURE 3-131 COLORADO STATE-OWNED ASSETS



In a review of local hazard mitigation plans none of them identified critical infrastructure disruption as a stand-alone hazard. Most plans address critical infrastructure disruption as a consequence of other hazards.

## **8. FUTURE DEVELOPMENT**

Future development can increase vulnerability to infrastructure failure by placing additional strains on existing infrastructure, as well as by increasing the size and thus the exposure of infrastructure networks. For example, the number of vehicle miles traveled (VMT) on Colorado's highway system has increased by 57 percent since 1990; during that same time, road capacity throughout the state increased by only two percent. Projections show that VMT is expected to grow by another 47 percent by 2040.

While similar data is not available for all CI sectors, anecdotal information and media reports give the impression that Colorado's infrastructure is not growing fast enough to sustain its current population growth. A more detailed study of the ability of CI lifeline systems and emergency services to absorb projected population growth should be considered in future updates to this plan.

## **9. CLIMATE CHANGE**

According to the best data available at the time of this plan update, the future impacts of climate change are not expected to influence future hazard events.

## **10. RISK TO STATE ASSETS**

State assets are just as vulnerable to critical infrastructure failure as the public sector. The state owns and/or operates some of its own infrastructure, such as radio communications systems, state highways, and many state buildings. For example, the 2013 Colorado Floods damaged 486 miles of state roadway and 120 bridges, at an estimated cost of more than \$535 million. Total infrastructure damage resulted in over \$262 million in public assistance funds.

But the state is also heavily reliant on privately-owned infrastructure, such as telecommunications, commercial vendors, hospitals, and drinking water. Even in sectors where public-sector ownership is common, such as emergency services, public health, and wastewater services, state assets are often dependent on local government assets. These dependencies must be evaluated on a facility-by-facility basis as part of their Continuity of Operations Planning (COOP).

## **11. RESOURCES**

- 2009 National Academy of Sciences report, "Sustainable Critical Infrastructure Systems: A Framework for Meeting 21st Century Imperatives"

- 2013 National Infrastructure Protection Plan (NIPP) and Sector-Specific Plans
- 2016 Colorado Threat and Hazard Identification and Risk Assessment (THIRA) and State Preparedness Report (SPR)
- Colorado Public Utilities Commission (PUC)
- Ernst & Young's Global Information Security Survey, 2002
- "When Communications Infrastructure Fails During a Disaster," by Christina Richards, Disaster Recovery Journal, November 12, 2015

# DAM AND LEVEE FAILURE



## 1. DEFINITION

Dams are human-designed structures built for a variety of uses, including flood protection, power generation, agriculture, water supply, and recreation. Dams typically are constructed of earth, rock, concrete, or mine tailings. 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.

Levees are embankments constructed along the banks of rivers, canals, and coastlines to protect adjacent lands from flooding by reinforcing the banks. Levees can be natural or man-made. A natural levee is formed when sediment settles on the river bank, raising the level of the land around the river. To construct a man-made levee, workers pile dirt or concrete along the river banks, creating an embankment. This embankment is flat at the top, and slopes at an angle down to the water. For added strength, sandbags are sometimes placed over dirt embankments. Levees provide strong flood protection, but they are not failsafe. Levees only reduce the risk to individuals and structures behind them; they do not eliminate risk. Levees are designed to protect against a specific flood level and could be overtopped during severe weather events.

Hydrologic failures of dams and levees can result from any one or a combination of the following causes:

- Prolonged periods of rainfall and flooding, which can result in overtopping
- Seismic activity
- 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
- Levee opening/breaching (similar to overtopping)

Water released by a failed dam or levee generates tremendous energy and can cause a flood that is catastrophic to life and property. A catastrophic hydrologic containment structure (e.g. dams and levees) failure could challenge local response capabilities and require evacuations to

save lives. Impacts to life safety will depend on the warning time and the resources available to notify and evacuate the public. Major loss of life could result as well as potentially catastrophic effects to roads, bridges, and homes. Associated water quality and health concerns could also be an issue.

In general, there are three types of dams: concrete arch or hydraulic fill, earth-rockfill, and concrete gravity. Each type of dam has different failure characteristics. A concrete arch or hydraulic fill dam can fail almost instantaneously: the flood wave builds up rapidly to a peak then gradually declines. An earth-rockfill dam fails gradually due to erosion of the breach: a flood wave will build gradually to a peak and then decline until the reservoir is empty. And, a concrete gravity dam can fail instantaneously or gradually with a corresponding buildup and decline of the flood wave.

Privately owned high and significant hazard dams are required by Colorado regulations to have Emergency Action Plans (EAPs) in place. Federally-owned high hazard dams are also required to have EAPs by federal regulations.

In 2004 FEMA produced the Federal Guidelines for Dam Safety document, which details the classification determinations for low, significant, and high hazard dams. The system is based on a dam failure’s potential for probable loss of human life, and the impacts on economic, environmental, and lifeline interests. As shown in Table 3-219 low hazard dams are classified based on the improbability of loss of human life and/or economic/environmental losses. Significant hazard dams may result in some economic/environmental losses; however, there is no probable loss of human life, while the failure of a high hazard dam almost inevitably leads to fatalities.

**TABLE 3-219 FEMA HAZARD POTENTIAL CLASSIFICATION SYSTEM FOR DAMS**

<b>Hazard Category</b>	<b>Loss of Human Life</b>	<b>Economic, Environmental, Lifeline Losses</b>
<b>Low</b>	None expected	Low and generally limited to owner
<b>Significant</b>	None expected	Yes
<b>High</b>	Probable. One or more expected	Yes (but not necessary for this classification)

Source: FEMA, 2004

Dam failures may be categorized into two types:

- 1) component failure of a structure that does not result in a significant reservoir release

- 2) uncontrolled breach failure that leads to a significant release

For levees, breaches and overtoppings are the most common types of failure that occur. With an uncontrolled breach failure of a levee or dam, there is a sudden release of the water, sometimes with little warning.

Another consequence of hydrologic containment structure failures is the potential for flooding as a result of discharge from dam outlet structures or spillways during excessive rain or snowmelt events. The risk from this type of flooding is also discussed in this hazard profile.

**TABLE 3-220 DAM FAILURE PROFILE SUMMARY**

<b>Consideration</b>	<b>Impact</b>	<b>Description</b>
<b>Location</b>	Statewide	Over 85% of counties in Colorado have one high hazard dam. Location is based on the purpose (recreation, energy, potable water), however, there is not a strong trend determining the site of dams in Colorado.
<b>Previous Occurrence</b>	Year-Round	Dam failure can occur at any time of year. A dam is more likely to overtop or exceed capacity during periods of heavy rain or spring runoff in the spring through summer months.
<b>Probability</b>	Unlikely	There are no official recurrence intervals calculated for dam failures, so estimating the frequency of occurrence is extremely difficult. Based on historical data indicating that there have been 130 dam failure events in 128 years, the risk of future occurrences is likely. The structural integrity of dams can decrease with age and other factors, thus regular inspections and maintenance should remain a priority.
<b>Extent</b>	Varies	Depending on the cause, dam failure flooding can be minimal and handled locally or, the event can be catastrophic. A catastrophic dam failure could challenge local response capabilities and require evacuations to save lives.

## 2. LOCATION

There are dams in every county across the State of Colorado. Fifty-five counties report having high hazard dams. Larimer County has the largest number of high hazard dams (54), followed by Boulder (28), El Paso (24), Delta (21), Jefferson (21), and Mesa (20). Figure 3-132 shows the locations of High and Significant Hazard dams, while Table 3-221 details the ten largest (in terms of maximum storage capacity) dams in the state.

FIGURE 3-132 HIGH AND SIGNIFICANT HAZARD DAMS IN COLORADO

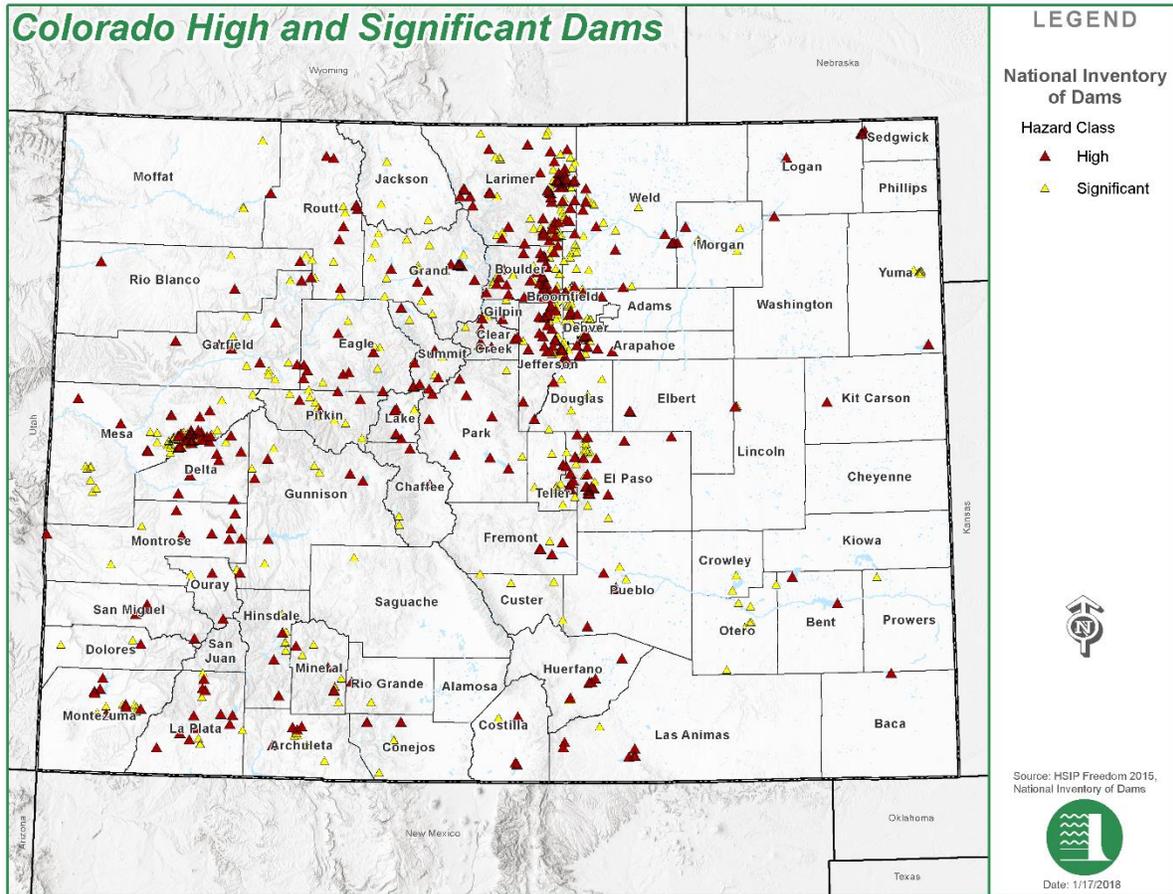


TABLE 3-221 DAMS WITH THE GREATEST MAXIMUM STORAGE CAPACITY

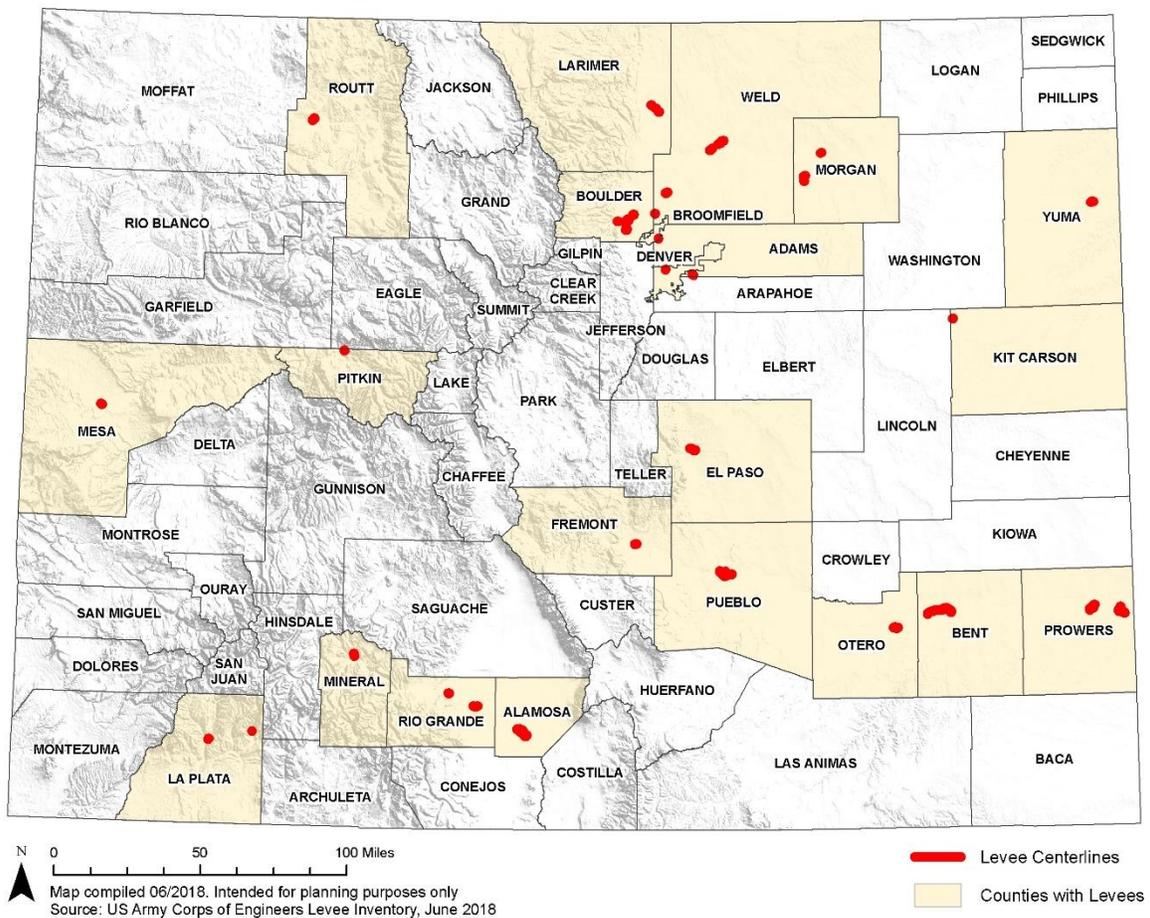
Name	Type of Dam	Year Built	Max Storage Capacity	Operator	River	County
<b>Blue Mesa</b>	Earth	1965	940,700	Bureau of Reclamation	Gunnison River	Gunnison
<b>John Martin</b>	Gravity	1943	608,245	US Army Corps of Engineers	Arkansas	Bent
<b>Granby</b>	Earth	1949	539,760	Bureau of Reclamation	Colorado River	Grand
<b>Pueblo</b>	Earth	1975	535,507	Bureau of Reclamation	Arkansas River	Pueblo
<b>Lemon</b>	Rockfill/ Earth	1962	487,660	Bureau of Reclamation	Florida River	La Plata
<b>McPhee</b>	Earth	1983	399,200	Bureau of Reclamation	Dolores River	Montezuma
<b>Chatfield</b>	Earth	1973	355,000	Bureau of Reclamation	South Platte River	Douglas
<b>Bonny</b>	Earth	1951	348,390	US Bureau of Reclamation	South Republican River	Yuma

Name	Type of Dam	Year Built	Max Storage Capacity	Operator	River	County
Dillon	Earth	1963	305,000	City and County of Denver	Blue River	Summit
Spring Canyon	Earth	1949	171,335	US Bureau of Reclamation	Spring Creek	Larimer

Source: FEMA, National Inventory of Dams 2015

Levee structures are also present in many counties throughout the state, according to the U.S. Army Corps of Engineers database. Figure 3-133 below displays the locations of these levees. The Colorado Flood Plan Update of 2018 goes into deeper discussion on levees, past breach events, and other such details of interest.

FIGURE 3-133 LEVEES IN COLORADO



In 2017, Colorado DWR Dam Safety set out to systematically evaluate all high hazard dams related to operational and flood releases. The analysis produced the “Colorado High Hazard Dam Release- Downstream Floodplain Impacts Databased and Ranking Tool”, containing information for both private and publicly owned high hazard dams across the state. The ranking of the dams identifies the dams with the highest threat of downstream flooding associated with

releases of excess water during high runoff or heavy rain. DWR Dam Safety screened the state’s dam database using information from USGS (Streamstats), FEMA Flood Insurance Studies (FIS), and the National Flood Hazard Layer (NFHL). The data was used to compare natural flows versus natural flows in combination with dam release flows. The resulting ranks were developed based on the severity of the conditions, estimated safe channel capacity of the downstream channel, and maximum controlled discharge. The report assesses 415 dams in the State of Colorado and provides a ranking for 366 dams where there is either a high, moderate, or low likelihood of dangerous conditions created by dam and reservoir release operations simultaneously with naturally occurring flood conditions. The high, moderate, or low designations were assigned by DWR by dividing the total number of ranked dams into thirds.

Table 3-222 below shows the top 10 highest ranked high hazard dams (122 total) based on the likelihood of dangerous conditions created by the dam release operations.

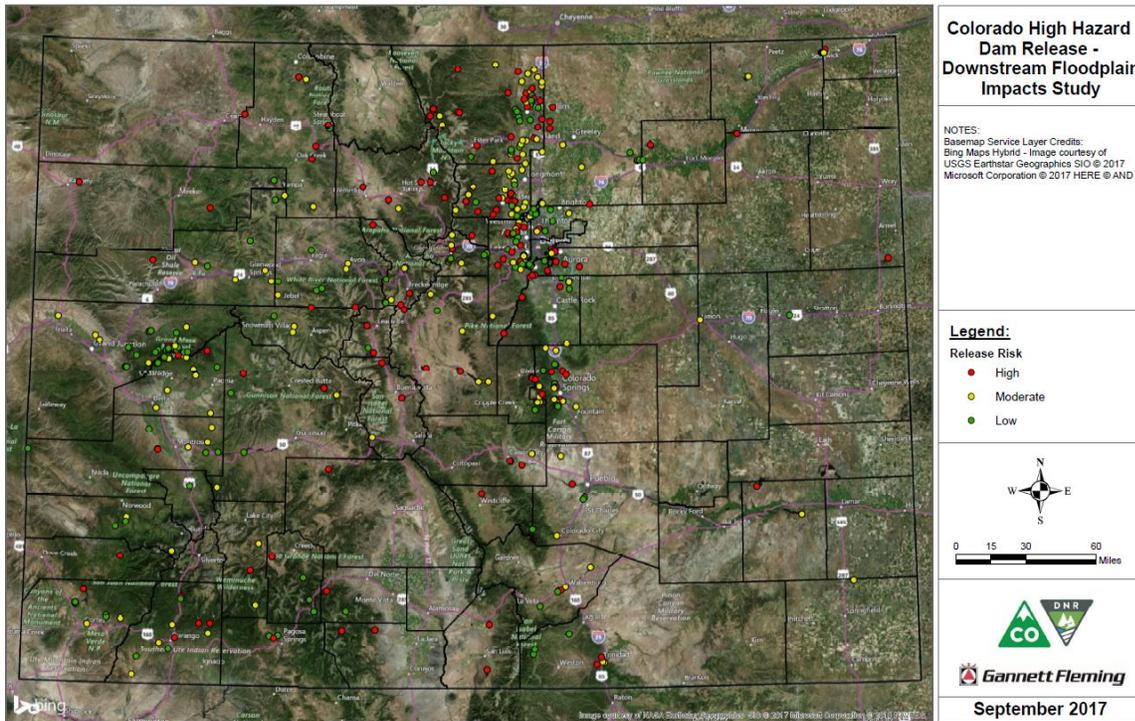
**TABLE 3-222 COLORADO DAM SAFETY RANKING BASED ON DAM RELEASE OPERATIONS**

<b>Ranking</b>	<b>Dam Name</b>	<b>Location (County)</b>
<b>1</b>	Rueter Hess	Douglas
<b>2</b>	Maple Grove	Jefferson
<b>3</b>	Bear Creek	Jefferson
<b>4</b>	Chatfield	Douglas
<b>5</b>	Kelly Road Detention	Denver
<b>6</b>	Blunn	Jefferson
<b>7</b>	Standley Lake	Jefferson
<b>8</b>	Ralston	Jefferson
<b>9</b>	Trinidad	Las Animas
<b>10</b>	South Platte Reservoir	Arapahoe

Source: Colorado DWR Dam Safety, 2017

The Colorado DWR high hazard dam release study results are exhibited in Figure 3-134 below. 366 dams across the state are symbolized based on release rating (high, moderate, low). The map indicates a concentration of high risk dams in the Front Range corridor.

FIGURE 3-134 COLORADO HIGH HAZARD DAM RELEASE STUDY RESULTS



Source: Colorado DWR Dam Safety, 2017

### 3. EXTENT (MAGNITUDE/STRENGTH)

The extent or magnitude of a dam failure event can be measured in terms of the classification of the dam. In a high hazard dam failure, the event will cause loss of human life, whereas the failure of a Significant Hazard dam would not result in loss of human life but could cause economic loss, environmental damage, disruption of lifeline facilities, or other significant damage. Low hazard potential dams are those at which failure would probably not result in loss of human life but would cause limited economic and/or environmental losses. Losses would be limited mainly to the owner's property.

With levees, on the other hand, damage can occur in several ways (which can impact the structure in question as well as other amenities, environment, property, and life). Strong river currents and waves can erode the surface of a levee. Debris and ice carried by floodwaters—and even large objects such as boats or barges—can collide with and gouge the levee. Trees growing on a levee can blow over, leaving a hole where the root wad and soil used to be. Burrowing animals can create holes that enable water to pass through a levee. If severe enough, any of these situations can lead to a zone of weakness that could cause a levee breach. In seismically active areas, earthquakes and ground shaking can cause a loss of soil strength. Seismic activity can also cause levees to slide or slump, both of which can lead to failure and ultimately destruction of property and possibly hurting human life.

According to the 2013 Colorado Natural Hazard Mitigation Plan, all high-hazard dams in Colorado have EAPs in place, which provide for the emergency notification procedures in the event of a dam emergency event. According to the National Inventory of Dams, a component of the Homeland Security Infrastructure Program, there are 1,733 dams in the State of Colorado. Of these dams, 1,004 are rated as low hazard, 342 are rated as significant hazard, 386 are high hazard, and one dam is unclassified.

The extent of impacts of a hydrologic containment structure failure incident can range from minor overtopping and exceedance of spillway capacity, to full blown catastrophic flooding that inundates major population centers. When assessing magnitude of a dam failure event, it is important to consider: 1) severity of failure and 2) location of dam/proximity to urban centers. Some structure failure events lead to shallow flooding or a slow release, while other failures completely overwhelm the spillway and result in a rush of large volumes of water. Severity is directly linked to the cause of failure, as described in previous sections. In terms of location, some dams and levees are located in rural areas, while other structures are located above cities, such as the Barker Reservoir in Boulder County. Complete failure of urban dams and levees has potential to severely damage property, shutdown facilities and services for more than 30 days, and result in fatalities or leave residents stranded.

## 4. PROBABILITY

There have been at least 130 known dam failures and incidents since 1890 (Flood Hazard Mitigation Plan for Colorado, 2013). This number reflects all incidents associated with a dam, ranging from small leakages to catastrophic failure. While structural malfunctions or overtopping caused by excessive rainfall may be an annual occurrence, dam and levee failure events that cause damage to people and property are much less common. Since 1950, there have been six major dam failure events in the state. Using this information, a destructive dam failure occurs once every eleven years. See Section 0 for more detail.

The probability of a dam failure event is related to the source of breakdown. As described in the 2013 Colorado State Flood Mitigation Plan, dam failure floods are primarily a result of either hydrologic or structural deficiencies.

**Hydrologic Deficiency:** The result of inadequate spillway capacity, which can cause a dam to be overtopped during large flows into the reservoir. Dam and levee failure by hydrologic deficiency occurs from excessive runoff after unusually heavy precipitation. Large waves generated from landslides into a reservoir, or the sudden inflow from upstream hydrologic containment structure failures, are other causes of dam and levee failure by overtopping. Overtopping is especially dangerous for an earthen dam or levee because the down-rush of water over the crest will erode the structural face and, if continued long enough, will breach the structure embankment and release all the stored water suddenly into the downstream floodplain.

**Structural Deficiency:** The mechanics of a structural failure depends on the type of dam/levee and the mode of failure. Dam or levee failure floods due to structural deficiencies are characterized by a sudden rise in stream level and relatively short duration similar to a thunderstorm flood. They can occur at any time, but earthen dams and levees appear to be most susceptible to structural failure during the fall and spring freezing and thawing cycles. Old age is often at the root of structural deficiencies. Seismic activity in Colorado has recently been recognized as a potential source of structural problems due to liquefaction of sand layers in the embankment of a dam or levee. Examples of structural deficiencies in dams and levees include seepage through the embankment, piping along internal conduits, erosion, cracking, sliding, overturning, rodent tunneling, or other weakness in the structure.

Another key factor to consider when assessing the likelihood of a hydrologic containment structure failure is the age of the structure. According to the National Inventory of Dams, in 2015 Colorado had 281 high hazard dams over 50 years old. Of these dams built before 1968, eighty-six have been modified or retrofitted. This means that many old dams exist, which potentially makes them more vulnerable to problems and an increasing risk for failure.

## 5. PREVIOUS OCCURRENCES

The text below details a few major dam and levee failure flood events occurring in the state between 1950 and 2018.

**Larimer County, Lilly Lake Dam, 1951:** The earliest recorded dam failure flood in the Estes Park region occurred on May 25, 1951, when Lilly Lake Dam failed, sending flood waters down Fish Creek and into Lake Estes.

**Prowers County, Clay Creek, 1965:** In June 1965, a flood occurred on Clay Creek in Prowers County, which overtopped an earthen dam being constructed by the Colorado Game, Fish, and Parks Commission. Although the dam did not fail, it did divert floodwater into an adjacent drainage. The subsequent damage and death from this flood resulted in an important legal controversy known as the Barr Case. This case was finally decided in 1972 by the Colorado Supreme Court, which recognized the concept of probable maximum flood as a predictable and foreseeable standard for spillway design purposes.

**Weld County, Lower Latham Reservoir Dam, 1973:** The failure of the Lower Latham Reservoir Dam in 1973 and subsequent flooding in the Town of Kersey, resulted in a Presidential Major Disaster Declaration.

**San Juan County, Lake Emma, 1979:** The San Juan Mountains above Silverton experienced a dam failure flood when Lake Emma, a natural lake, was completely drained on June 4, 1979 by a series of abandoned mine tunnels beneath the lake. On June 4, 1979, floodwater flowed through a network of abandoned mine tunnels that extended beneath the lake.

**Larimer County, Lawn Lake Dam, 1982:** The Lawn Lake Disaster of 1982 caused four deaths and over \$31 million in property damage when a privately-owned dam failed in Rocky Mountain National Park above the Town of Estes Park in Larimer County. Gradual deterioration of the earthen dam led to a breach that released 220 million gallons of water. A lawsuit awarded \$480,000 to the family of one of the four persons killed in the disaster.

**Delta County, Carl Smith Reservoir, 1998:** The Carl Smith Reservoir failed on the evening of May 2, 1998. Carl Smith Dam is an 850-acre foot, Class 1 off-channel reservoir in Leroux Creek Basin north of Hotchkiss, Colorado. The failure was a result of a large slide on the downstream slope that extended across the crest and into the upstream slope. The releasing water swiftly eroded down through the top half of the remaining embankment and quickly released about 500 acre-feet of storage. The peak discharge just below the dam was determined to be around 3,300 cfs. Several residences were evacuated. The only loss of life was livestock. The high water washed out numerous bridges, and diversion structures were quickly rebuilt to restore water to irrigators.

**Dikes North of La Junta, Otero County, 1999:** A three-day rainfall event occurred on April 29 to May 1, 1999. Heavy rain and saturated soil caused flooding in two major areas along the Front Range, specifically in Northeastern Colorado along the South Platte River and some of its tributaries, and Southeastern Colorado along the Arkansas River and some of its tributaries. Rainfall totals of up to 13 inches were recorded in the Cheyenne Mountain region of Colorado Springs. The La Junta region recorded approximately 8 inches over the same three-day period. The Arkansas River broke the dikes near North La Junta, flooding approximately 200 residences and businesses. The stormwater runoff from the three-day general rain resulted in large flood inundation and erosion in the Arkansas River and Fountain Creek water sheds.

**La Plata County Levees and Dikes, 2006:** In 2006, La Plata County experienced prolonged and heavy rainfall over October 5 and 6. Vallecito Creek overflowed, resulting in flash flooding. Levees and dikes built in the 1970s along the Creek breached on the night of October 6.

**Embankment North of Pueblo, Pueblo County, 2007:** The area north of Pueblo was inundated by heavy rainfall in early May 2007. On the morning of May 7, an earthen embankment along Fountain Creek failed and 15 structures were flooded. The flooding was not a result of overtopping, but rather structural failure. This embankment was not a certified levee and was not identified on the effective FIRM.

**Riverside Park Levee, Evans, Weld County, 2013:** The Riverside Park levee failed in Evans during the September 2013 flooding. The floodwaters created a 70-foot gap in the levee. The flood put the sewage treatment plant out of operation, leaving residents unable to shower or flush their toilets for over a week.

**Morgan and Washington Counties Levee Breach, 2015:** On June 15, 2015, a levee breach, about 100 yards wide along the South Platte River, produced farmland flooding over northeast Morgan and northwest Washington Counties. Floodwaters, three to four feet deep, washed out

the Union Pacific railroad tracks southwest of Messex. Up to ten inches of water covered several miles of track. Approximately 30 trains per day had to be diverted until the tracks could be repaired and inspected. Washington County Road 58.3 was also washed out.

## 6. IMPACT ANALYSIS

All populations in a dam or levee failure inundation zone are potentially exposed to the risk of a hydrologic containment structure failure. Potential for loss of life is determined by the capacity and number of evacuation routes available for residents in the inundation zone, and ability to provide timely warning. Flood waters may cut off evacuation routes, limit emergency access, and create isolation issues. Populations without adequate warning are also increasingly vulnerable. Any buildings, property, state-owned facilities, and critical infrastructure located within or close to the dam inundation zone have the greatest potential to be impacted by the surge of water. Utilities such as overhead power lines, cable, and phone lines in the inundation zone are also vulnerable.

Beyond impacts for people and infrastructure, a dam failure event also exposes the environment to many risks. Like any other type of flood event, the inundation may introduce foreign elements and debris into local waterways and destroy downstream habitat, having significant effects on many species of both plants and animals. Table 3-223 below summarizes impacts from dam failure and similar hydrologic containment structure failure, as outlined by the Emergency Management Accreditation Program, or EMAP.

TABLE 3-223 EMAP DAM FAILURE IMPACT SUMMARY

Consideration	Description
<b>General Public</b>	Dam failure rarely results in fatalities, however, localized impact expected to be severe for inundated areas and moderate to light for other adversely affected areas. Contamination due to flooding of hazardous waste results in public health issues, as well as damage to sanitation services. Depending on severity of event, many people may be displaced or left homeless.
<b>First Responders</b>	Localized impact damages to personnel in flooded areas at the time of incident. Impacts to transportation corridors and communications lines affect first responders' ability to effectively respond.
<b>Property</b>	Some severe damage possible. Private property losses are at increased risk to those who do not have insurance.
<b>Facilities and Infrastructure</b>	Localized impact to facilities and infrastructure in incident area. Critical facilities impacted by dam failure flooding include communications services, hospitals, schools, nursing homes, utilities, waste-water treatment plants, roadways.
<b>Economic</b>	Local economy and finances adversely affected, possibly for an extended period depending on damage.

Consideration	Description
<b>Environment</b>	Wetland impacts due to dam or levee failure flooding can result in water quality impacts and wildlife habitat impacts. Dam/levee failure flooding may alter stream flow patterns, increase erosion, and lead to release of hazardous materials, sediment, or waste into streams, rivers, drinking water supply, ground water, and air.
<b>Continuity of Government and Services</b>	Loss of facilities or infrastructure for the provision of government services is expected to be non-existent or negligible. Possible short-term accessibility issues for first responders performing routine duties or personnel reporting to work locations. Damage to facilities/personnel in incident area may require temporary relocation of some operations.
<b>Confidence in Government</b>	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective. Localized impact expected to adversely affect confidence in local, state, and federal government, regardless of the dam owner.
<b>Critical Assets</b>	Risk to any critical assets is limited to state or local facilities located within inundation areas.

Dam failure inundation maps are used to quantify impacts of potential dam failure. These maps contain sensitive information and are not available due to the public nature of this Plan.

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

The vulnerability and potential for loss of a county to dam or levee failure can be modeled by the exposure and location of high and significant hazard dams in relation to the surrounding built environment. Though 55 counties have a high hazard dam located within county boundaries, there is an increased risk of failure and more serious impacts for some jurisdictions. To determine the areas with the most exposure and elevated risk of dam failure, the following table highlights the counties with over five high hazard dams. Table 3-224 identifies counties with a moderate or high risk to dam failure based on the number of high hazard dams. Using the Jenks Natural Breaks algorithm as detailed in Table 3-124, there are 20 counties with over seven High Hazard dams. This list includes Colorado’s most populous counties (Denver, El Paso, Arapahoe, Jefferson, Adams, Larimer, Boulder, Larimer), the majority of which are concentrated in the Front Range area. These counties contain some of the largest and most dense municipal areas including the cities of Denver, Colorado Springs, Aurora, Fort Collins, Lakewood, Thornton, Arvada, Westminster, Centennial, Boulder, and Greeley.

More detailed estimates can be generated using geospatial analysis of dam inundation areas, which can be found in each dam’s Emergency Action Plan. In addition, FEMA programs such as the Risk Mapping, Assessment, and Planning (Risk MAP) are designed to generate detailed flood hazard mapping and determination of hazards due to hydrologic containment structures such as levees, to inform governments as well as the general public.

TABLE 3-224 COUNTIES WITH OVER FIVE HIGH HAZARD DAMS

County	Number of High Hazard Dams
Larimer	54
Boulder	28
El Paso	24
Delta	21
Jefferson	21
Mesa	20
Weld	13
Eagle	11
Grand	10
La Plata	9
Montezuma	9
Montrose	9
Arapahoe	8
Routt	8
Adams	7
Clear Creek	7
Denver	7
Garfield	7
Park	7
Summit	7

Source: National Inventory of Dams, 2015  
U.S. Census Bureau 2016 Population Estimates

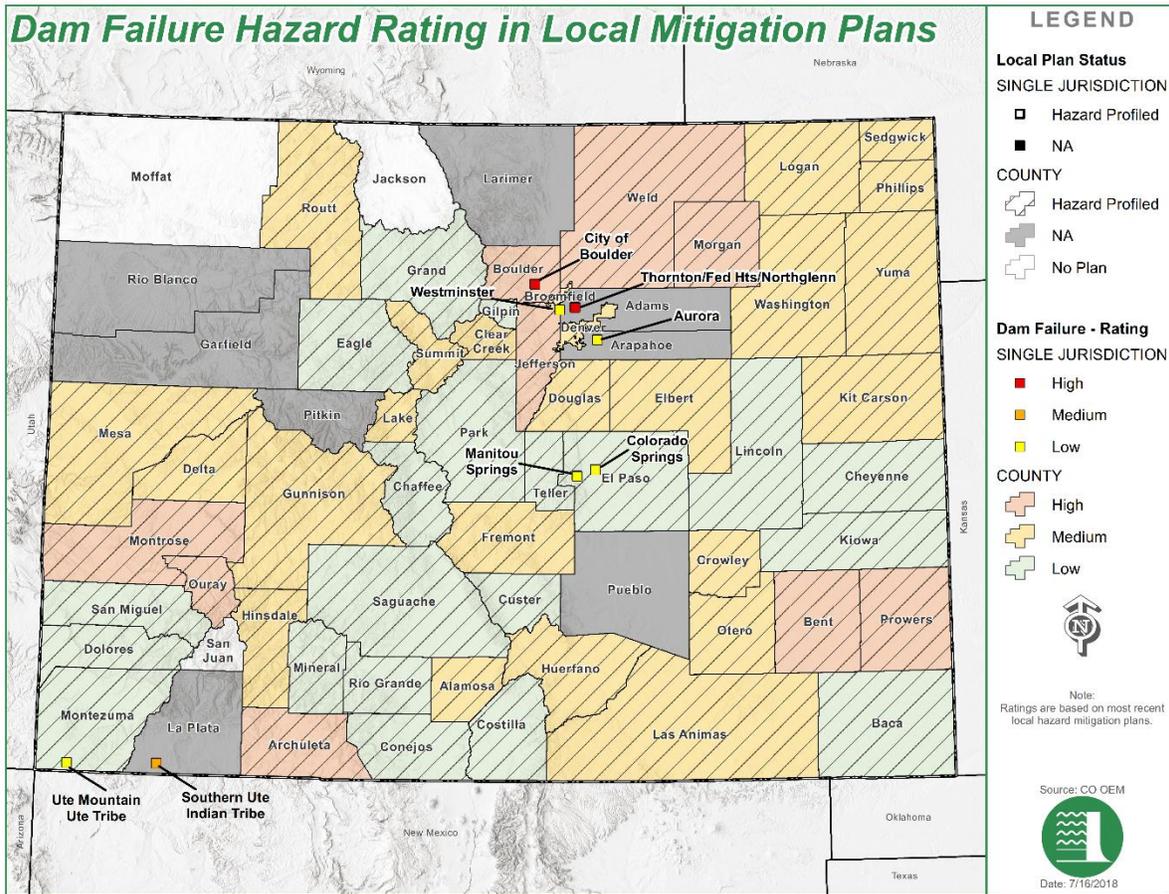
Based upon a recent (2018) review of local mitigation plans, Figure 3-135 shows which counties analyzed dam failure risk (though levee failure risk can be closely associated with said rankings) and which counties identified associated mitigation actions. The 2018 review of local mitigation plans indicates that 61 plans (out of 69 total) include a dam failure hazard analysis. Of these plans, dam failure received a “High Hazard” significance rating 11 times, “Medium Hazard” 25 times, and “Low Hazard” 25 times. Additionally, seven jurisdictions ranked dam failure as one of their top four hazards. Within those jurisdictions, there are a total of 8,556 structures/parcels and 145 critical facilities. Table 3-225 shows more detail as well as loss estimates.

TABLE 3-225 DAM FAILURE LOCAL ROLLUP RESULTS

Jurisdiction	# of Structures/ Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate (\$\$)	Loss Estimate Methodology
Bent County		130	Hazus	\$5,503,000	(same as flooding)
Boulder County					

Jurisdiction	# of Structures/ Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate (\$\$)	Loss Estimate Methodology
<b>City of Boulder</b>	8,210			\$1,864,568,000	
<b>Morgan County</b>		10 (didn't count bridges)		\$97,477,000	Hazus
<b>Ouray County</b>					
<b>Sedgwick County</b>		5 (didn't count bridges)		\$5,079,000	same as Hazus 100 yr
<b>Southern Ute Indian Tribe</b>	346 (Dams that could affect area)			\$69,622,428	Building and contents loss for resulting 6ft flood
<b>Total</b>	<b>8,556</b>	<b>145</b>		<b>\$2,042,249,428</b>	

FIGURE 3-135 DAM FAILURE HAZARD IN LOCAL MITIGATION PLANS



## 8. FUTURE DEVELOPMENT

Future developments will continue to be vulnerable to dam and levee failure. Increasing population figures and growing urbanization translates to a higher risk for communities located downstream of significant or high hazard dams, and generally located within or near the inundation areas of hydrologic containment structures including levees. Additionally, development downstream of existing low and significant hazard dams will elevate these dams to high hazard. Development downstream of dams does not only increase exposure to dams in general through growth, but also the exposure to high hazard dams by increasing the hazard itself.

The following section provides county-scale dam failure exposure projections by comparing dam failure risk based on number of high hazard dams with projected population growth data. Larimer County shows the highest exposure rating. Boulder, El Paso, Jefferson, Mesa, Adams, Denver, La Plata, Routt, Summit, and Weld Counties are also projected to experience the next

highest exposure to dam failure through 2030. These exposure projections will be very similar for any other hydrologic containment structure failure event, including levees.

**TABLE 3-226 DAM FAILURE EXPOSURE PROJECTIONS**

Future Dam Failure Exposure Projections					
		County Population Percent Change Projections, 2010 to 2030			
Risk		-13% to 2%	3% to 17%	18% to 34%	35% to 89%
<b>High</b>  <b>Moderate</b>	3	Moderate	High	Severe	Extreme
	2	Slight	Moderate	High	Severe
	1	Negligible	Slight	Moderate	High
	0	Negligible	Negligible	Negligible	Negligible

The Risk calculations in Table 3-226 are determined based on the number of High Hazard dams located within each county. The Jenks Natural Breaks algorithm was used to classify these historical data sets.

**TABLE 3-227 RISK METHODOLOGY**

Number of High Hazard Dams	Value
14 – 54	3
7 – 13	2
1 – 6	1
0	0

As population increases, more people will be exposed to dam failure. The darker, more red colors in Table 3-228 illustrate relative rates of increase in exposure between counties. This same information is also shown in Figure 3-136. Exposure is greatest in the north/central portion of the state in the Front Range region. Larimer County is considered to have extreme exposure to dam failure, which is primarily a result of the number of high hazard dams (54), which is 14% of the total number of high hazard dams in the state. Boulder, El Paso, Jefferson, Mesa, Adams, Denver, La Plata, Routt, Summit, and Weld Counties all have severe exposure rankings. As Colorado’s population increases, infrastructure, housing, and businesses will follow these population centers. This further adds to the potential future exposure that counties face from dam and other hydrologic containment structure failure. Colorado’s population and related

business and infrastructure is concentrated in, and will continue to intensify, in areas with high hazard dams.

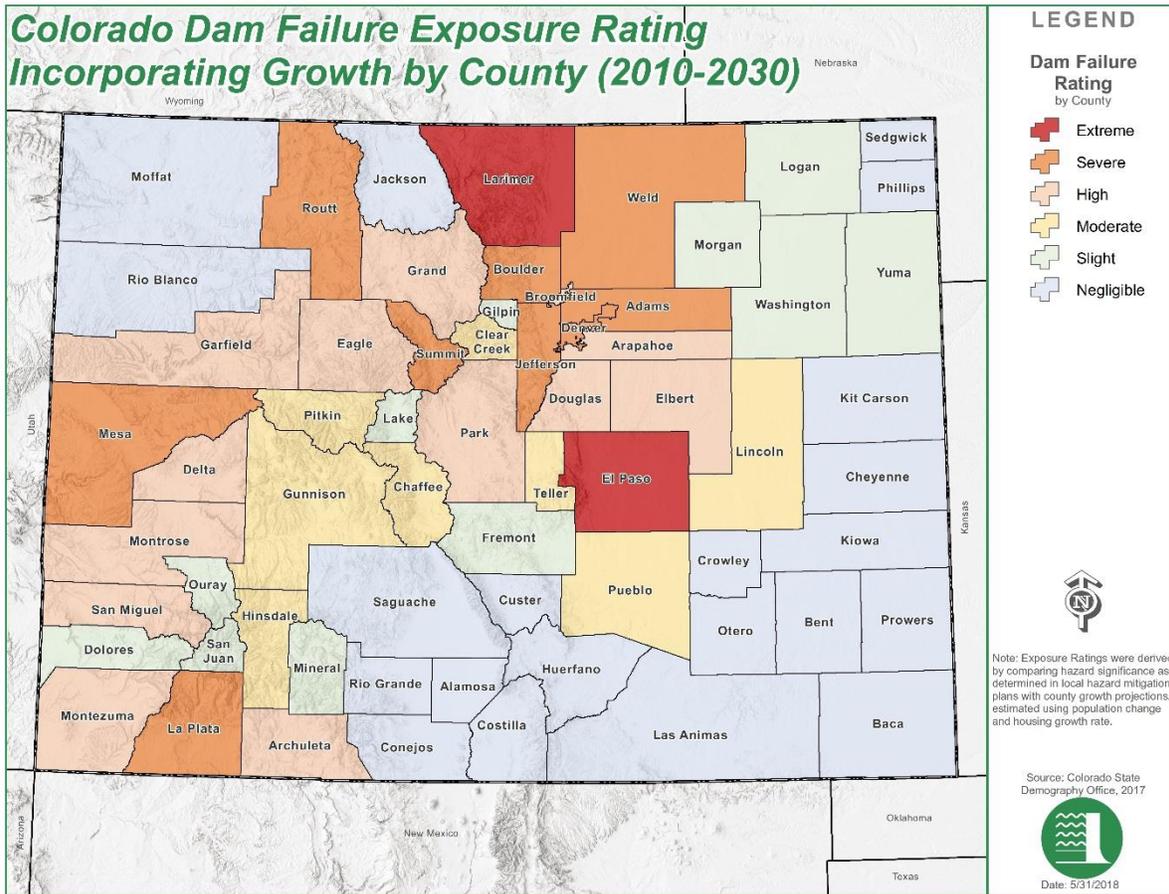
TABLE 3-228 DAM FAILURE EXPOSURE PROJECTIONS, 2010 TO 2030

County	Combined Risk	Population Change	Exposure Rating
El Paso	3	36%	Extreme
Larimer	3	42%	Extreme
Boulder	3	28%	Severe
Adams	2	48%	Severe
Denver	2	42%	Severe
Jefferson	3	21%	Severe
Mesa	3	24%	Severe
Routt	2	40%	Severe
Summit	2	41%	Severe
La Plata	2	42%	Severe
Weld	2	81%	Severe
Delta	3	8%	High
Arapahoe	2	36%	High
Archuleta	1	40%	High
Broomfield	1	71%	High
Douglas	1	44%	High
Eagle	2	34%	High
Elbert	1	89%	High
Garfield	2	38%	High
Grand	2	32%	High
Montezuma	2	37%	High
Montrose	2	30%	High
Park	2	34%	High
San Miguel	1	59%	High
Clear Creek	2	14%	Moderate
Chaffee	1	29%	Moderate
Gunnison	1	26%	Moderate
Hinsdale	1	29%	Moderate
Lincoln	1	21%	Moderate
Pitkin	1	18%	Moderate
Pueblo	1	20%	Moderate
Teller	1	25%	Moderate
Dolores	1	5%	Slight
Fremont	1	5%	Slight
Lake	1	17%	Slight
Gilpin	1	13%	Slight
Logan	1	14%	Slight

County	Combined Risk	Population Change	Exposure Rating
Mineral	1	16%	Slight
Morgan	1	16%	Slight
Ouray	1	17%	Slight
San Juan	1	5%	Slight
Washington	1	5%	Slight
Yuma	1	7%	Slight
Baca	1	-13%	Negligible
Alamosa	0	22%	Negligible
Bent	1	-5%	Negligible
Cheyenne	0	2%	Negligible
Conejos	1	1%	Negligible
Costilla	0	7%	Negligible
Crowley	0	5%	Negligible
Custer	0	20%	Negligible
Huerfano	1	-1%	Negligible
Jackson	0	-7%	Negligible
Kiowa	0	-8%	Negligible
Kit Carson	1	-1%	Negligible
Las Animas	1	-9%	Negligible
Moffat	1	-3%	Negligible
Otero	1	-7%	Negligible
Phillips	0	-3%	Negligible
Prowers	0	-5%	Negligible
Rio Blanco	1	2%	Negligible
Rio Grande	1	-5%	Negligible
Saguache	0	9%	Negligible
Sedgwick	1	-3%	Negligible

Source: Colorado State Demography Office, 2017

FIGURE 3-136 DAM FAILURE EXPOSURE BY COUNTY



## 9. CLIMATE CHANGE

With a potential for increase in extreme precipitation events, climate change may result in large floods that could stress dams and levees, and thus potentially increase the risk of failure of these structures. Dams and other hydrologic containment structures are designed based on calculations of a river’s flow behavior, and any changes in weather patterns can have significant effects on the hydrologic information used for the design of a dam or levee. Climate change may alter the dam/levee profile and affect the designed margin of safety. If freeboard is reduced, dam operators may be forced to release increased volumes of water to maintain the required safety parameters. Such early releases can increase flood potential downstream and possibly involve the spillway. Additionally, the structural integrity of earthfill dams may be compromised by climate change impacts such as drought and severe storms. Changes in vegetation and prolonged drying due to drought, embankment erosion due to severe storms, and more extreme fluctuations in water levels due to severe storms and increased frequency of drought all make earthfill dams vulnerable to climate change. The structural integrity of non-erodible dams or

levees, such as concrete, are less vulnerable to climate change, but extreme temperatures may lead to cracking or joint movement.

## 10. RISK TO STATE ASSETS

With the majority of state asset value located along Colorado’s Front Range, it follows that many state assets located in this area could potentially be at risk from dam or levee failure. For those counties with an extreme or severe future exposure to dam failure, asset valuation totals over \$13.9 billion, roughly 42% of the state’s total assets by count and 68% of the state’s total valuations for all assets. Table 3-229 shows state asset exposure projections from 2010 to 2030 with the dam failure exposure rating as an indication of potential risk to dam or other similar hydrologic containment structure failure. Available data did not support a more specific analysis of state assets within specific inundation zones

TABLE 3-229 STATE ASSET EXPOSURE PROJECTIONS, 2010 TO 2030

County	State Assets	Asset Valuation	Exposure Rating
El Paso	252	\$ 664,445,003.20	Extreme
Larimer	931	\$ 2,520,380,927.56	Extreme
Boulder	289	\$ 3,184,873,780.29	Severe
Adams	225	\$ 2,161,277,205.10	Severe
Denver	479	\$ 2,631,589,250.53	Severe
Jefferson	481	\$ 1,220,747,270.09	Severe
Mesa	316	\$ 571,483,873.39	Severe
Routt	153	\$ 19,636,862.59	Severe
Summit	54	\$ 210,520,143.35	Severe
Weld	269	\$ 723,621,025.70	Severe
Delta	116	\$ 39,890,610.27	High
Arapahoe	231	\$ 539,093,242.90	High
Archuleta	68	\$ 12,576,015.48	High
Broomfield	7	\$ 7,925,505.49	High
Douglas	139	\$ 41,437,868.03	High
Eagle	148	\$ 22,080,215.55	High
Elbert	252	\$ 664,445,003.20	High
Garfield	227	\$ 935,656,624.55	High
Grand	69	\$ 12,702,273.31	High
Lake	21	\$ 2,881,105.35	High
Montezuma	92	\$ 26,250,957.48	High
Montrose	65	\$ 19,168,190.06	High
Park	120	\$ 17,071,984.23	High
San Miguel	36	\$ 6,959,484.80	High
Clear Creek	75	\$ 117,846,308.75	Moderate

County	State Assets	Asset Valuation	Exposure Rating
Chaffee	196	\$ 135,641,023.78	Moderate
Gunnison	146	\$ 297,472,630.56	Moderate
Hinsdale	19	\$ 1,605,114.35	Moderate
Lincoln	80	\$ 115,435,435.78	Moderate
Pitkin	14	\$ 712,333.73	Moderate
Pueblo	391	\$ 1,100,717,917.35	Moderate
Teller	53	\$ 9,932,426.70	Moderate
Dolores	20	\$ 4,252,291.50	Slight
Fremont	360	\$ 762,885,780.91	Slight
Gilpin	39	\$ 10,009,237.23	Slight
La Plata	27	\$ 4,146,763.60	Slight
Logan	174	\$ 321,168,914.23	Slight
Mineral	21	\$ 30,302,497.25	Slight
Morgan	168	\$ 67,190,695.01	Slight
Ouray	46	\$ 8,684,296.55	Slight
San Juan	22	\$ 4,603,609.20	Slight
Washington	31	\$ 4,317,254.74	Slight
Yuma	84	\$ 14,101,083.60	Slight
Baca	14	\$ 1,559,394.45	Negligible
Alamosa	123	\$ 361,142,476.56	Negligible
Bent	173	\$ 116,882,345.50	Negligible
Cheyenne	9	\$ 712,471.20	Negligible
Conejos	41	\$ 6,598,803.40	Negligible
Costilla	28	\$ 4,179,435.88	Negligible
Crowley	28	\$ 99,475,999.08	Negligible
Custer	6	\$ 1,130,092.55	Negligible
Huerfano	66	\$ 35,640,305.12	Negligible
Jackson	85	\$ 13,799,847.03	Negligible
Kiowa	8	\$ 1,308,651.10	Negligible
Kit Carson	27	\$ 4,146,763.60	Negligible
Las Animas	118	\$ 152,450,902.98	Negligible
Moffat	90	\$ 15,349,886.63	Negligible
Otero	83	\$ 79,711,658.53	Negligible
Phillips	5	\$ 196,988.78	Negligible
Prowers	86	\$ 73,450,933.12	Negligible
Rio Blanco	66	\$ 63,910,055.25	Negligible
Rio Grande	155	\$ 134,839,206.68	Negligible
Saguache	49	\$ 5,188,186.65	Negligible
Sedgwick	30	\$ 1,827,494.15	Negligible

## 11. RESOURCES

- Colorado Division of Water Resources Dam Safety Section
- Colorado State Flood Hazard Mitigation Plan, 2013
- FEMA's RiskMAP program
- National Inventory of Dams, Homeland Security Infrastructure Program, HSIP Freedom 2015
- U.S. Army Corps of Engineers National Levee Database

# HAZARDOUS MATERIALS RELEASE



## 1. DEFINITION

A hazardous material (also known as HAZMAT) is defined by the U.S. Department of Transportation as, “A threat that poses an unreasonable risk to health and safety of operating or emergency personnel, the public, and/or the environment if not properly controlled during handling, storage, manufacturing, processing, packaging, use, disposal, or transportation.” Hazardous materials are defined and regulated in the United States primarily by laws and regulations administered by the U.S. Environmental Protection Agency (EPA), the U.S. Occupational Safety and Health Administration (OSHA), the U.S. Department of Transportation (DOT), and the U.S. Nuclear Regulatory Commission (NRC). Each has its own definition of a ‘hazardous material.’ For the purpose of tracking and managing hazardous materials, the DOT divides regulated hazardous materials into nine classes, listed in Table 3-230.

TABLE 3-230 HAZARDOUS MATERIAL CLASSES

Hazard Class	Description
<b>Class 1: Explosives</b>	1.1 Mass explosion hazard 1.2 Projectile hazard 1.3 Minor blast/projectile/fire 1.4 Minor blast 1.5 Insensitive explosives 1.6 Very insensitive explosives
<b>Class 2: Compressed Gases</b>	2.1 Flammable gases 2.2 Non-flammable compressed 2.3 Poisonous
<b>Class 3: Flammable Liquids</b>	Flammable (flash point below 141°F) Combustible (flash point 141°-200°F)
<b>Class 4: Flammable Solids</b>	4.1 Flammable solids 4.2 Spontaneously combustible 4.3 Dangerous when wet
<b>Class 5: Oxidizers and Organic Peroxides</b>	5.1 Oxidizer 5.2 Organic Peroxide
<b>Class 6: Toxic Materials</b>	6.1 Material that is poisonous 6.2 Infectious Agents
<b>Class 7: Radioactive Material</b>	Radioactive I Radioactive II Radioactive III
<b>Class 8: Corrosive Material</b>	Destruction of the human skin Corrode steel at a rate of 0.25 inches per year
<b>Class 9: Miscellaneous</b>	A material that presents a hazard during shipment but does not meet the definition of the other classes

Source: U.S. Department of Transportation

For the purposes of this Plan, HAZMAT releases are broken down by type of potential release:

- Fixed Releases
  - Fixed Facilities
  - Oil and Gas Wells
- Transportation Related Releases
  - Roadways, Rail, and Air
  - Pipelines

Table 3-231 shows the hazard profile summary for HAZMAT releases.

**TABLE 3-231 HAZARD PROFILE SUMMARY**

Consideration	Impact	Description
<b>Location</b>	Statewide	HAZMAT fixed facilities are located throughout the state, and transportation related incidents can happen on any infrastructure throughout the state.
<b>Previous Occurrence</b>	Sporadic	HAZMAT releases may happen at any time.
<b>Probability</b>	Expected	With continued use of hazardous materials in society, HAZMAT releases will continue to occur.
<b>Extent</b>	Moderate (Variable)	Depends on a variety of factors such as type of chemical, size of spill, location, weather, time of day, etc. A large incident in an area with high population may have severe public health and environmental impacts, and may cause costly property damage.

## 2. LOCATION

### 2.1 FIXED FACILITIES

Generally, with a fixed facility, the hazards are pre-identified. The Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 requires industries to report on the storage, use, and releases of hazardous substances to federal, state, and local governments. Facilities in Colorado must submit an emergency and hazardous chemical inventory form (Tier II form) to the Colorado Department of Public Health and Environment (CDPHE) and, if required by local reporting regulations, the Local Emergency Planning Committee (LEPC) and local fire departments annually. Tier II forms provide state and local officials and the public with information on the general hazard types and locations of hazardous chemicals present at facilities during the previous calendar year. The inventory forms require basic facility identification information, employee contact information for both emergencies and non-emergencies, and information about chemicals stored or used at the facility.

The Environmental Protection Agency (EPA) also maintains a National Priority List (NPL) which serves primarily informational purposes, identifying known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States and its

territories. In Colorado, there are currently 20 active NPL sites. Those sites are listed in Table 3-232. The Site Score is derived from the Hazard Ranking System (HRS), which is a methodology used by the EPA to assess the relative potential of sites to pose a threat to human health or the environment. This approach assigns numerical values to factors that relate to risk based on conditions at the site (U.S. EPA).

TABLE 3-232 COLORADO NATIONAL PRIORITY LIST SITES

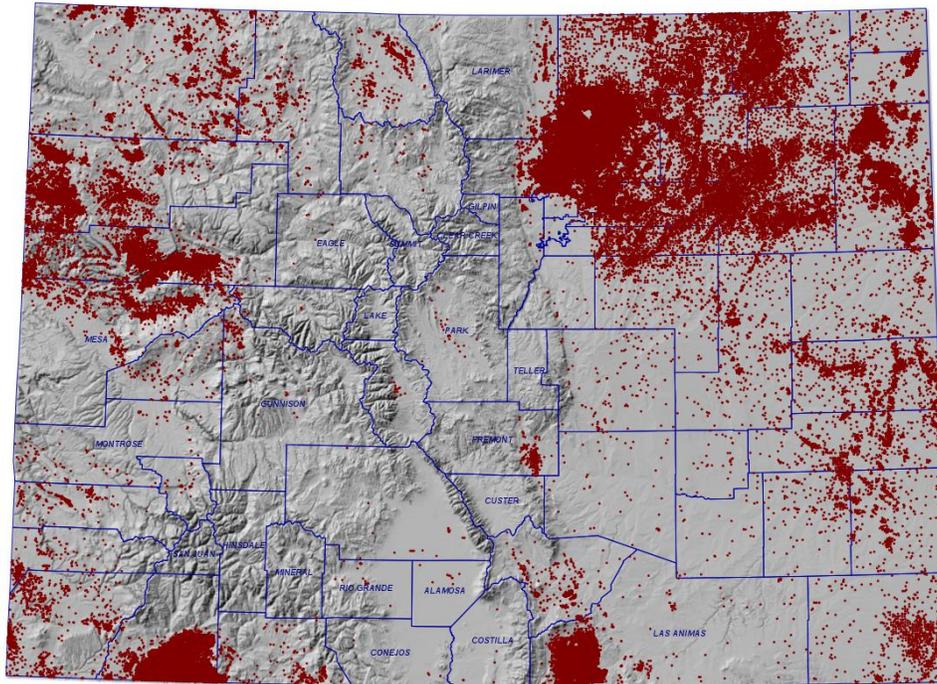
Site Name	Location	Listing Date	Site Score
<b>Air Force Plant PJKS</b>	Waterton	11/21/1989	42.93
<b>Bonita Peak Mining District</b>	San Juan County	9/9/2016	50
<b>Broderick Wood Products</b>	City and County of Denver	9/21/1984	35.13
<b>California Gulch</b>	Leadville	9/8/1983	55.84
<b>Captain Jack Mill</b>	Ward	9/29/2003	50.56
<b>Central City, Clear Creek</b>	Idaho Springs	9/8/1983	51.39
<b>Chemical Sales Co.</b>	City and County of Denver	8/30/1990	37.93
<b>Colorado Smelter</b>	Pueblo	12/11/2014	50
<b>Denver Radium Site</b>	City and County of Denver	9/8/1983	44.11
<b>Eagle Mine</b>	Minturn, Redcliff	6/10/1986	47.19
<b>Lincoln Park</b>	Canon City	9/21/1984	31.31
<b>Lowry Landfill</b>	Arapahoe County	9/21/1984	48.36
<b>Marshall Landfill</b>	Boulder County	9/8/1983	
<b>Nelson Tunnel/Commodore Waste Rock</b>	Creede	9/3/2008	48.03
<b>Rocky Flats Plant (USDOE)</b>	Golden	10/4/1989	64.32
<b>Rocky Mountain Arsenal (USARMY)</b>	Adams County	7/22/1987	58.15
<b>Standard Mine</b>	Gunnison National Forest	9/14/2005	50
<b>Summitville Mine</b>	Rio Grande County	5/31/1994	50
<b>Uravan Uranium Project (Union Carbide Corp.)</b>	Uravan	6/10/1986	43.53
<b>Vasquez Boulevard and I-70</b>	City and County of Denver	7/22/1999	50

Source: U.S. EPA, January 2018

## 2.2 OIL AND GAS WELLS

The oil and gas industry plays an important role in Colorado's economy. As of January 2018, there were over 100,000 active and plugged wells in Colorado (Colorado Oil & Gas Conservation Commission (COGCC), 2018). Figure 3-137 shows the locations of active and plugged oil and gas wells in Colorado on a map. Each well is represented by a red dot. The highest number of wells is in the northeastern portion of the state. Portions of southern and western Colorado also have a high number of wells. Lower densities of wells are located statewide. Weld County currently has 38,621 active and plugged wells, the highest amount in Colorado.

FIGURE 3-137 ACTIVE AND PLUGGED OIL AND GAS WELLS IN COLORADO



Source: COGCC, January 2018

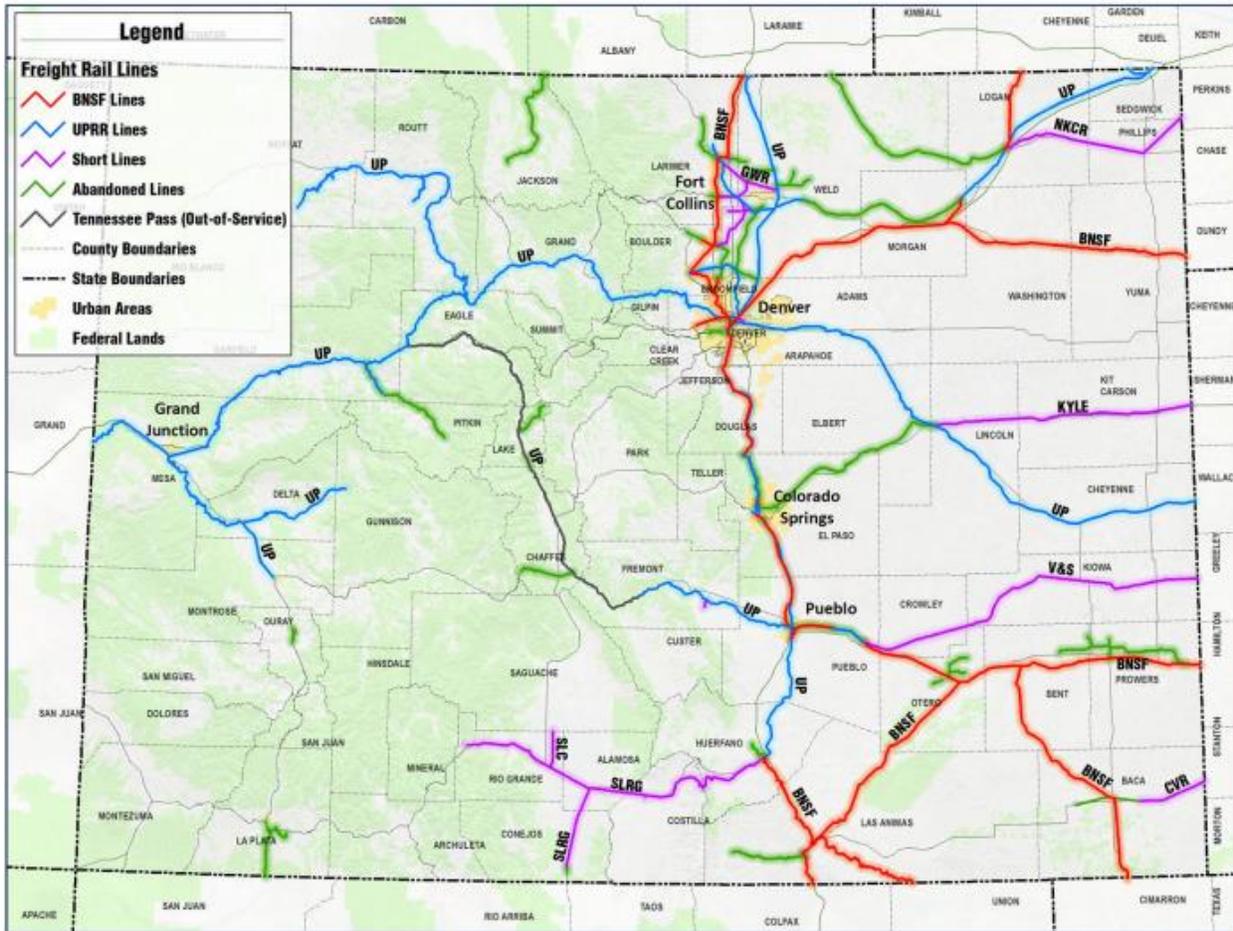
### **2.3 TRANSPORTATION (RAILWAYS, ROAD, AIR, AND PIPELINES)**

Transportation accidents address the transport of hazardous materials by rail, road, water, air, and pipeline. In these events, the exact location of a hazardous materials accident is not possible to predict. The close proximity of railroads, highways, pipelines, and airports to populated areas, schools, and businesses could put a large number of individuals in danger at any time. In addition, essential service facilities, such as police and fire stations, hospitals, nursing homes, and schools near major transportation routes in the state are also at risk from potential HAZMAT transportation incidents. Transportation of hazardous materials through the state happens at all times of day. Additionally, Colorado is an origination point of nuclear waste as well as a corridor state through which nuclear materials transit. The U.S. Census Bureau's 2012 Commodity Flow Survey, the most recent available, estimated that 26.5 million tons of hazardous material either originating or destined for Colorado were transported through the state that year.

### **2.4 RAILWAYS**

The railroad systems in Colorado transport various types and amounts of hazardous materials on their 2,800 miles of freight rails that traverse the state (Figure 3-138). It is difficult to estimate exactly when and how much hazardous materials move through Colorado by rail, but these materials do move through the state on a daily basis.

FIGURE 3-138 COLORADO RAILROAD SYSTEM

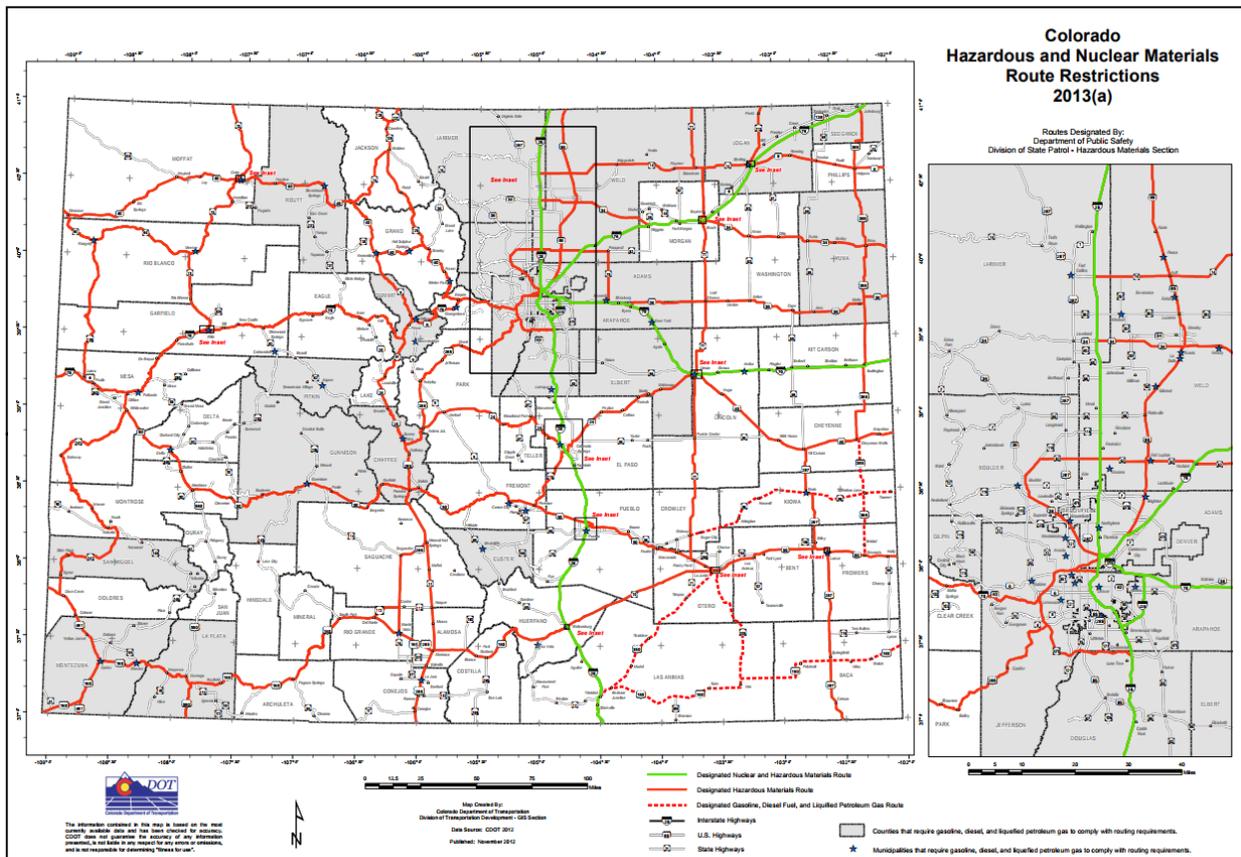


Source: CDOT Colorado State Freight and Passenger Rail Plan, 2012

### 2.5 ROADWAYS

Colorado has a diverse network of roadways that are authorized to transport hazardous and nuclear materials, as shown in Figure 3-139. These restricted routes are coordinated through the Colorado Department of Transportation and the Colorado State Patrol.

**FIGURE 3-139 COLORADO HAZARDOUS AND NUCLEAR MATERIALS ROUTE RESTRICTIONS**



Source: Colorado State Patrol, 2013

Title 42, Article 20 of the Colorado Revised Statutes governs the routing of hazardous materials by motor vehicles on all public roads in the state. CDOT Policy Directive 1903.0 (effective 5/20/2010), and CDOT Procedural Directive 1903.1 (effective 2/3/2011), govern CDOT’s role in the designation of HAZMAT routes. In order to designate a state highway in Colorado as HAZMAT route, CDOT staff members, local governments, or private entities must request the Mobility Section of the Division of Transportation Development to perform an analysis of the route. To perform this analysis, the Mobility Section convenes a “HAZMAT Advisory Team” to determine if the proposed route meets the required criteria. If the required criteria are met and approved by the Transportation Commission, CDOT will file a petition with the Colorado State Patrol for approval. Once the Colorado State Patrol approves the petition, the route is designated a HAZMAT route. The required criteria that the route must meet before it is brought before the Transportation Commission are as follows:

The route(s) under consideration are feasible, practicable, and not unreasonably expensive for such transportation.

- The route(s) is continuous within a jurisdiction and from one jurisdiction to another.
- The route(s) does not unreasonably burden interstate or intrastate commerce.

- The route(s) designation is not arbitrary or intended by the petitioner merely to divert the transportation of hazardous materials to other communities.
- The route(s) designation will not interfere with the pickup or delivery of hazardous materials.
- The route(s) designation is consistent with all applicable state and federal laws and regulations.
- The route(s) provides greater safety to the public than other feasible routes.

Considerations include but are not limited to:

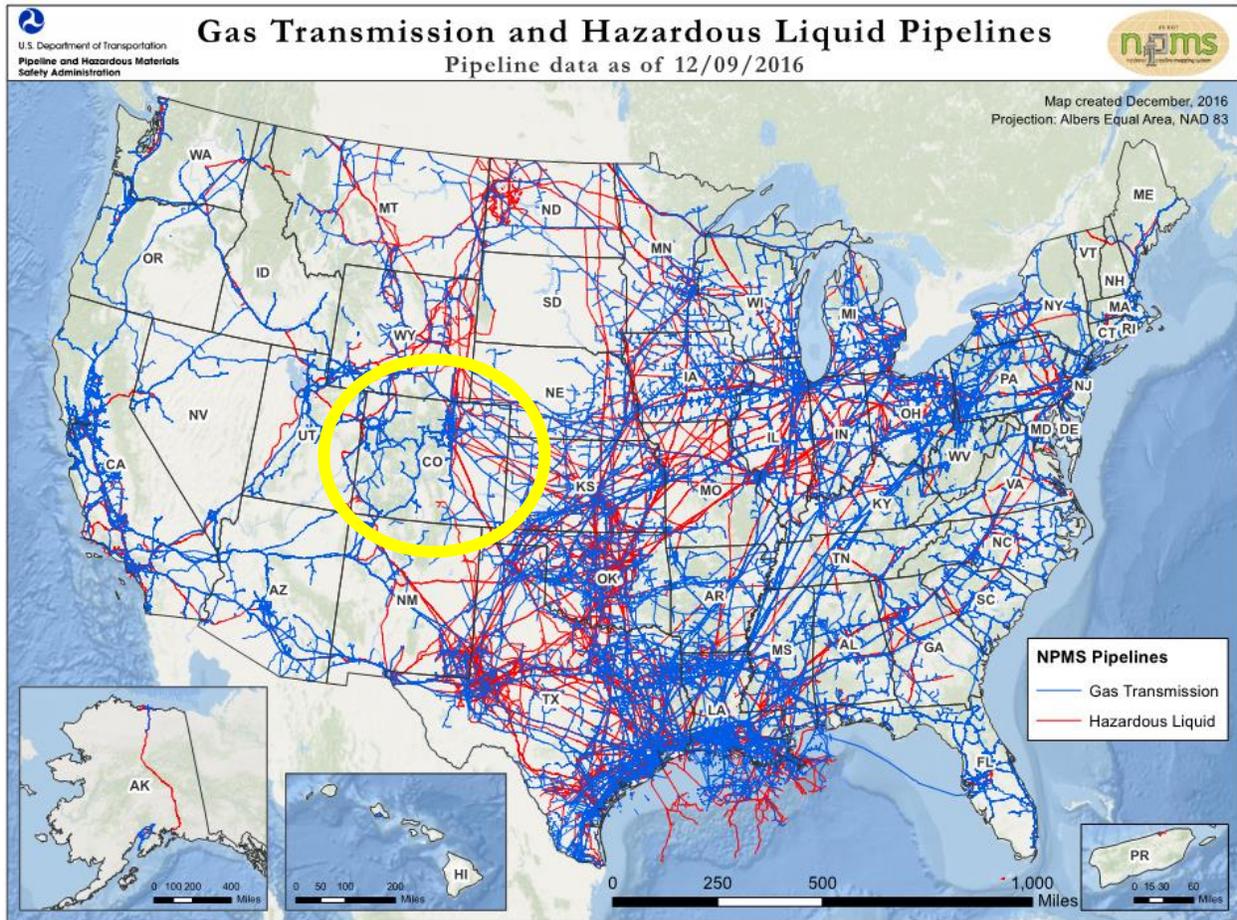
- AADT, crash, and fatality rates
- Population within a one-mile swath of each side of the highway
- Locations of schools, hospitals, sensitive environmental areas, rivers, lakes, etc.
- Emergency response capabilities on the route
- Condition of the route, i.e., vertical and horizontal alignment, pavement condition, level of access to the route, etc.

Troop 8-C is the Hazardous Materials Section of the Colorado State Patrol. Their mission is to contribute to the safety of hazardous materials transportation in order to protect citizens and the environment. Twenty-eight troopers trained as Hazardous Materials Technicians are deployed throughout the state.

## **2.6 PIPELINE**

Pipelines in Colorado may include large-diameter lines carrying energy products to population centers (transmission pipelines), as well as small-diameter lines that may deliver natural gas to businesses and households in neighborhoods (distribution pipelines). Gathering pipelines are pipeline systems that gather raw natural gas from production wells and transport it to large cross-country transmission pipelines. For the purposes of HAZMAT releases, pipeline transport focuses on two types of pipelines, hazardous liquids; including crude oil, petroleum products, anhydrous ammonia, highly volatile liquids, and carbon dioxide; and natural gas. In 2016, there were approximately 4,357 miles of pipeline carrying hazardous liquids through the state. Broken down by hazardous liquid commodity, there were 244 miles of pipeline carrying carbon dioxide, 1,194 miles carrying crude oil, 1,881 miles carrying highly volatile liquids, and 1,036 carrying refined petroleum products in 2016. Additionally, in 2016 there were 64,620 total miles of natural gas pipeline in Colorado (U.S. DOT Pipeline and Hazardous Materials Safety Administration). Figure 3-140 shows hazardous liquid and natural gas transmission pipelines throughout the United States, with Colorado highlighted in yellow.

FIGURE 3-140 GAS TRANSMISSION AND HAZARDOUS LIQUID PIPELINES IN THE U.S.



Source: U.S. Department of Transportation, 2016

### 3. EXTENT (MAGNITUDE/STRENGTH)

The entire State of Colorado is susceptible to HAZMAT releases. However, the magnitude of a release incident will vary in every case depending on the amount spilled or released, type of chemical, method of release, location of release, time of day, and weather conditions. Close coordination between the Colorado Department of Public Health and Environment (CDPHE), the Colorado State Patrol (CSP), the U.S. Environmental Protection Agency (EPA), the local jurisdiction, and the spiller (responsible party) will be required to minimize the potential impacts to public health and the environment.

#### 3.1 HAZARDOUS MATERIALS FIXED-FACILITY ACCIDENT

The chemical from a fixed-facility accident would be expected to move into the surrounding environment unless prompt and effective corrective actions are taken. An explosion from the hazardous material would impact the site and potentially neighboring facilities and infrastructure.

### 3.2 HAZARDOUS MATERIALS TRANSPORTATION ACCIDENT

As a result of the extensive use of chemicals in our society, all modes of transportation – highway, rail, air, and pipeline – are carrying thousands of hazardous materials shipments on a daily basis through local communities. A transportation accident involving any one of those hazardous material shipments could cause a local emergency affecting many people (CDOT THIRA).

## 4. PROBABILITY

With continued need for chemicals in our society, it is likely that HAZMAT releases from both fixed facilities and transportation will continue to occur. With Colorado’s population and housing growth expecting to increase, and as development encroaches on industrial areas, the exposure of the public to hazardous material releases may increase. However, continued regulation of hazardous materials may decrease the likelihood of hazardous material incidents.

## 5. PREVIOUS OCCURRENCES

### 5.1 FIXED RELEASES

The Emergency Planning and Community Right-to-Know Act (EPCRA) was passed by Congress in 1986. It was included as Title III of the U.S. Environmental Protection Agency’s Superfund Amendments and Reauthorization Act (SARA) and is usually referred to as “SARA Title III”. The act provides for the collection of and access to information about the use, storage, production and release of hazardous chemicals, to help inform emergency planners/responders and the public. Under SARA Title III, fixed facilities that spill more than the reportable quantity are required to immediately notify the National Response Center (NRC), the Colorado Emergency Planning Committee (CEPC), represented by CDPHE; and the Local Planning Committee (LEPC). Table 3-233 shows the number of HAZMAT incidents from fixed facilities per year reported to the NRC from 1990 to 2016 in Colorado. It is important to note that NRC reported incidents include any occurrence reported to the NRC, including a spill, sheen sighting, terrorist attack, discovery of illegal dumping, or a drill (U.S. Coast Guard, National Response Center). In total, there were 2,649 incidents from 1990 to 2017. The number of incidents vary every year, ranging from 71 to 150 incidents each year.

TABLE 3-233 COLORADO FIXED FACILITY HAZMAT INCIDENTS PER YEAR, 1990 TO 2016

Year	No. of Incidents	Year	No. of Incidents
1990	73	2004	82
1991	71	2005	114
1992	87	2006	122
1993	76	2007	142
1994	90	2008	119
1995	117	2009	92

Year	No. of Incidents	Year	No. of Incidents
1996	102	2010	87
1997	103	2011	78
1998	98	2012	72
1999	83	2013	100
2000	150	2014	88
2001	118	2015	94
2002	129	2016	73
2003	89	<b>Total</b>	2,649

Source: U.S. Coast Guard, National Response Center, January 2018

Table 3-234 shows the number of oil spills from wells in Colorado from 1999 to 2017. Production of oil and gas has increased every year from 2001 to 2015 (CNBC). The years 2015 to 2017 saw a decline in production due to falling oil prices, but is expected to increase with a rebound in prices. With increased production comes the potential for increased number of spills.

**TABLE 3-234 NUMBER OF OIL SPILLS FROM WELLS IN COLORADO FROM 1999 TO 2017**

Year	No. of Spills	Year	No. of Spills
1999	263	2009	368
2000	254	2010	499
2001	206	2011	501
2002	193	2012	407
2003	213	2013	633
2004	222	2014	792
2005	326	2015	624
2006	336	2016	529
2007	376	2017	605
2008	408	<b>Total</b>	7,755

Source: COGCC, January 2018

## 5.2 TRANSPORTATION

For transportation incidents that occur on state and federal highways, if the incident results in a hazardous material spill that exceeds the thresholds for reporting, immediate notification must be sent to CDPHE, NRC, the Designated Emergency Response Authority (DERA), Colorado State Patrol (CSP), and CDOT Water Quality Hotline. Table 3-235 shows HAZMAT transportation incidents reported in Colorado from 2009 to 2017 by transport type. Highway HAZMAT incidents are consistently the most common and most costly type of transportation spill in Colorado, with a total of 3,387 reported incidents and \$23,092,487 in damages from 2009 to 2017. Additionally, highway incidents produce the most injuries and fatalities of any mode of transportation, though a relatively low amount, with 12 total injuries and three total fatalities from 2009 to 2017.

TABLE 3-235 HAZARDOUS MATERIAL TRANSPORTATION INCIDENTS REPORTED IN COLORADO FROM 2009 TO 2017 BY TRANSPORT TYPE

Year	Incidents	Hospitalized	Non-Hospitalized	Fatalities	Damages
<b>Air</b>					
2009	6	0	0	0	\$0
2010	4	0	0	0	\$0
2011	9	0	0	0	\$0
2012	11	0	0	0	\$0
2013	14	0	0	0	\$0
2014	9	0	9	0	\$112,500
2015	10	0	0	0	\$0
2016	13	0	0	0	\$5,000
2017	7	0	0	0	\$0
<b>Total</b>	<b>83</b>	<b>0</b>	<b>9</b>	<b>0</b>	<b>\$117,500</b>
<b>Highway</b>					
2009	370	0	3	0	\$3,381,896
2010	359	0	0	0	\$1,204,591
2011	375	0	1	3	\$3,711,178
2012	365	0	4	0	\$2,257,357
2013	317	0	1	0	\$2,655,505
2014	351	0	1	0	\$2,715,906
2015	353	0	1	0	\$3,509,832
2016	459	0	1	0	\$2,488,951
2017	438	0	0	0	\$1,167,271
<b>Total</b>	<b>3,387</b>	<b>0</b>	<b>12</b>	<b>3</b>	<b>\$23,092,487</b>
<b>Rail</b>					
2009	13	0	0	0	\$26,121
2010	13	0	0	0	\$11,274
2011	10	0	0	0	\$151,175
2012	5	0	0	0	\$10,915
2013	10	0	0	0	\$10,723
2014	11	0	0	0	\$325,015
2015	7	0	0	0	\$11,433
2016	10	0	0	0	\$14,506
2017	2	0	0	0	\$505
<b>Total</b>	<b>81</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>\$561,667</b>

Source: U.S. Department of Transportation, January 2018

Significant\* hazardous liquid pipeline and natural gas pipeline incidents from 1997 to 2016 in Colorado are listed in Table 3-236. Pipelines result in few incidents per year, however can be costly when they do occur.

**TABLE 3-236 COLORADO SIGNIFICANT HAZARDOUS LIQUID AND NATURAL GAS PIPELINE INCIDENTS FROM 1997 TO 2016**

Calendar Year	Hazardous Liquid				Natural Gas				Totals			
	Number	Fatalities	Injuries	Total Cost Current Year Dollars	Number	Fatalities	Injuries	Total Cost Current Year Dollars	Number	Fatalities	Injuries	Total Cost Current Year Dollars
1997	1	0	1	\$85,754	3	0	1	\$614,570	4	0	2	\$700,324
1998	1	0	0	\$423,547	2	0	0	\$705,912	3	0	0	\$1,129,459
1999	1	0	0	\$153,355	2	0	2	\$174,267	3	0	2	\$327,622
2000	1	0	0	\$239,033	1	0	0	\$125,663	2	0	0	\$364,696
2001	1	0	0	\$2,000	5	0	2	\$906,884	6	0	2	\$908,884
2002	1	0	0	\$70,879	2	0	0	\$4,987,780	3	0	0	\$5,058,659
2003	1	0	0	\$97,885	2	0	0	\$1,103,535	3	0	0	\$1,201,420
2004	1	0	0	\$233,268	4	0	1	\$1,705,279	5	0	1	\$1,938,547
2005	1	0	0	\$659,247	2	0	1	\$304,802	3	0	1	\$964,049
2006	3	0	0	\$516,432	2	0	0	\$2,073,121	5	0	0	\$2,589,553
2007	3	0	0	\$194,387	6	0	0	\$4,669,137	9	0	0	\$4,863,524
2008	1	0	0	\$172,448	2	1	7	\$507,735	3	1	7	\$680,183
2009	1	0	0	\$247,709	3	0	2	\$485,610	4	0	2	\$733,319
2010					5	0	1	\$3,737,918	5	0	1	\$3,737,918
2011					2	0	2	\$982,531	2	0	2	\$982,531
2012					0	0	0	\$0	0	0	0	\$0
2013					3	0	3	\$1,177,141	3	0	3	\$1,177,141
2014	3	0	0	\$2,056,350	1	0	0	\$136,430	4	0	0	\$2,192,780
2015	2	0	0	\$716,199	1	0	0	\$202,963	3	0	0	\$919,162
2016	2	0	0	\$241,975	3	0	1	\$923,305	5	0	1	\$1,165,280
<b>Grand Total</b>	<b>24</b>	<b>0</b>	<b>1</b>	<b>\$6,110,469</b>	<b>51</b>	<b>1</b>	<b>23</b>	<b>\$25,524,582</b>	<b>75</b>	<b>1</b>	<b>24</b>	<b>\$31,635,051</b>

\*Significant Incidents are those including any of the following conditions, but Fire First incidents are excluded:

1. Fatality or injury requiring in-patient hospitalization.
2. \$50,000 or more in total costs, measured in 1984 dollars.
3. Highly volatile liquid releases of five barrels or more or other liquid releases of 50 barrels or more.
4. Liquid releases resulting in an unintentional fire or explosion.

Property Damage values are presented in dollars for the most recently completed calendar year. Value of gas lost is adjusted using the Energy Information Administration, Natural Gas City Gate Prices. All other values are adjusted using the Bureau of Economic Analysis, Government Printing Office inflation values in Table 10.1.

Source: U.S. DOT Pipeline and Hazardous Materials Safety Administration, January 2018

## 6. IMPACT ANALYSIS

The impacts of a HAZMAT release can vary depending on many factors such as location of the incident, weather, time of day, type of chemical involved, amount of people exposed, and response time. Impacts to a hazardous material incident could be severe, however they are typically localized to the direct area of the incident. People are exposed to a toxic chemical in three ways, through inhalation, ingestion, or touching the chemical. Many hazardous materials do not have any odor, and may only be detected once physical symptoms like watering eyes or nausea occur. Some hazardous materials can cause death, serious injury, long-lasting health effects, and damage to buildings and property. They can have an immediate effect (a few seconds to a few minutes) or a delayed effect (two to 48 hours). A fixed facility or transportation incident in a highly populated area could have a great impact on the public surrounding the site and the operators at the site of the incident. An explosion could lead to complete destruction of property. Ensuring safety information is distributed to a large population surrounding an event could be difficult. Contamination from hazardous materials also has the potential to make buildings surrounding the incident uninhabitable temporarily or permanently. A hazardous material transportation incident can lead to road and bridge closures causing service disruptions to the public as well as to first responders.

Additionally, if a hazardous material spill contaminates the surrounding environment such as surface water, groundwater, or soil, it could be extremely costly to clean-up. Wildlife dependent on the surrounding environment would be impacted. Such an event can also impact tourism in the effected community, which could severely affect local economies in Colorado where outdoor recreation is a major industry. Table 3-237 describes the impact summary for hazardous material incidents.

TABLE 3-237 HAZARDOUS MATERIAL INCIDENT EMAP IMPACT SUMMARY

Consideration	Description
<b>General Public</b>	Depending on amount and type of hazardous material spilled, impact can be severe. Areas with high population are more at risk.
<b>First Responders</b>	Adverse impact expected to be severe for unprotected personnel. Risk is reduced with use of proper personal protective equipment (PPE) and precautions.
<b>Property</b>	Real property may become generally unusable due to contamination depending on the nature of the hazardous material event. Property in the immediate vicinity of a hazardous material event could become temporarily or permanently uninhabitable due to contamination. Method of transportation (trucks, airplane, rail, etc.) may be severely impacted during a transportation incident and may become unusable.

Consideration	Description
<b>Facilities and Infrastructure</b>	Damage to facilities and infrastructure could be severe depending on the type of hazardous material. An explosion or fire could cause severe damage. Any hazardous material event could cause facilities and infrastructure to become unusable until the contamination is cleaned up.
<b>Economic</b>	Local economy and finances adversely affected, possibly for an extended period of time.
<b>Environment</b>	May cause extensive damage that requires costly remediation.
<b>Continuity of Government and Services</b>	Loss of facilities or transportation infrastructure can impact the ability to deliver goods and services efficiently.
<b>Confidence in Government</b>	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective. May cause widespread fear and panic and cause a population to lose confidence in their government.
<b>Critical Assets</b>	Potential impact to water treatment facilities, government buildings, public safety facilities and equipment, healthcare services.

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

Table 3-238 shows incidents, damages, fatalities, injuries, and number of people evacuated from fixed facility HAZMAT incidents by county from 1990 to 2016. Figure 3-141 shows damages by county on a statewide map. This table includes any fixed facility occurrence reported to the NRC, including a spill, sheen sighting, terrorist attack, discovery of illegal dumping, or a drill (U.S. Coast Guard, National Response Center). During this time, Colorado has experienced \$2,540,050 in damages, five fatalities, 165 injuries, and 20,926 evacuations due to fixed facility HAZMAT incidents. Weld County has experienced the most in damages, with \$805,000. Denver County has experienced the most fatalities, with two from 1990 to 2016, and Weld County has experienced the most injuries, with 39. Douglas County has had the most evacuations, with 6,012 people needing to be evacuated due to fixed facility HAZMAT incidents.

**TABLE 3-238 HAZMAT FIXED FACILITY INCIDENT DAMAGES, FATALITIES, INJURIES, AND PEOPLE EVACUATED FROM 1990 TO 2016**

County	No. of Incidents	Damages	Fatalities	Injuries	Evacuated
<b>Adams</b>	363	\$70,000	0	13	739
<b>Alamosa</b>	11	\$0	0	0	0
<b>Arapahoe</b>	150	\$550,050	1	10	97
<b>Archuleta</b>	6	\$0	0	0	0
<b>Baca</b>	3	\$0	0	0	0
<b>Bent</b>	5	\$0	0	0	0
<b>Boulder</b>	121	\$100,000	0	5	830

County	No. of Incidents	Damages	Fatalities	Injuries	Evacuated
Broomfield	0	\$0	0	0	0
Chaffee	6	\$0	0	0	0
Cheyenne	12	\$0	0	0	0
Clear Creek	16	\$0	0	0	0
Conejos	2	\$0	0	0	0
Costilla	0	\$0	0	0	0
Crowley	1	\$50,000	0	4	0
Custer	0	\$0	0	0	0
Delta	18	\$0	0	0	0
Denver	314	\$90,000	2	16	868
Dolores	1	\$0	0	0	0
Douglas	42	\$50,000	0	9	6,012
Eagle	25	\$0	1	8	0
El Paso	180	\$50,000	1	39	4,179
Elbert	4	\$0	0	0	0
Fremont	24	\$0	0	1	0
Garfield	66	\$0	0	1	2
Gilpin	7	\$0	0	1	0
Grand	15	\$0	0	1	10
Gunnison	10	\$0	0	0	0
Hinsdale	1	\$0	0	0	0
Huerfano	8	\$0	0	0	24
Jackson	4	\$0	0	0	0
Jefferson	271	\$250,000	0	5	4,372
Kiowa	3	\$0	0	0	0
Kit Carson	10	\$0	0	0	0
La Plata	82	\$0	0	0	10
Lake	3	\$100,000	0	1	0
Larimer	114	\$0	0	15	158
Las Animas	11	\$0	0	0	0
Lincoln	4	\$0	0	0	0
Logan	17	\$0	0	0	0
Mesa	68	\$0	0	11	4
Mineral	0	\$0	0	0	0
Moffat	31	\$0	0	0	0
Montezuma	17	\$25,000	0	0	0
Montrose	23	\$0	0	0	0
Morgan	43	\$50,000	0	0	2,403
Otero	12	\$0	0	12	0
Ouray	4	\$0	0	0	0

County	No. of Incidents	Damages	Fatalities	Injuries	Evacuated
Park	11	\$0	0	0	0
Phillips	2	\$0	0	0	0
Pitkin	10	\$0	0	0	50
Prowers	5	\$0	0	0	0
Pueblo	68	\$250,000	0	3	30
Rio Blanco	114	\$0	0	2	10
Rio Grande	11	\$0	0	0	30
Routt	19	\$100,000	0	0	0
Saguache	4	\$0	0	0	0
San Juan	44	\$0	0	0	0
San Miguel	3	\$0	0	0	0
Sedgwick	1	\$0	0	0	0
Summit	36	\$0	0	2	400
Teller	7	\$0	0	3	0
Washington	4	\$0	0	0	0
Weld	176	\$805,000	0	3	698
Yuma	5	\$0	0	0	0
<b>Total</b>	<b>2,648</b>	<b>\$2,540,050</b>	<b>5</b>	<b>165</b>	<b>20,926</b>

Source: U.S. Coast Guard, National Response Center, January 2018

FIGURE 3-141 HAZMAT FIXED FACILITY INCIDENT DAMAGES, 1990 TO 2016

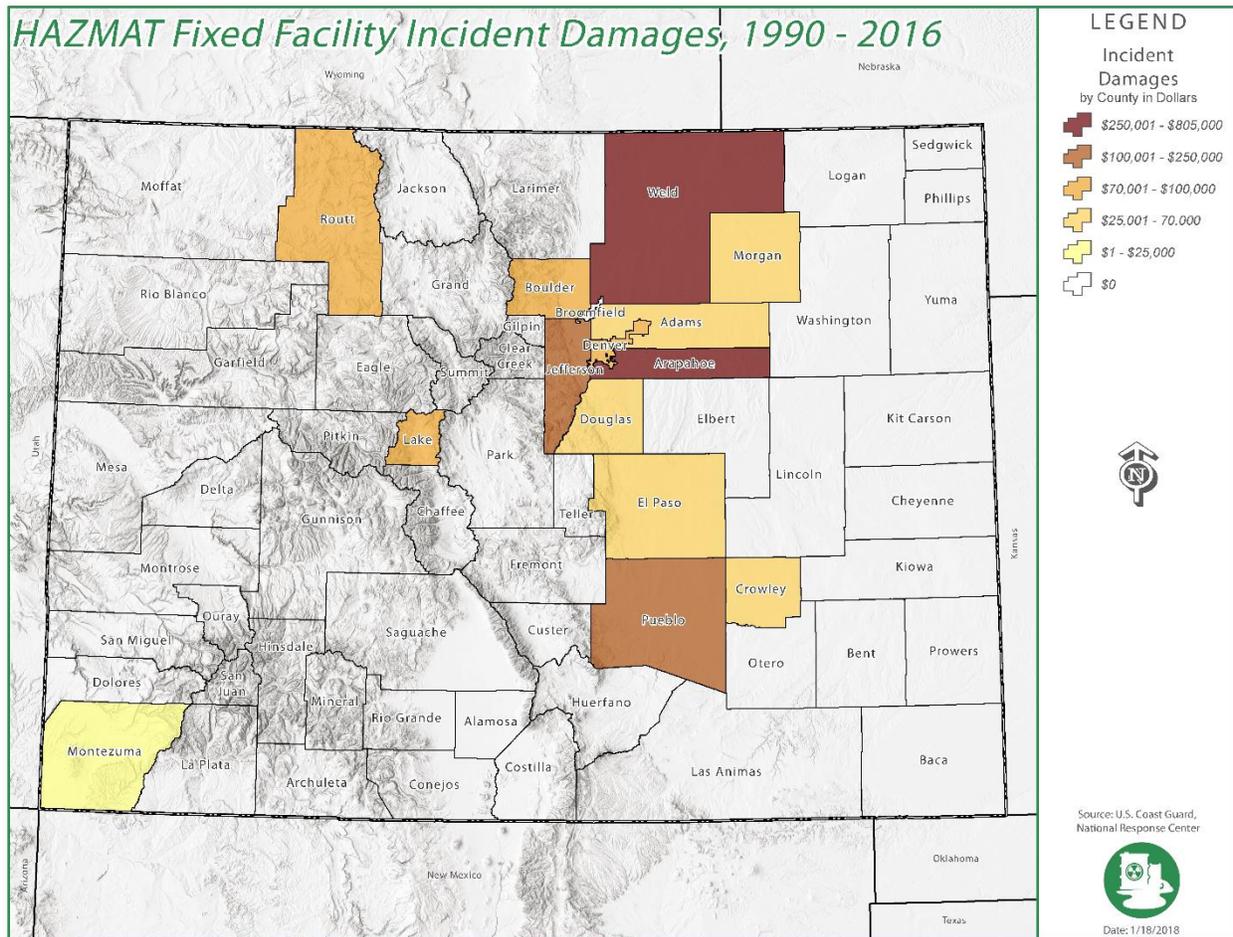


Table 3-239 shows oil and gas well spills by county from 2013 to 2017. During this time, Colorado experienced 5,514 spills from oil and gas wells. Over half of the reported spills occurred in Weld County alone, with 3,061 since 2013 (COGCC). Depending on the size of the spill, oil spills can cause extensive environmental damage leading to costly remediation efforts. Releases from oil and gas wells can also expose local workers and facilities/personnel near the well to hazardous chemicals or byproducts related to oil and gas production. Additionally, oil and gas wells are at risk for fire and explosion which could cause extensive damage to people and property.

TABLE 3-239 OIL AND GAS WELL SPILLS BY COUNTY FROM 2013 TO 2017

County	No. of Spills	County	No. of Spills
Adams	181	Kit Carson	1
Alamosa	0	La Plata	148
Arapahoe	48	Lake	0
Archuleta	19	Larimer	40
Baca	5	Las Animas	321

County	No. of Spills	County	No. of Spills
Bent	0	Lincoln	14
Boulder	35	Logan	21
Broomfield	13	Mesa	85
Chaffee	0	Mineral	0
Cheyenne	21	Moffat	78
Clear Creek	0	Montezuma	31
Conejos	0	Montrose	0
Costilla	0	Morgan	11
Crowley	0	Otero	0
Custer	0	Ouray	0
Delta	0	Park	0
Denver	0	Phillips	0
Dolores	8	Pitkin	0
Douglas	0	Prowers	0
Eagle	0	Pueblo	0
El Paso	0	Rio Blanco	374
Elbert	10	Rio Grande	0
Fremont	0	Routt	3
Garfield	623	Saguache	0
Gilpin	0	San Juan	0
Grand	0	San Miguel	0
Gunnison	15	Sedgwick	0
Hinsdale	0	Summit	0
Huerfano	3	Teller	0
Jackson	125	Washington	53
Jefferson	0	Weld	3,061
Kiowa	3	Yuma	164
<b>Total</b>	<b>5,514</b>		

Source: COGCC, January 2018

Table 3-240 shows hazardous material incidents, damages, fatalities, injuries, and amount of people evacuated from 1971 to 2017 from highway, air, or rail transportation related incidents. Figure 3-142 shows damages by county on a statewide map. During this time, Colorado experienced \$51,101,755 in total damages from HAZMAT transportation incidents. Total damages include material loss, carrier damage, property damage, response cost, and remediation cost. There have been nine fatalities, 193 injuries, and 3,847 people in need of evacuation due to transportation HAZMAT incidents. Weld County has the most reported damages, at \$5,655,770 since 1971. Denver and Chaffee Counties have had the most fatalities, both having two since 1971, and Denver County also had the most injuries, with 63. Adams County has had the most people evacuated due to a transportation HAZMAT incident, having to

evacuate 2,062 since 1971 (U.S. DOT Pipeline and Hazardous Materials Safety Administration, 2017).

**TABLE 3-240 HAZARDOUS MATERIAL TRANSPORTATION INCIDENT DAMAGES, FATALITIES, INJURIES, AND PEOPLE EVACUATED FROM 1971 TO 2017**

County	No. of Incidents	Damages	Fatalities	Injuries	Evacuated
Adams	7,225	\$3,877,005	0	61	2,062
Alamosa	4	\$128,661	0	0	0
Arapahoe	281	\$2,802,229	0	3	0
Archuleta	1	\$54,772	0	0	0
Baca	12	\$305,651	0	1	200
Bent	4	\$669,274	0	0	0
Boulder	151	\$1,507,053	0	3	249
Broomfield	1	\$0	0	0	0
Chaffee	7	\$1,317,700	2	1	0
Cheyenne	7	\$87,857	0	0	0
Clear Creek	30	\$2,627,255	0	2	31
Conejos	0	\$0	0	0	0
Costilla	1	\$0	0	0	0
Crowley	0	\$0	0	0	0
Custer	2	\$170,200	0	0	0
Delta	3	\$223,700	0	0	0
Denver	2,223	\$1,696,611	2	63	98
Dolores	3	\$450,019	0	0	0
Douglas	25	\$358,412	0	0	1
Eagle	44	\$3,601,373	0	0	0
El Paso	285	\$1,045,372	0	8	713
Elbert	1	\$90,121	0	0	0
Fremont	6	\$2,287	0	0	0
Garfield	56	\$2,458,314	1	1	17
Gilpin	3	\$90,003	0	0	0
Grand	18	\$2,368,433	0	0	0
Gunnison	9	\$1,971,810	0	0	0
Hinsdale	0	\$0	0	0	0
Huerfano	6	\$15,611	0	1	0
Jackson	3	\$630,445	0	1	0
Jefferson	132	\$799,937	0	6	78
Kiowa	2	\$58,926	0	0	0
Kit Carson	9	\$399,658	0	0	0
La Plata	18	\$497,870	0	0	0
Lake	1	\$38,798	0	0	0
Larimer	137	\$836,717	1	4	0
Las Animas	10	\$22,157	0	3	11

County	No. of Incidents	Damages	Fatalities	Injuries	Evacuated
Lincoln	15	\$486,387	0	0	0
Logan	17	\$38,488	0	1	0
Mesa	226	\$1,892,033	0	12	1
Mineral	1	\$901,432	0	0	0
Moffat	13	\$925,158	1	0	2
Montezuma	8	\$111,219	0	0	0
Montrose	12	\$625	0	0	0
Morgan	13	\$307,897	0	0	0
Otero	19	\$66,317	0	2	6
Ouray	1	\$78,700	0	0	0
Park	13	\$1,812,127	1	0	100
Phillips	1	\$702	0	0	0
Pitkin	1	\$0	0	0	0
Prowers	11	\$295,483	0	0	0
Pueblo	123	\$478,381	1	9	4
Rio Blanco	17	\$1,660,689	0	1	0
Rio Grande	4	\$32,394	0	0	0
Routt	18	\$1,421,921	0	1	0
Saguache	1	\$4,861	0	0	0
San Juan	0	\$0	0	0	0
San Miguel	1	\$234,766	0	0	0
Sedgwick	5	\$30,197	0	0	0
Summit	44	\$2,593,394	0	5	0
Teller	5	\$435,542	0	0	242
Washington	6	\$413,537	0	1	0
Weld	182	\$5,655,770	0	3	32
Yuma	11	\$19,504	0	0	0
<b>Total</b>	<b>11,488</b>	<b>\$51,101,755</b>	<b>9</b>	<b>193</b>	<b>3,847</b>

Source: U.S. DOT Pipeline and Hazardous Materials Safety Administration, January 2018

**FIGURE 3-142 HAZMAT TRANSPORTATION INCIDENT DAMAGES BY COUNTY, 1971 TO 2017**

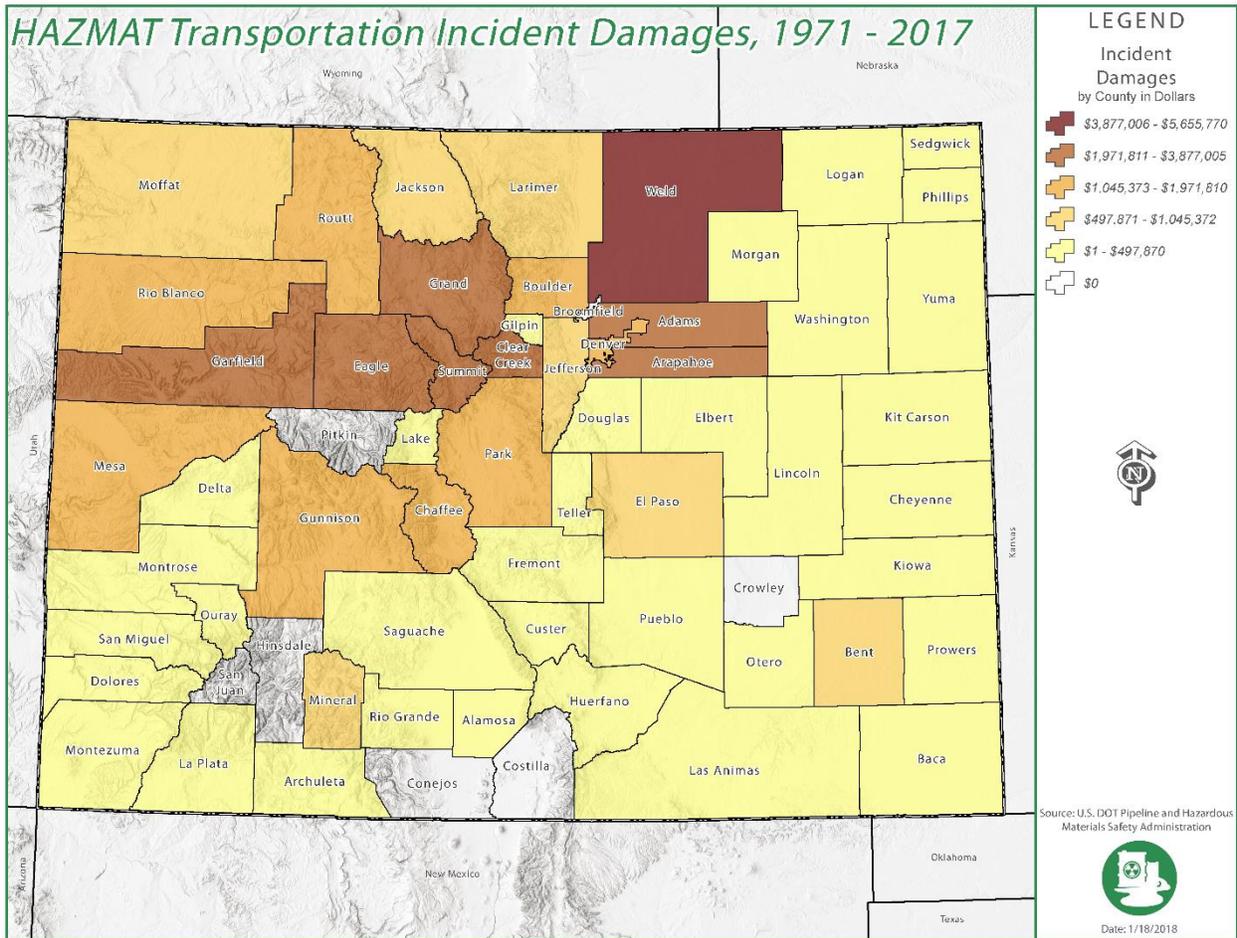


Table 3-241 shows hazardous material incidents, damages, fatalities, and injuries from 1968 to 2017 from hazardous liquid and natural gas pipeline related incidents. Figure 3-143 shows the total damages on a statewide map. During this time, Colorado experienced \$42,683,508 in total damages from pipeline incidents. Total damages include operator cost, cost of material released, property damage, emergency costs, and environmental costs. There were seven fatalities and 92 injuries due to pipeline incidents. Weld County had the most reported damages, at \$4,964,237 since 1968. Adams County had the most injuries, with 15 since 1968 and Mesa County had the most fatalities, with three fatalities (U.S. DOT Pipeline and Hazardous Materials Safety Administration).

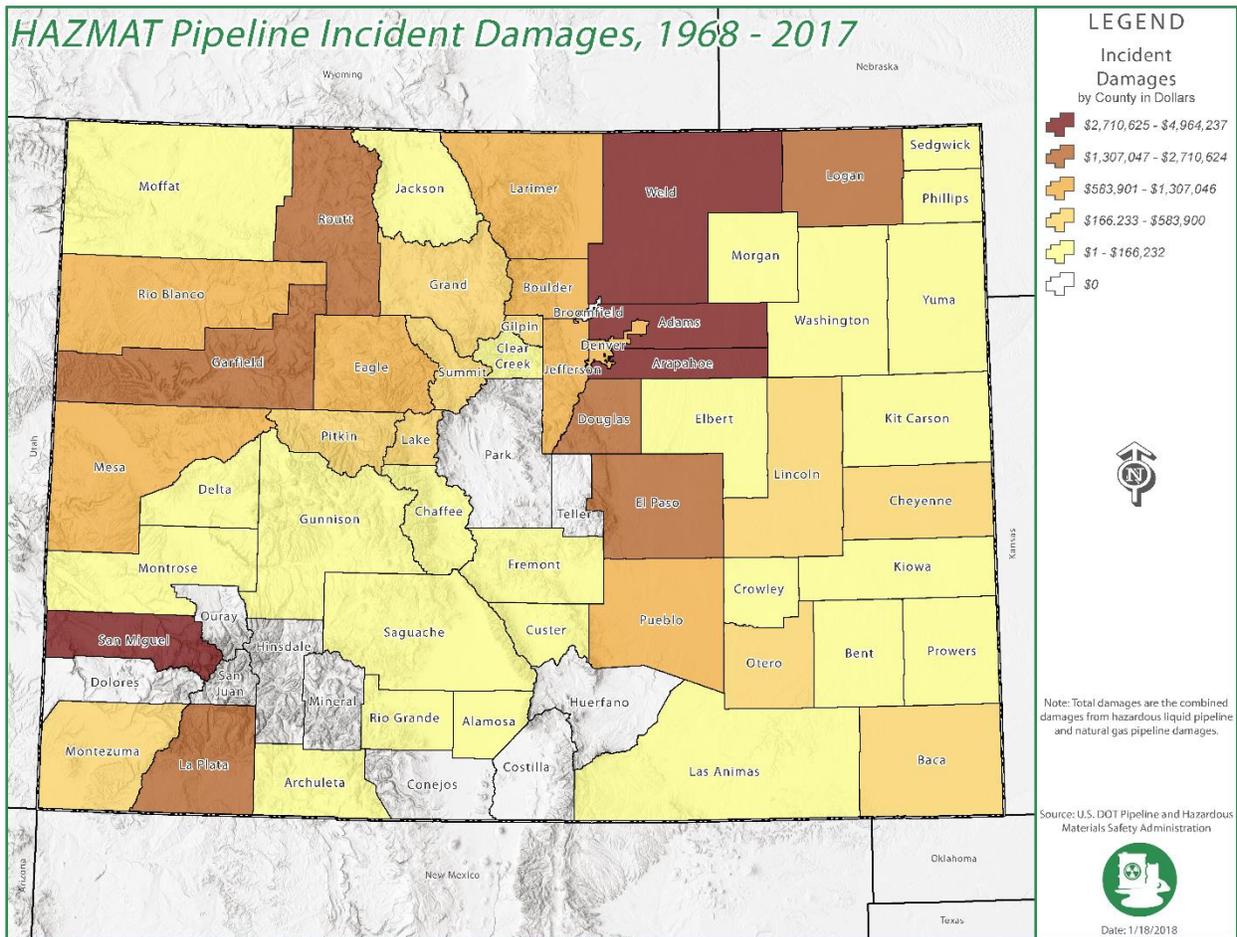
TABLE 3-241 HAZARDOUS LIQUID AND NATURAL GAS PIPELINE INCIDENT DAMAGES, FATALITIES, AND INJURIES FROM 1968 TO 2017

County	Hazardous Liquid				Natural Gas				Totals			
	Incidents	Damages	Fatalities	Injuries	Incidents	Damages	Fatalities	Injuries	Incidents	Damages	Fatalities	Injuries
Adams	43	\$1,007,133	0	9	37	\$2,687,439	0	6	80	\$3,694,572	0	15
Alamosa	0	\$0	0	0	2	\$6,300	0	0	2	\$6,300	0	0
Arapahoe	4	\$596,563	0	1	44	\$3,475,080	1	6	48	\$4,071,643	1	7
Archuleta	0	\$0	0	0	3	\$700	0	0	3	\$700	0	0
Baca	4	\$13,140	0	0	4	\$230,650	0	0	8	\$243,790	0	0
Bent	0	\$0	0	0	3	\$1,250	0	0	3	\$1,250	0	0
Boulder	0	\$0	0	0	26	\$870,066	0	4	26	\$870,066	0	4
Broomfield	0	\$0	0	0	0	\$0	0	0	0	\$0	0	0
Chaffee	0	\$0	0	0	3	\$2,100	0	0	3	\$2,100	0	0
Cheyenne	2	\$82,344	0	0	4	\$182,245	0	0	6	\$264,589	0	0
Clear Creek	0	\$0	0	0	3	\$500	0	0	3	\$500	0	0
Conejos	0	\$0	0	0	0	\$0	0	0	0	\$0	0	0
Costilla	0	\$0	0	0	0	\$0	0	0	0	\$0	0	0
Crowley	4	\$101,341	0	0	0	\$0	0	0	4	\$101,341	0	0
Custer	0	\$0	0	0	1	\$950	0	0	1	\$950	0	0
Delta	0	\$0	0	0	6	\$3,700	0	0	6	\$3,700	0	0
Denver	0	\$0	0	0	45	\$1,206,275	1	12	45	\$1,206,275	1	12
Dolores	0	\$0	0	0	0	\$0	0	0	0	\$0	0	0
Douglas	2	\$300,002	0	0	9	\$1,368,505	0	0	11	\$1,668,507	0	0
Eagle	0	\$0	0	0	6	\$1,011,700	0	0	6	\$1,011,700	0	0
El Paso	7	\$117,727	0	0	14	\$1,750,451	0	7	21	\$1,868,178	0	7
Ebert	4	\$109,032	0	1	7	\$57,200	0	0	11	\$166,232	0	1
Fremont	0	\$0	0	0	7	\$3,400	0	0	7	\$3,400	0	0
Garfield	5	\$355,555	0	0	17	\$1,619,960	0	1	22	\$1,975,515	0	1
Gilpin	0	\$0	0	0	1	\$350,267	0	0	1	\$350,267	0	0
Grand	0	\$0	0	0	2	\$333,505	0	1	2	\$333,505	0	1
Gunnison	0	\$0	0	0	2	\$41,703	0	0	2	\$41,703	0	0
Hinsdale	0	\$0	0	0	0	\$0	0	0	0	\$0	0	0
Huerfano	0	\$0	0	0	0	\$0	0	0	0	\$0	0	0
Jackson	0	\$0	0	0	2	\$8,300	0	1	2	\$8,300	0	1
Jefferson	0	\$0	0	0	56	\$1,307,046	0	5	56	\$1,307,046	0	5
Kiowa	0	\$0	0	0	2	\$897	0	0	2	\$897	0	0
Kit Carson	2	\$11,063	0	0	2	\$100,100	0	1	4	\$111,163	0	1
La Plata	1	\$250	0	0	12	\$2,710,374	0	0	13	\$2,710,624	0	0
Lake	0	\$0	0	0	3	\$234,027	0	0	3	\$234,027	0	0

County	Hazardous Liquid				Natural Gas				Totals			
	Incidents	Damages	Fatalities	Injuries	Incidents	Damages	Fatalities	Injuries	Incidents	Damages	Fatalities	Injuries
Larimer	1	\$0	0	0	19	\$924,109	0	5	20	\$924,109	0	5
Las Animas	0	\$0	0	0	7	\$114,494	0	0	7	\$114,494	0	0
Lincoln	1	\$5,000	0	0	10	\$578,900	0	0	11	\$583,900	0	0
Logan	4	\$1,468,950	0	0	9	\$895,000	0	0	13	\$2,363,950	0	0
Mesa	1	\$0	0	0	15	\$1,046,628	3	7	16	\$1,046,628	3	7
Mineral	0	\$0	0	0	0	\$0	0	0	0	\$0	0	0
Moffat	10	\$37,635	0	0	1	\$21,487	0	0	11	\$59,122	0	0
Montezuma	4	\$15,530	0	0	5	\$366,500	0	0	9	\$382,030	0	0
Montrose	0	\$0	0	0	3	\$145,262	0	0	3	\$145,262	0	0
Morgan	1	\$800	0	0	10	\$61,740	0	2	11	\$62,540	0	2
Otero	4	\$470,637	0	0	1	\$8	0	0	5	\$470,645	0	0
Ouray	0	\$0	0	0	0	\$0	0	0	0	\$0	0	0
Park	0	\$0	0	0	0	\$0	0	0	0	\$0	0	0
Phillips	0	\$0	0	0	3	\$500	0	0	3	\$500	0	0
Pitkin	0	\$0	0	0	5	\$201,700	0	2	5	\$201,700	0	2
Prowers	0	\$0	0	0	11	\$68,740	0	0	11	\$68,740	0	0
Pueblo	1	\$1,600	0	0	11	\$957,450	1	8	12	\$959,050	1	8
Rio Blanco	11	\$766,370	0	0	15	\$402,865	1	3	26	\$1,169,235	1	3
Rio Grande	0	\$0	0	0	3	\$106,201	0	0	3	\$106,201	0	0
Routt	0	\$0	0	0	5	\$1,946,700	0	7	5	\$1,946,700	0	7
Saguache	0	\$0	0	0	1	\$25,527	0	0	1	\$25,527	0	0
San Juan	0	\$0	0	0	0	\$0	0	0	0	\$0	0	0
San Miguel	0	\$0	0	0	5	\$4,533,842	0	2	5	\$4,533,842	0	2
Sedgwick	0	\$0	0	0	1	\$150	0	0	1	\$150	0	0
Summit	0	\$0	0	0	11	\$278,153	0	0	11	\$278,153	0	0
Teller	0	\$0	0	0	0	\$0	0	0	0	\$0	0	0
Washington	2	\$2,200	0	0	2	\$0	0	0	4	\$2,200	0	0
Weld	22	\$1,864,567	0	0	11	\$3,099,670	0	1	33	\$4,964,237	0	1
Yuma	0	\$0	0	0	11	\$15,753	0	0	11	\$15,753	0	0
<b>Total</b>	<b>140</b>	<b>\$7,327,439</b>	<b>0</b>	<b>11</b>	<b>498</b>	<b>\$35,356,069</b>	<b>7</b>	<b>81</b>	<b>638</b>	<b>\$42,683,508</b>	<b>7</b>	<b>92</b>

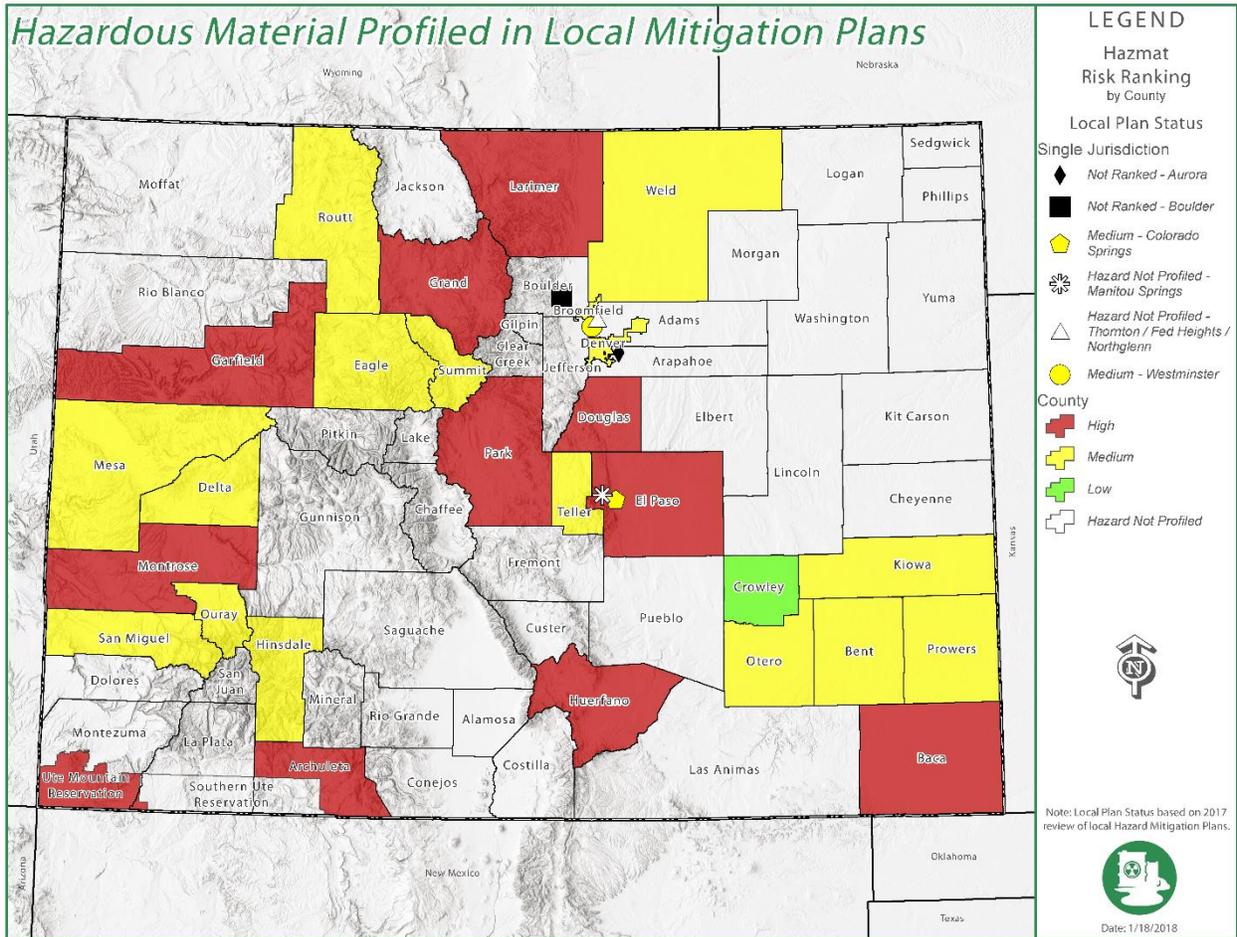
Source: U.S. DOT Pipeline and Hazardous Materials Safety Administration, January 2018

FIGURE 3-143 HAZMAT PIPELINE INCIDENT DAMAGES BY COUNTY, 1968 TO 2017



Based upon an updated (2017) review of local mitigation plans, Figure 3-144 illustrates which local jurisdictions profiled HAZMAT releases as a hazard and their relative risk ranking (high, medium, or low) for each jurisdiction.

FIGURE 3-144 HAZMAT RISK RANKING IN LOCAL HAZARD MITIGATION PLANS



Based on review of local hazard mitigation plans, six jurisdictions profile hazardous material incidents as one of their top four hazards. Within those six jurisdictions, a total of 10,583 structures and parcels are identified in hazardous material incident hazard areas, and 170 critical facilities are identified in HAZMAT release hazard areas. Table 3-242 describes this information in more detail, as well as the total estimated losses. Note: not all six jurisdictions provided structure and parcel, critical facility, and loss estimate data.

TABLE 3-242 LOCAL HAZARD MITIGATION PLANS

Jurisdiction	# of Structures/Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate	Loss Estimate Methodology
Douglas County					
El Paso County (Unincorporated)	10,583		Tier II	\$4,831,470,705	
Grand County		170			
Huerfano County					

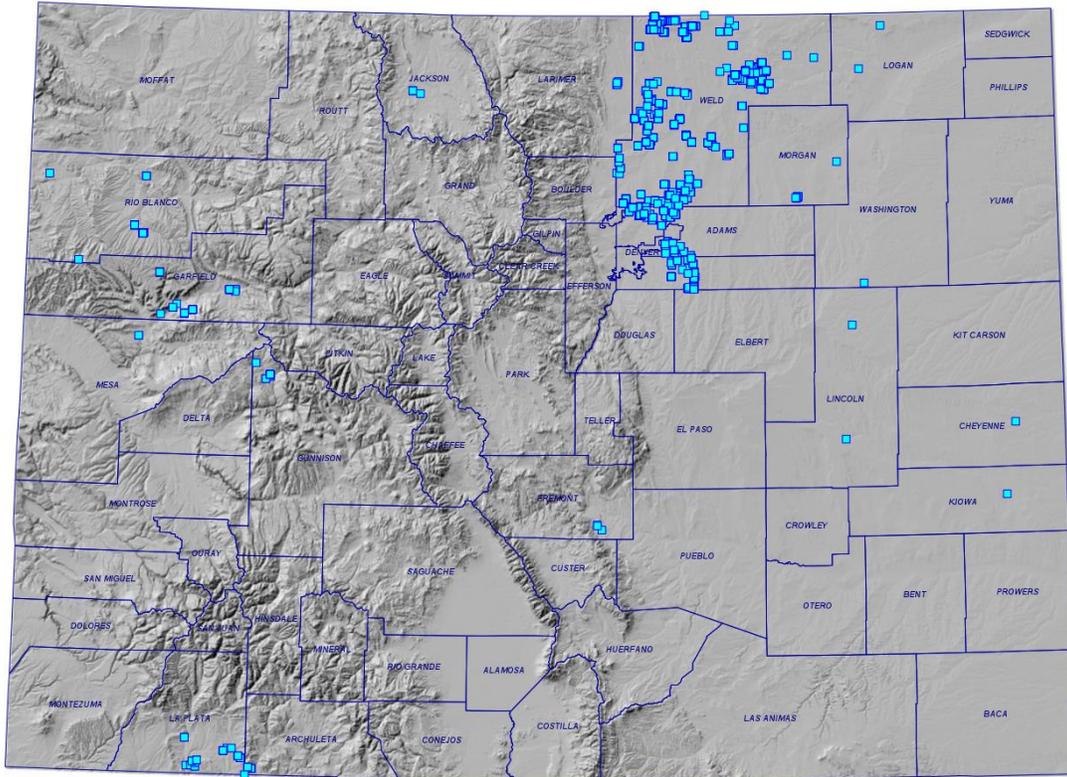
Jurisdiction	# of Structures/ Parcels in Hazard Area	# Critical Facilities in Hazard Area	Vulnerability Methodology	Loss Estimate	Loss Estimate Methodology
Park County					
Ute Mountain Ute Tribe (Montezuma)					
<b>Total</b>	<b>10,583</b>	<b>170</b>		<b>\$4.8 B</b>	

## 8. FUTURE DEVELOPMENT

Continued population growth in Colorado can expose more people to HAZMAT releases. In areas that are already highly populated, increased growth can push residential and commercial development into more industrialized areas, putting more people near fixed facilities that use hazardous materials. Additionally, areas that have traditionally been rural and are now being developed are placing people closer to pipelines and oil and gas drilling operations than ever before. In April 2017, two people were killed and two sent to the hospital in Weld County from a home explosion and subsequent fire that resulted from unrefined natural gas leaking from a small abandoned pipeline from a nearby well not properly capped (The Coloradoan, 2017). The house was constructed in 2015 and was located within 200 feet of the well and about 10 feet from the pipeline (9 News; The Denver Post, 2017). The pipeline that caused the incident was a flow line, which connect wells to tanks or other collection points. These pipelines are typically only one to two inches in diameter, and are not currently mapped with precision. This incident prompted new discussions for oil and gas companies to provide pipeline locations for use by developers and homeowners.

With a rebound in oil prices, oil and gas operations are projected to grow. Figure 3-145 shows the number of pending well permits in Colorado as of January 2018. The majority of pending permits are located in the northeastern Front Range. There are currently 2,543 pending well permits across Colorado, with 1,723 of those in Weld County. Adams County contains the next highest number of permits, with 408. It is important to note that not all pending permits will result in a well. However, the permits can be used as an indicator of desired locations of most future oil and gas wells. Additionally, the pending wells are located in areas that already have some of the highest amounts of oil and gas wells in the state, such as Weld County. Counties in the northeastern Front Range with heavy oil and gas development are also some of the fastest growing counties in the state. For example, Weld County has an expected housing growth rate of 93 percent from 2010 to 2030, and 40,344 current well operations and pending permits. Adams County has an expected housing growth rate of 60 percent from 2010 to 2030, and 4,839 current well operations and pending permits. However, continued regulation can help reduce the risk of oil and gas HAZMAT releases even with increased development.

FIGURE 3-145 PENDING WELL PERMITS



Source: COGCC, January 2018

As population increases, the demand for hazardous materials may increase as well, creating increased production and transport of hazardous materials. Even if the amount of hazardous material incidents remain consistent over time, increased population and housing growth may expose more people to hazardous material incidents.

## 9. CLIMATE CHANGE

Due to the human-caused nature of a HAZMAT release, this hazard is not directly related to climate change. However, impacts from climate change could indirectly effect HAZMAT incidents. HAZMAT releases at fixed facilities could result from increases in severe weather events, such as flooding or wildfire. Transportation infrastructure, especially bridges, roads, highways, and rail lines can be structurally damaged as a result of very high heat conditions or extended exposure to high heat conditions, which could lead to transportation related HAZMAT incidents.

## 10. RISK TO STATE ASSETS

There are many factors that determine the risk of state assets to HAZMAT releases, which makes it difficult to determine vulnerability. Damage to state assets due to a hazardous material

incident would depend on factors such as the severity of the incident, the proximity to the incident, the chemical released, time of day, weather, etc. A hazardous material incident may cause structural damage to state assets as well as impact the health of personnel. If environmental contamination occurs remediation efforts could be costly, however the cost is typically the responsibility of the spiller. Quick response to a HAZMAT incident may help minimize the damages. According to the DHSEM CHIRRP, the Colorado State Patrol is responsible for oil and hazardous materials response, including coordinating response and recovery actions to prepare for, prevent, minimize, or mitigate a threat to public health, welfare, or the environment.

## 11. RESOURCES

- 9 News, 2017; <http://www.9news.com/article/news/investigations/uncapped-abandoned-gas-line-caused-firestone-home-explosion/73-436094693>. Accessed 12 January 2018.
- [CNBC, 2017; https://www.cnbc.com/2017/07/11/colorado-stages-slow-and-steady-oil-recovery.html](https://www.cnbc.com/2017/07/11/colorado-stages-slow-and-steady-oil-recovery.html). Accessed 12 January 2018.
- Colorado Department of Public Health and Environment (CDPHE)
- Colorado Department of Transportation (CDOT) State Freight and Passenger Rail Plan
- Colorado Department of Transportation (CDOT) Threat and Hazard Identification and Risk Assessment (THIRA)
- Colorado Hazard and Incident Response and Recovery Plan (CHIRRP)
- Colorado Oil and Gas Conservation Commission (COGCC)
- The Coloradoan, 2017; <https://www.coloradoan.com/story/news/2017/05/02/cut-abandoned-gas-line-caused-firestone-home-explosion/309230001/>. Accessed 12 January 2018.
- The Denver Post, 2017; <https://www.denverpost.com/2017/06/30/firestone-explosion-oil-gas-lines-map/>. Accessed 12 January 2018.
- U.S. Census Bureau
- U.S. Coast Guard, National Response Center (NRC)
- U.S. Department of Transportation (DOT) Pipeline and Hazardous Materials Safety Administration (PHMSA)
- U.S. Environmental Protection Agency (EPA)

# MINE ACCIDENTS



## 1. DEFINITION

Mining is one of the defining industries in Colorado’s history and economic development. Unsubstantiated reports of gold in Colorado date back to the mid-18<sup>th</sup> century, but the State’s mining industry truly emerged in 1859 with the Pike’s Peak Gold Rush. The influx of prospectors and settlers helped pave the road for Colorado to become a territory in 1861 and a state in 1876. Over the next few decades, hopeful gold prospectors also found silver, lead, zinc, and molybdenum. Coal mining began with the arrival of settlers and miners and continues today. Uranium deposits were discovered in the 1950s. Gypsum, limestone, clay, marble, and sodium bicarbonate mining were integral to Colorado’s economic boom beginning in the late 1990s and 2000s. Colorado is also known for gemstone mining including aquamarine, rhodochrosite, beryl, and diamonds.

With nearly 160 years of mining activity, mine accidents are bound to occur. The National Institute for Occupational Safety and Health (NIOSH) defines mining disasters as incidents with five or more fatalities (NIOSH). Mine accidents in Colorado have caused several hundred injuries and fatalities, as well as environmental damage. Mine accidents investigated in this chapter include human-caused incidents such as explosions, release of hazardous materials, exploration of abandoned mine shafts, and other mining accidents (e.g., tunnel flooding, cage accidents, and gas poisoning). Damages to structures as a result of subsidence over abandoned mining operations are discussed in the subsidence hazard profile.

TABLE 3-243 HAZARD PROFILE SUMMARY

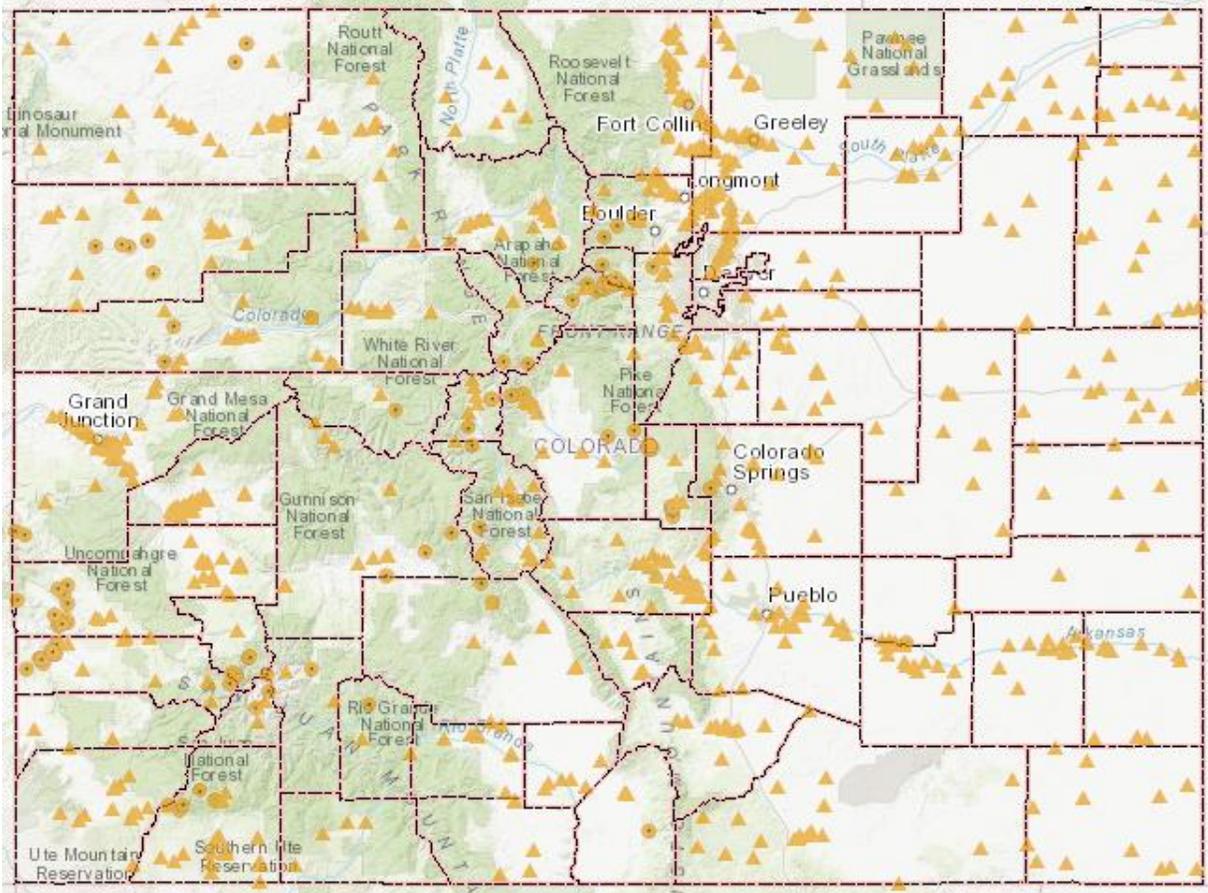
Consideration	Impact	Description
<b>Location</b>	Local	Concentrated along the Front Range, Western Slope, and Southwestern Colorado.
<b>Previous Occurrence</b>	Sporadic	Isolated incidents may occur every few years.
<b>Probability</b>	Likely	Isolated fatalities are likely to occur every few years. Catastrophic hazardous mining materials releases are rarer.
<b>Extent</b>	Moderate	Isolated injuries and fatalities from mine explosions and abandoned mine shaft falls. Hazardous materials releases can be more extensive.

## 2. LOCATION

Colorado’s abandoned and operating mines are primarily located along the Front Range, Western Slope, and southwestern corner. The location of currently active mines is shown in Figure 3-146. The Colorado Geological Survey (CGS) Abandoned Mine Land Inventory (AMLI)

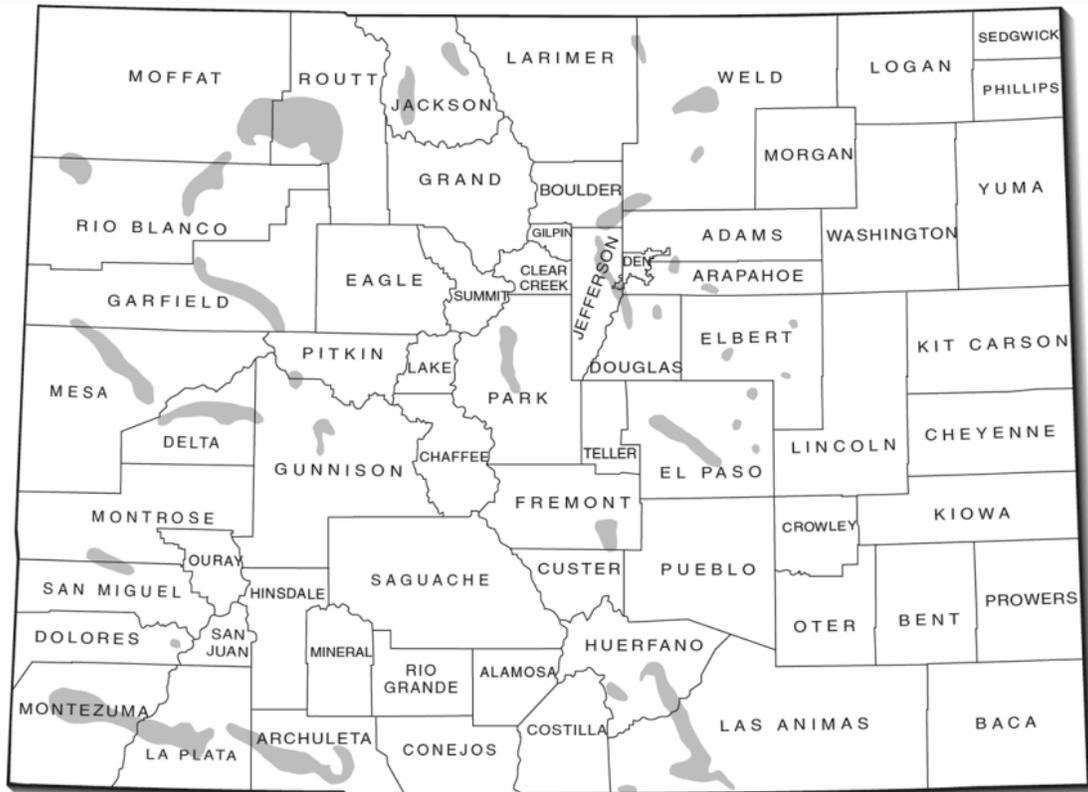
project identified roughly 18,000 abandoned mine-related features on National Forest System lands in Colorado between 1991 and 1999. The mine-related features include mine openings, waste rock dumps, tailings dumps, and mine structures. The Colorado Division of Reclamation, Mining and Safety (DRMS) estimated that there are approximately 23,000 abandoned mines in Colorado. General locations of inactive coal mines are shown in Figure 3-147.

**FIGURE 3-146 ACTIVE MINE LOCATIONS**



Source: DRMS, 2014

FIGURE 3-147 INACTIVE COAL MINE LOCATIONS



Source: Colorado Geological Survey, 2015

### 3. EXTENT (MAGNITUDE/STRENGTH)

Although historical mine disasters often claimed dozens of lives at once, most Colorado mine accidents in recent years have typically resulted in one or two fatalities at a time. The exception is large hazardous mining materials releases, such as the Gold King mine toxic waste water release in 2015. Events of this magnitude can impact several thousand people at once, damage crops, impact revenue to businesses and tourism, kill wildlife, and damage watersheds. As of April 2017, the claims filed against the EPA for the Gold King mine spill totaled \$420 million. The State of New Mexico sued the State of Colorado for immediate response and future cleanup costs in the magnitude of millions of dollars, though an exact amount was not specified (*State of New Mexico v. State of Colorado*). Another event of this magnitude, especially if located in a critical watershed shared by multiple states, could cause a similar amount of damage.

### 4. PROBABILITY

The probability of injuries or fatalities caused by mine accidents has dropped steeply with the passage of several federal mining safety laws, including the Federal Coal Mine Safety Act of 1952, Federal Metal and Non-Metallic Mine Safety Act of 1966, Federal Coal Mine Health and

Safety Act of 1969, Mine Safety and Health Act of 1977, and the Mine Improvement and New Emergency Response (MINER) Act of 2006. However, due to the inherently dangerous nature of mining and lack of public awareness regarding the location and dangers of abandoned mines, isolated fatalities will likely continue to occur. According to the Mine Safety and Health Administration (MSHA), eight mining fatalities occurred in Colorado between 2004 and 2017, for an average of approximately one fatality every two years.

Colorado has not experienced a mining disaster as defined by NIOSH (five or more fatalities) since 1981. Mining disasters have occurred elsewhere in the U.S. in recent years, so mining disasters are not an impossibility here. However, these recent disasters occurred in the country's top coal producing states where the opportunity for disaster is higher. While most of Colorado's historical mining fatalities occurred in coal mines, coal production has dropped substantially in the past several years and hit a record low in 2016, reducing the risk of coal mine disasters (The Denver Post, 2017). The potential for casualties may increase if more mining jobs come to Colorado as a result of commodity fluctuations.

Fatalities from abandoned mine exploration are quite rare. Sixteen fatalities were recorded in Colorado between 1955 and 2018, for an average of one fatality roughly every four years. The probability that these kinds of fatalities will occur is likely to decrease as more abandoned mines are closed.

Hazardous materials releases from mining activity occur regularly in Colorado. An estimated 230 mines are leaking water tainted with heavy metals into Colorado's rivers and streams (The Denver Post, 2016). Mines were often closed and abandoned once ores were depleted, leaving no one accountable for clean-up. Thousands of abandoned mines exist in Colorado, and State and Federal agencies have insufficient resources to monitor and clean up hazardous mine drainage at so many locations. Due to an 1872 mining law that is still in effect, companies opening new mines are not required to pay royalties that could be used for abandoned mine cleanup. The lack of resources means that many abandoned mine sites go untreated until a crisis occurs, so hazardous mining materials releases will continue to occur each year, though perhaps not at crisis levels.

## 5. PREVIOUS OCCURRENCES

Most historical mine accidents in Colorado can be attributed to lax safety standards in an inherently dangerous environment. Injuries and fatalities were especially common in the late 1800s and early 1900s. Many mine workers killed on the job were poor immigrants with little political power to fight the mining companies for safer working conditions. Safety conditions and regulations have vastly improved since then, but isolated incidents still occur. Colorado mine disasters from 1839 to the present are listed in Table 3-244. Fatalities related to abandoned mine shaft exploration are listed in Table 3-245. Mine accidents that caused significant injuries, fatalities, or damages, or were otherwise especially infamous, are also profiled in case studies below.

TABLE 3-244 MINE ACCIDENT FATALITIES: 1839 TO 2000

Date	Mine Name	County	Fatalities	Product	Cause
01/24/1884	Crested Butte	Gunnison	59	Coal	Explosion
11/13/1885	Bull Domingo	Custer	10	Silver, Gold	Dynamite explosion
09/09/1889	White Ash	Jefferson	10	Coal	Mine flooded
01/10/1893	Como	Park	24	Coal	Explosion
08/29/1895	Sleepy Hollow	Gilpin	12	Gold	Mine flooded
09/26/1895	Belgian	Lake	6	Gold	Dynamite explosion
01/04/1896	Anna Lee	El Paso	8	Gold	Cave in of shaft
02/18/1896	Vulcan	Garfield	49	Coal	Explosion
09/03/1897	Sunshine	Garfield	12	Coal	Explosion
9/16/1901	Spring Gulch	Pitkin	6	Coal	Explosion
11/20/1901	Smuggler-Union	San Miguel	31	Gold, Silver	Bunk house fire
8/7/1902	Bowen	Las Animas	13	Coal	Explosion
1/26/1904	Stratton's Independence	Teller	14	Gold	Cage accident
10/28/1904	Tercio	Las Animas	19	Coal	Explosion
2/19/1906	Maitland	Huerfano	14	Coal	Explosion
4/22/1906	Cuatro	Las Animas	18	Coal	Explosion
1/23/1907	Primero	Las Animas	24	Coal	Explosion
5/19/1907	Engleville	Las Animas	5	Coal	Fire
7/6/1909	Toller	Las Animas	9	Coal	Explosion
1/31/1910	Primero	Las Animas	75	Coal	Explosion
10/8/1910	Starkville	Las Animas	56	Coal	Explosion
11/8/1910	Victor American No. 3	Las Animas	79	Coal	Explosion
12/14/1910	Leyden	Jefferson	10	Coal	Fire
2/9/1911	Cokedale	Las Animas	17	Coal	Explosion
6/18/1912	Hastings	Las Animas	12	Coal	Explosion
12/16/1913	Vulcan	Garfield	37	Coal	Explosion
4/27/1917	Hastings	Las Animas	121	Coal	Explosion

Date	Mine Name	County	Fatalities	Product	Cause
3/31/1919	Empire	Las Animas	13	Coal	Explosion
8/18/1919	Oakdale	Huerfano	18	Coal	Explosion
2/12/1921	Moffat Nos. 1 & 2	Routt	5	Coal	Explosion
12/13/1921	Satanic	Jefferson	6	Coal	Fire
3/24/1922	Sopris No. 2	Las Animas	17	Coal	Explosion
5/5/1923	Southwestern	Las Animas	10	Coal	Explosion
10/7/1923	Midwest	Mesa	6	Coal	Explosion
5/27/1927	Delagua	Las Animas	7	Coal	Explosion
6/7/1930	Climax Mine, Fremont Pass	Lake	5	Molybdenum	Cave-in stope
1/20/1936	Monarch No. 2	Boulder	8	Coal	Explosion
1/9/1942	Pride	San Juan	8	Copper, Zinc, Lead, Gold, Silver	Fumes from surface fire at portal
1/27/1942	Wadge	Routt	34	Coal	Explosion
12/28/1965	Dutch Creek Mine	Pitkin	9	Coal	Explosion
4/15/1981	Mid-Continent Resources Dutch Creek #1	Pitkin	15	Coal	Explosion
		<b>TOTAL</b>	<b>911</b>		

Source: NIOSH, 2013

TABLE 3-245 ABANDONED MINE SHAFT FATALITIES AND INJURIES: 1955 TO 2000

Date	Mine Name	County	Injuries	Fatalities	Fatality Cause
9/15/1955				2	Lack of oxygen
8/1/1958				1	Fall
2/12/1961				1	Shot
5/14/1961			1		
11/10/1962			2		
5/24/1965				1	Fall
8/6/1967			1		
9/15/1968		Teller		1	Fall
4/5/1970	Glory	Gilpin		1	Fall

Date	Mine Name	County	Injuries	Fatalities	Fatality Cause
9/28/1971			1		
5/19/1974	Glory Hole	Gilpin	1		
8/7/1975			1		
10/1/1977	Glory Hole	Gilpin		1	Fall
8/26/1983		Gilpin	1		
10/27/1985		Gilpin	1		
4/27/1986	Mary McKinney	Teller		1	Fall
6/19/1986	Weaver	La Plata	1		
8/24/1986	Alps Hill	Gilpin	2		
12/7/1986		Pitkin		1	Fall
1987	Chicago	Teller	1		
6/19/1987	Empress	Gilpin		1	Fall
3/24/1989		Gilpin		1	Fall
May 1989	Cashier	Gilpin	1		
8/1/1989	Skyline Clay	Fremont		1	Rock fall/suffocation
8/13/1989	Bookcliffs	Mesa		3	CO2
8/24/1991	Taylor Gulch West Limestone	Fremont	1		
1/13/1996	Gearhart	Mesa		1	Lack of oxygen
9/1/1999	Chicago			1	Lack of oxygen
		<b>TOTAL</b>	<b>15</b>	<b>16</b>	

Source: DRMS, 2014

### 5.1 EXPLOSIONS

**Crested Butte, Gunnison County – January 24, 1884:** An explosion and collapse at the Jokerville coal mine near Crested Butte killed 59 miners. At the time this was the worst mining accident in Colorado, and the incident led to the mine’s abandonment. The explosion was likely caused by “firedamp,” or methane gas. The combination of methane with air and coal dust is highly volatile (Crested Butte News, 2017).

**Trinidad, Las Animas County – April 27, 1917:** On April 27, 1917, an explosion ripped through the Hastings coal mine outside Trinidad. The explosion and resulting tunnel collapse killed 124 men, making this the deadliest mining disaster in Colorado history. The exact cause of the disaster is unknown, but it was speculated that a safety inspector accidentally triggered

the explosion with his safety lamp. Investigators also found 22 matches on the safety inspector's body, in violation of the law at the time. A fire boss inspected the mine and reported it was safe only hours before the disaster occurred (The Denver Post, 2017).

**Mt. Harris, Routt County – January 27, 1942:** Colorado's worst coal mine explosion since 1917 claimed the lives of 34 miners at the Wadge Mine outside Mt. Harris, near Steamboat Springs. The explosion may have been caused by methane gas mixing with oxygen or a spark from an electric coal trolley (Steamboat Today, 2017).

**Redstone, Pitkin County – April 15, 1981:** Fifteen miners were killed in an explosion and collapse at the Dutch Creek No. 1 mine near Redstone. Seven other miners escaped. Investigators concluded that a spark from a defective headlamp ignited a methane gas explosion (The Aspen Times, 2006). This was the worst mining accident in Colorado since the 1942 Wadge Mine disaster.

### **Hazardous Mining Materials Releases**

**Golden, Jefferson County – April 15, 2010:** Uranium from the closed Schwartzwalder Mine near Golden contaminated groundwater supplies with concentrations exceeding 1,000 times the human health standard. The drinking water supply was unaffected. State officials demanded that the mine owner develop a plan to clean up the contamination (The Denver Post, 2010).

**Silverton, San Juan County – August 5, 2015:** On August 5, 2015, Environmental Protection Agency (EPA) officials and contractors attempted to access contaminated water stored behind a plug in the adit (tunnel) of the inactive Gold King Mine. The plan was to assess and treat the contaminated water, which was leaking into Cement Creek. The water behind the plug was highly pressurized, and as the contractors breached the seal, three million gallons of toxic waste water spilled into the Animas River. Residents along the Animas River were advised to test their water prior to use and keep animals from drinking it. Many municipalities stopped drawing drinking water from the river. The river was closed to recreation until August 14, 2015. The Navajo Nation experienced damage to their crops, gardens, and livestock. Utah and New Mexico were also impacted as the Animas River flowed into the San Juan and Colorado rivers. As of April 3, 2017, claims filed against the EPA totaled roughly \$420 million (The Denver Post, 2017).

The State of New Mexico also sued the State of Colorado in 2016, arguing that decades of poor environmental decision-making by Colorado contributed to the Gold King disaster (The Durango Herald, 2016). New Mexico's petition to the U.S. Supreme Court stated that Colorado was "liable to New Mexico for all response costs incurred and costs that New Mexico will incur to clean up the Animas and San Juan Rivers, including enforcement costs and prejudgment interest on those costs" (*State of New Mexico v. State of Colorado*). New Mexico stated they incurred millions of dollars in response costs and would incur millions more in cleanup costs, though the exact amount of the petition was unspecified. The U.S. Supreme Court denied New

Mexico's petition in 2017 (The Durango Herald, 2017). Long-term environmental impacts from the spill are still unknown.

### **5.2 ABANDONED MINE SHAFTS**

**Golden, Jefferson County – December 7, 2017:** A high school student from Golden tried to climb down an abandoned clay mine when the rope he was using snapped. The teen fell about 60 feet and broke his leg. He was pulled out of the mine and treated for injuries after a three-hour rescue operation (The Denver Post, 2017).

### **5.3 OTHER ACCIDENTS**

**Golden, Jefferson County – September 9, 1889:** Ten miners were killed when the White Ash Mine flooded. The abandoned Loveland Mine on the opposite side of Clear Creek had filled with water. It was believed that a 90-foot thick rock wall separated the two mines, but a fire that previously burned through a section of the White Ash Mine likely ate away at the wall, leaving much less of a barrier between the two mines than expected. The wall failed, and the water from the Loveland Mine poured into the White Ash Mine, drowning the miners (City of Golden Visitors Bureau, 2018).

**Victor, Teller County – January 26, 1904:** Fifteen miners were being hauled to the surface when the cable supporting the cage they were riding in snapped. Fourteen miners plummeted 1,500 feet. Miraculously, one of the miners survived by grabbing a timber rod sticking into the shaft before the cage dropped. Lack of properly installed safety equipment was determined to be the cause of the accident (Mark Wyman, *Hard Rock Epic, Western Miners and the Industrial Revolution, 1860-1910*, 1979, page 100).

**Ouray, Ouray County – November 17, 2013:** Two miners at the Revenue-Virginus mine died of carbon monoxide poisoning. Twenty other miners were taken to the hospital. The MSHA determined that the mine operators were responsible for the two deaths due to repeated safety violations; explosives were detonated inside the mine, and the resulting toxic gases were not ventilated. The Department of Labor fined the mine operators \$1.077 million (The Denver Post, 2016).

## **6. IMPACT ANALYSIS**

Colorado has not experienced a mine disaster that killed more than five people since 1981. However, other states have experienced mining disasters in recent years, such as the Upper Big Branch mine disaster in West Virginia that killed 29 miners in 2010. Colorado could still face mining disasters in the future. Fatal explorations into abandoned mines also typically only affect one or two people at a time. Mine explosions and other accidents such as tunnel flooding can result in property damages to the mine structure and economic losses from temporarily or permanently shutting down mining operations. Hazardous materials releases can cause widespread damages to property and agriculture, public health issues, economic losses from disruptions to business and tourism, widespread environmental contamination, and loss of

confidence in government if the response to a hazardous materials release is deemed inadequate by the public.

All critical infrastructure key resource sectors can potentially be affected by mine accidents. Potential impacts to each sector are summarized in Table 3-246.

**TABLE 3-246 MINE ACCIDENTS EMAP IMPACT SUMMARY**

<b>Consideration</b>	<b>Description</b>
<b>General Public</b>	Mine workers, individuals, and communities downstream of hazardous materials releases.
<b>First Responders</b>	Some exposure exists to personnel performing Search and Rescue operations or hazardous materials cleanup.
<b>Property</b>	Mine shafts may partially or completely collapse. See subsidence/abandoned mine lands chapter for abandoned mine impacts on property.
<b>Facilities and Infrastructure</b>	Mostly limited to mining facilities.
<b>Economic</b>	Potentially millions of dollars in mine explosions, collapses, or hazardous mining materials releases.
<b>Environment</b>	Potential widespread impact from hazardous materials releases.
<b>Continuity of Government and Services</b>	None or limited loss of facilities or infrastructure function or accessibility or ability to provide services.
<b>Confidence in Government</b>	Public confidence in regulatory agencies at risk during hazardous materials releases. Abandoned mine warnings are posted but difficult to enforce.
<b>Critical Assets</b>	Critical assets are most at risk to hazardous materials releases.

## **7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION**

Historical mine accident fatality data is not necessarily a reliable indicator of current vulnerability by jurisdiction due to changes in safety regulations and the closure of many historical mines. However, the Front Range, Western Slope, and southwestern corner of the State will continue to face the highest potential for losses due to the presence of abandoned and currently operating mines. Based on the historical data summarized in Table 3-245, Gilpin and Teller Counties may have the highest potential for injuries and fatalities related to abandoned mine shaft incidents. Fremont, Jefferson, La Plata, Mesa, and Pitkin Counties also have potential for

injuries and fatalities from abandoned mine shaft accidents. Impacts to population, property, and economy are generally geographically isolated, but hazardous mining materials releases may impact a larger area if a water supply is contaminated. A contaminated water supply could potentially cause temporary closure of businesses and loss of tourism. Economic losses may also result from temporary or permanent mine closures.

A small number of counties identified mine accidents as a potential hazard in their local hazard mitigation plans. Montrose County's plan identifies potential environmental impacts of mining as a concern in the Hazardous Materials section, but does not have any mitigation actions specifically related to mine accidents. The Ouray County plan profiles mass casualty events, and the County's active mines are recognized as a potential location for that hazard.

## 8. FUTURE DEVELOPMENT

Hazardous materials releases from mines pose the biggest threat to future development in Colorado. As the population and demand for housing continues to grow along the Front Range, Western Slope, and southwestern Colorado, more people and properties may be exposed to toxic mine waste water spills. State and federal agencies currently do not have the resources needed to clean up the hundreds of abandoned mines leaking hazardous materials. Mine explosions and other industrial accidents will likely only affect the small percentage of Colorado's population employed in the mining industry. As coal production in Colorado continues to decline, fewer miners will be exposed to coal mine explosions. Gilpin and Teller Counties have several recorded injuries and fatalities related to abandoned mine shaft accidents, and the proximity of these counties to the growing population of the Front Range may increase this risk in the future. The potential risk posed by mines to Colorado's increasing population may be mitigated by mine closures.

## 9. CLIMATE CHANGE

According to the best data available at the time of this plan update, the future impacts of climate change are not expected to influence future hazard events.

## 10. RISK TO STATE ASSETS

As mines are typically private enterprises, risk to state assets is considered low. It is possible that some state assets may be at risk to hazardous mining materials spills, particularly if a water source is contaminated, and could include impacts to state lands and possibly parks.

## 11. RESOURCES

- *Aspen Times*, 2006; <https://www.aspentimes.com/news/carbondales-deep-scar/>, accessed January 13, 2018
- Colorado Geological Survey (CGS)

- Colorado Division of Reclamation, Mining, and Safety;  
<http://mining.state.co.us/Programs/Abandoned/Pages/impwelcomepage.aspx>, accessed January 13, 2018
- *Crested Butte News*, 2017; <http://crestedbuttenews.com/2017/08/crested-butte-looks-to-commemorate-the-jokerville-miners/>, accessed January 13, 2018
- *The Denver Post*, 2017; <https://www.denverpost.com/2017/04/16/colorado-coal-donald-trump-jobs/>, accessed January 14, 2018
- *The Denver Post*, 2017; <https://www.denverpost.com/2017/04/27/hastings-mine-explosion-1917-colorado-history/>, accessed January 15, 2018
- *The Denver Post*, 2017; <https://www.denverpost.com/2017/04/03/gold-king-mine-spill-losses/>, accessed January 13, 2018
- *The Denver Post*, 2017; <https://www.denverpost.com/2017/12/07/colorado-mine-shaft-rescue/>, accessed January 13, 2018
- *The Denver Post*, 2016; <https://www.denverpost.com/2015/08/15/230-colorado-mines-are-leaking-heavy-metals-into-state-rivers/>, accessed January 15, 2018
- *The Denver Post*, 2016; <https://www.denverpost.com/2014/10/21/ouray-mine-fined-1-million-in-deaths-of-two-workers/>, accessed January 14, 2018
- *The Denver Post*, 2010; <https://www.denverpost.com/2010/04/15/defunct-uranium-mine-contaminating-groundwater-near-reservoir/>, accessed January 14, 2018
- *The Durango Herald*, 2017; <https://durangoherald.com/articles/168076>, accessed February 19, 2018
- *The Durango Herald*, 2016; <https://durangoherald.com/articles/1513-new-mexico-sues-colorado-over-gold-king-mine-spill>, accessed February 19, 2018
- City of Golden Visitor's Bureau;  
[http://www.goldenvisitorsbureau.com/history/history\\_white\\_ash.php](http://www.goldenvisitorsbureau.com/history/history_white_ash.php), accessed January 15, 2018
- Mine Safety and Health Administration (MSHA)
- National Institute for Occupational Safety and Health;  
<https://www.cdc.gov/niosh/mining/statistics/minedisasters.html>, accessed January 13, 2018
- *State of New Mexico v. State of Colorado*; <https://www.env.nm.gov/wp-content/uploads/2016/01/160604-for-filing.pdf>, accessed February 19, 2018
- *Steamboat Today*, 2017; <http://www.steamboattoday.com/news/reliving-the-1942-mount-harris-coal-mine-explosion/>, accessed January 13, 2018
- Wyman, Mark. *Hard Rock Epic, Western Miners and the Industrial Revolution, 1860-1910*, 1979

# POWER FAILURE



## 1. DEFINITION

Power failure is a loss of electricity or natural gas service to residential, commercial, or public sector facilities. Power failure can be a stand-alone hazard, or a cascading hazard resulting from another event, such as a winter storm or flood. Some outages can occur with little-to-no advance warning, such as with an equipment failure or a cyber-attack. In other cases, advance indications may provide some warning hours or days ahead of time, such as a prolonged heat wave or a disruption in out-of-state fuel supply.

Minor power outages affecting a small number of people for a short period of time occur frequently in Colorado, and are typically resolved by the utilities without public sector assistance. State government typically only becomes involved when a power failure affects a large number of people and lasts for a prolonged period. Extended power outages can have a significant impact on the people, infrastructure, and economy of Colorado. In particular, power failures that occur during periods of extreme cold or extreme heat are more likely to have widespread impacts on the public.

TABLE 3-247 HAZARD PROFILE SUMMARY

Consideration	Impact	Description
<b>Location</b>	Statewide	Power failures can occur in any populated area of Colorado.
<b>Previous Occurrence</b>	Year-Round	Power failures are slightly more common during summer months, due to increased demand, but can happen anytime throughout the year.
<b>Probability</b>	Expected	Power failures are expected to occur as in the past.
<b>Extent</b>	Varies	Localized, short-term outages are extremely likely, but have minimal impact. Widespread, long-lasting outages resulting from other hazards are possible, and could have severe impacts. The possibility of a catastrophic-systemic failure resulting from a cyber-attack cannot be ruled out.

## 2. LOCATION

Power failures can occur in any populated area of Colorado.

## 3. EXTENT (MAGNITUDE/STRENGTH)

Depending upon the cause, outages can last a few seconds, a few hours, or in extreme cases several days. The most common causes of power outages in Colorado are human error,

equipment failure (to include excavation and vehicle accidents), and natural causes (to include weather events and wildlife disruptions).

Colorado commercial and residential customers are served by a combination of investor-, municipal- and cooperatively-owned utilities. Approximately 89 percent of Colorado's electricity is generated in-state, using a mix of coal, natural gas, hydroelectric, and renewable sources; this makes the state somewhat less vulnerable to out-of-state disruptions. Colorado's electrical grid also has a relatively high degree of redundancy and extra capacity, making it easier for service providers to reroute and restore power to most areas. Widespread, long-term outages are therefore uncommon, but can have major impacts when they do occur.

There are three commonly-identified types of energy infrastructure interdependency failures:

- **Cascading:** A disruption in one infrastructure causes a disruption in a second infrastructure
- **Escalating:** A disruption in one infrastructure exacerbates an independent disruption of a second infrastructure
- **Common-Cause:** A disruption in two or more infrastructures at the same time is the result of a common cause

A natural or human-caused disaster can disable key electric and liquid fuel facilities, resulting in local, statewide, or possibly regional (e.g., western United States) blackouts and/or brownouts. A widespread electricity outage can cause shortages in generation of fuel supplies and vice versa.

While Colorado is largely self-sufficient in terms of electricity and natural gas production, the interconnected nature of the national electric system means electrical service within the state can still be adversely affected by outages in other states.

## 4. PROBABILITY

The risk of a widespread outage varies substantially depending on what part of the system is directly affected.

Generation: Given Colorado's surplus of generating capacity, the risks from loss of a single generating plant are relatively low. The electrical system is designed to manage both planned outages (e.g., for routine maintenance) and emergencies, and can typically manage the loss of any single component without problem. The biggest threats to the system therefore are the loss of multiple generating sources at the same time, most likely from an event like cyber-attacks, terrorist action, or possibly a major geomagnetic storm that knocks out step-up transformers at the generating stations. Serious damage to generating stations would lead to prolonged recovery periods.

**Transmission:** Loss of multiple extra high voltage transformers would have a major effect on the ability to deliver power to large areas in Colorado, as the lead time for replacement is a year or more. The primary risk of this scenario would be cyber or terrorist attack or a major geomagnetic storm that knocks out extra high voltage transformers.

**Distribution:** Distribution is the most vulnerable portion of the electricity system, as above-ground local lines are especially susceptible to weather events. The local distribution infrastructure, however, is generally able to be restored fairly quickly (i.e., in hours or a few days) as long as there is access to the area. Utilities have well-developed and exercised plans for quick restoration, including mutual aid pacts to provide skilled labor from sister utilities when needed.

Natural and human-caused hazards can impact energy generation, transmission, or distribution, and may impact more than one of these categories simultaneously. Similarly, supply chain interdependencies may result in outages even in cases where the energy sector is not directly impacted.

The hazards most likely to have significant impacts on the energy sector in Colorado, as determined by analysis conducted for the 2016 Colorado Energy Assurance Emergency Plan, are shown in Table 3-248.

**TABLE 3-248 HAZARDS MOST LIKELY TO AFFECT COLORADO'S ENERGY SUPPLY**

<b>Hazard</b>	<b>Hazard Classification</b>	<b>Potential Impact</b>
<b>Cyber Attack</b>	Human-Caused	Catastrophic-Systemic
<b>Winter Weather</b>	Natural	Severe
<b>Thunderstorm</b>	Natural	Severe
<b>Tornado</b>	Natural	Severe
<b>Wildfire</b>	Natural	Severe
<b>Flood</b>	Natural	Severe
<b>Explosive Attack</b>	Human-Caused	Severe
<b>Major Transport Disruption</b>	Technological	Severe
<b>Dam Failure</b>	Technological	Severe
<b>Precipitation</b>	Natural	Moderate
<b>Lightning</b>	Natural	Moderate
<b>Extreme Heat</b>	Natural	Moderate
<b>Windstorm</b>	Natural	Moderate
<b>Landslide/Mudflow/Rock Fall</b>	Natural	Moderate
<b>Physical Attack</b>	Human-Caused	Moderate

Hazard	Hazard Classification	Potential Impact
Biological Attack	Human-Caused	Moderate

Data Source: 2016 Colorado Energy Assurance Emergency Plan

Cyber-Attack – Catastrophic-Systemic Impact: Virtually all critical infrastructure sectors rely heavily on networked IT systems to monitor and coordinate operations. Modern energy delivery systems in particular utilize a variety of networked components. While less-sophisticated incidents of cybercrime and casual hacking are extremely frequent, sophisticated cyber-attacks capable of seriously disrupting critical infrastructure and services have so far been extremely rare. However, some nation-states and non-state actors are known or believed to be capable of mounting this level of attack.

Intrusions into a smart grid system, intelligent electronic device/smart device substation controller, Supervisory Control and Data Acquisition (SCADA) systems, or Intelligent Electronic Devices (IEDs) could be as severe as any physical sabotage, and potentially more far-reaching. Pipelines, generating facilities, substations and transformers, and other major components could be severely damaged or destroyed, with secondary impacts distributed across respective networks. A sophisticated cyber-attack could potentially target multiple assets simultaneously for increased disruption, or might combine cyber-attacks with physical attacks. If well-planned and well-executed, an attack of this sophistication could potentially produce catastrophic-systemic disruptions.

Winter Weather – Severe Impact: Extreme winter weather has caused significant outages and infrastructural damage in the past, and can be expected to do so in the future. High winds and heavy icing frequently down transmission and distribution lines, and extreme cold temperatures can lead to equipment failures. Winter weather conditions can also hinder maintenance and emergency response. Geographically widespread damage and difficult response conditions have resulted in localized multi-day outages, with concurrent impacts to critical services and facilities. Winter weather conditions may both cause and compound the impact of outages: continuity or recovery of aviation, rail, and road transport assets, telecommunications, and critical government services may be challenged by electrical outage and extreme weather conditions. Staffing is often hindered, as key personnel must secure transportation to and from worksites. Severe and sustained winter weather conditions may also slow delivery of liquid fuels, reducing or eliminating back-up generation capability among critical services and sectors in the case of prolonged electrical outage.

Thunderstorm – Severe Impact: See the sections on tornadoes, flooding, precipitation, lightning, and windstorm below.

Tornado – Severe Impact: While all tornadoes are capable of damaging or destroying energy infrastructure, the likelihood and severity of potential damage increases substantially at and above the EF3 classification. Tornadoes of this intensity are rare in Colorado, but they do occur. Electrical generation facilities and substations, transmission and distribution

lines, liquid fuels pipelines, maintenance vehicles and equipment, and other above-ground assets may be impacted.

Wildfire – Severe Impact: Wildfires can damage or destroy transmission and distribution lines, substations, and other vulnerable facilities and infrastructure. Lax vegetation management can result in contact with transmission lines, contributing to wildfire ignition as well as infrastructure damage. High intensity arc flashes can also melt conductors, destroy insulation, and start fires. Power may need to be deliberately interrupted during firefighting to reduce risk to responders. Wildfire may impact accessibility to energy assets for emergency response and recovery operations.

Flood – Severe Impact: Significant volumes of energy assets and infrastructure are located in floodplains and other flood-prone areas. Floodwaters can damage or destroy any submerged infrastructural asset, and can limit accessibility for emergency response and recovery operations.

Explosive Attack – Severe Impact: Vulnerability to explosive attack differs substantially depending on facility construction and standoff distances, and must be evaluated via individual facility security surveys. Generally-speaking, relatively small payloads may be sufficient to critically damage assets such as substations, transformers, or transmission towers. Mid-range to large vehicle-borne explosive payloads pose a serious hazard to large facilities. All explosives are a critical hazard to personnel located within minimum standoff distances, regardless of payload size.

Substantial systemic disruptions could be produced by a coordinated explosive attack against key components at multiple grid locations. Such an attack would reflect unusual sophistication and aggressiveness for a domestically-based terror attack, but remains a potentially severe hazard if employed by competent and coordinated adversaries.

Major Transportation Accident or Disruption – Severe Impact: The energy sector is heavily dependent on transportation. Conversely, the transportation sector is the most energy-consuming infrastructure in the United States. As a result, interdependencies between transportation and energy production are particularly likely to produce escalating or cascading impacts.

Refinement of liquid fuels for use by transportation assets is dependent on the transportation of unrefined fuels via pipeline, sea, road, and rail. Medium to long-term disruption of natural gas pipelines or electrical power to natural gas generation facilities could curtail natural gas production, leading to decreased heavy oil production and subsequent degrading of road, rail, and maritime freight transport. Disruption of oil pipelines or power delivery to oil pipelines could lead to decreased production of refined fuels essential for road transport and aviation.

Likewise, major disruption of maritime trade could produce shortages or price spikes in oil and natural gas necessary for electrical generation and liquid fuels refinement. Disruption of rail service could produce localized or regionalized shortages of coal and liquid fuels. Disruption of road transport networks could produce localized or regionalized shortages of liquid fuels necessary for road and air transport, and could increase the costs and difficulty of accessing and servicing infrastructure. However, though interdependencies within global and domestic intermodal transportation networks can multiply impacts and produce escalating and cascading effects in the event of major disruption, the increasing sophistication and consolidation of intermodal transport networks may also mitigate impacts, decreasing the potential for catastrophic-systemic failures in the transportation sector.

Dam Failure – Severe Impact: Modern engineering, monitoring and coordinating systems, and maintenance practices minimize the likelihood of rapidly developing catastrophic or cascading failures. However, rapid failure at hydroelectric facilities could compound flooding impacts with loss of generating capacity. Critical energy assets like transmission and distribution lines and transformers are often located in populated and serviceable valleys that constitute potential dam flooding corridors. Rapid overtopping or dam failure could produce floods capable of severely damaging or destroying energy assets in the flood zone.

Heavy Precipitation – Moderate Impact: Heavy icing can damage and disrupt power infrastructure and freeze pipes, and high precipitation conditions may complicate maintenance and response operations.

Lightning – Moderate Impact: Lightning often strikes electrical transmission and distribution systems. Most lightning strikes impacting the electrical grid result in only minor to moderate property damage, and only occasional minor disruptions to grid operations and electrical services. However, in rare cases lightning strikes can result in significant outages or interruptions. Lightning can also pose a significant danger to line workers conducting maintenance and repair work.

Extreme Heat – Moderate Impact: Electrical grid components may be damaged or overtaxed as increased electrical demand causes power lines to heat and sag. Transmission and distribution lines may fail and/or ignite nearby vegetation, causing service disruptions and potential wildfires. Particularly in urban areas, extreme heat leads to increased electrical demand. In cases of prolonged extreme heat this increased demand could exceed local or regional supply and distribution capabilities, necessitating rolling brownouts or causing blackouts.

Wind Storm – Moderate Impact: Wind storms have frequently downed electrical transmission and distribution lines in Colorado, and will continue to do so. Impacts are generally moderate, but can occasionally be severe when sustained, damaging winds occur across a wide geographic area and for an extended duration. Wind storms may complicate maintenance and emergency response operations.

Landslide – Moderate Impact: Energy sector assets and activity can be threatened by slide activity, and can also be a contributing factor to slide activity in rare cases. Assets potentially affected include conduits, utility lines, poles, access roads, and substations located on slopes and in termination zones. Though slide activity is capable of significant infrastructural damage, it is typically localized, and impacts to major assets are relatively infrequent.

Physical Attack – Moderate Impact: Unlike explosive attacks, a physical attack by active shooters armed with small arms weapons is unlikely to cause significant damage against physically-dispersed energy infrastructure and facilities, except as a prelude to other forms of sabotage. However, a competent and knowledgeable adversary organization utilizing anti-materiel rifles or incendiary devices could strategically damage and destroy grid components, causing significant disruption to energy sector operations within the state.

Biological Attack – Moderate Impact: The geographically dispersed nature of energy infrastructure makes it unlikely an adversary could use biological weapons to specifically target energy sector workers in multiple locations. Impacts to the energy sector in the case of a biological attack would likely be similar to general impacts to the public or other personnel-intensive and geographically-dispersed critical infrastructural sectors like transportation, government services, or health-care. These impacts could include potential staffing issues, staff treatment costs, lost productivity, and in less-likely cases, compulsory decontamination of impacted facilities.

Several High-Impact/Low-Probability Events would also likely impact the power sector if they occurred:

- Volcanic Activity - Catastrophic-Systemic Impact
- Electromagnetic Pulse Attack – Catastrophic-Systemic Impact
- Solar Weather/Geomagnetic Storm (GMS) Event – Catastrophic Impact
- Earthquake – Catastrophic Impact
- Nuclear Attack – Catastrophic Impact

## 5. PREVIOUS OCCURRENCES

According to data from the US Department of Energy (DOE), during the years 2000-2016 Colorado experienced 15 electrical transmission outages, affecting more than 677,000 customers. The duration of these outages ranged from one minute, to nearly 67 hours. Note however these numbers only include outages reported to the DOE, and likely exclude some smaller outages.

TABLE 3-249 ELECTRICAL TRANSMISSION OUTAGES AFFECTING COLORADO, 2000-2016

Event Description	Date Event Began	Duration (hrs/min)	Geographic Area	Demand Loss (MW)	No. of Customers Affected
<b>Fuel Supply Interruption</b>	6/28/2005	Unknown	Denver Metro Area	0	0
<b>Inadequate Electric Resources</b>	2/18/2006	4:19	Colorado	428	Unknown
<b>Severe Thunderstorm</b>	7/20/2009	44:10	Metro Denver	150	86,058
<b>Firm Load Shed</b>	6/7/2010	5:31	Denver Metro Area	300	31,000
<b>Load Shed</b>	7/13/2011	4:42	Pueblo	580	N/A
<b>Severe Weather</b>	10/26/2011	34:00	Denver; Ft. Collins	Unknown	204,000
<b>Suspected Physical Attack</b>	2/11/2012	1:43	Lamar	0	0
<b>Load Shed</b>	6/8/2012	0:05	Denver Metro Area	120	30,379
<b>Physical Attack; Vandalism</b>	10/25/2012	3:21	Pueblo	0	0
<b>Physical Attack; Vandalism</b>	10/30/2012	0:01	Pueblo	Unknown	Unknown
<b>Sabotage; Vandalism</b>	4/3/2013	2:55	Colorado Springs	0	0
<b>System Separation (Islanding)</b>	5/1/2013	0:02	Northeast Colorado	123	35,230
<b>Suspected Physical Attack</b>	2/9/2015	1:45	Colorado Springs	Unknown	Unknown
<b>Transmission Interruption</b>	8/31/2016	0:10	Colorado	0	0
<b>Winter Weather</b>	3/23/2016	66:59	Denver	Unknown	290,000

Data Source: US Department of Energy, 2017

Additional recent power failures impacting Colorado include:

2008 Windsor Tornado: The Windsor tornado damaged at least three power transmission lines, including a pair of 230,000-volt lines at the Fort St. Vrain power plant near Platteville. Additionally, 200 power poles and a half-dozen transmission poles were damaged or destroyed. At least 60,000 citizens lost power as the storm passed through the region.

2010 Fourmile Canyon Fire: In addition to destroying 169 homes and 5 structures, the Fourmile Canyon fire also damaged or destroyed at least 225 of Xcel Energy’s utility poles and 15,765 feet of overhead conductor. After containment, many evacuees were still unable to return to their homes due to wide-spread power outages. Xcel energy used a helicopter to deliver poles and restore transmission line to neighborhoods without power.

2012 Lower North Fork Fire: This wildfire destroyed 27 homes, and damaged or destroyed 2-3 miles of electric transmission line, causing an estimated \$1.2 million in utility losses.

2013 Colorado Floods: These severe floods resulted in a loss of electric and natural gas service to several flooded or threatened areas. In many cases, gas service was deliberately turned off as a protective measure; however, the fact that gas valves must be physically turned on by technicians makes restoration a slow and meticulous process. The floods also had a severe impact on Colorado's oil & gas industry, shutting down 1000 wells and spilling thousands of gallons of fuel.

Other notable recent American power failures include:

2003 Northeast Blackout: This two-day outage remains the most extensive blackout in North American history. The event began due to a high-voltage power line in northern Ohio brushing against some overgrown trees and shutting down. This fault would normally have triggered an alarm to alert the utility company, but the alarm system failed. Unbeknownst to system operators, three other faults then occurred in succession, burdening other power lines with excess electrical load. At 4:05pm, the grid in northern Ohio shut down, launching a cascade of failures across southeastern Canada and eight northeastern states. The outage left 50 million users without power, contributed to at least 11 deaths and caused an estimated \$6 million in damage.

April 2006 Texas Rolling Blackouts: Unexpected record-setting high temperatures resulted in a demand for electricity far in excess of what had been forecasted. Nearly 14,500 MW of generation was unavailable due to planned maintenance, and another 2,440 MW was lost during the day due to unplanned outages. Grid operators were forced to implement rolling blackouts lasting 2-3 hours.

February 2011 Texas Rolling Blackouts: In 2011, Texas again experienced rolling blackouts, this time due to extreme cold. Temperatures had fallen to the single-digits in certain cities and approximately 50 of the state's 550 power plants went down, resulting in a loss of 8,000 MW or about 12 percent of the electricity demand. An additional 12,000 MW was unavailable due to scheduled maintenance. Two coal-fired plants in Central Texas were forced offline by broken and frozen pipes. The power outages lasted anywhere from 20 minutes to over eight hours, causing significant disruptions across the state. The 911 and 311 systems became overloaded as people called to report blackouts. Several flights in and out of Austin International Airport were cancelled, and streets were backed up due to outages at major intersections. Natural gas production was also disrupted, leading in turn to a loss of gas service to 30,000 homes in neighboring New Mexico. To mitigate the effects of the blackouts, Texas imported about 300 MW from Mexico, and state officials encouraged households and businesses to conserve energy.

2014 Polar Vortex: This severe cold weather event resulted in many generator outages across the US, due to facilities exceeding the design basis of their plants, and difficulties facing the natural gas transportation sector. Several system operators used load reduction techniques such as voltage reduction, interruptible loads, and demand-side management, and made effective use of emergency procedures to manage loads and generation. Some plants, for example, failed to start up in the extreme cold after being off line for months. In Texas, the Mid-Atlantic, and the Midwest, wind energy supplied thousands of megawatts (MW) of power during critical times, helping to temper some price spikes and avoid blackouts.

## 6. IMPACT ANALYSIS

Much of our modern way of life is built around an assumption of easily-accessible and uninterrupted power supply. Virtually every critical infrastructure sector is heavily energy-dependent, as is the general public. Maintaining commercial, government, and even basic intra-organizational disaster response capabilities during a long-term and large-scale energy disruption becomes increasingly difficult over time.

Power failures are particularly critical at sites where the environment and public safety are at risk. Many critical facilities such as hospitals, telecommunications sites, and water treatment plants typically have backup power sources such as standby generators; however, it is not uncommon to have such generators fail just when they're needed most. And some facilities such as shelter sites, and even some local Emergency Operations Centers (EOCs) may not have generators at all. Furthermore, resupplying generators with diesel fuel becomes an additional logistical issue.

The costs associated with energy-sector disruptions are known to be significant. According to a 2005 study, losses due to power interruption across all business sectors are estimated at between \$104-164 billion annually, and costs associated with power quality problems are estimated at \$15-24 billion annually. Industrial, tech, and digital business firms lose an estimated \$5.7 billion annually due to power interruption, and among high-tech business firms, the costs of downtime due to power interruption can exceed \$1 million per minute. In 2009, the US Department of Energy estimated that power outages cost an average of \$150 billion annually, or about \$500 for every US citizen per year. Based on an interim Department of Energy report on the 2003 Northeast Blackout, a statewide power disruption in Colorado could cost between \$18-49 million per hour.

The residential segment constitutes 85 percent of retail electricity consumers in the United States, and the residential sector is most at-risk for disruption due to reliance on more extensive power distribution infrastructure than larger commercial and industrial end-users. The average duration of power interruption in the United States is seven minutes, and the vast majority of interruptions are less than 24 hours in duration.

Though residential consumers are primarily impacted by an electric energy disruption, it is the commercial and industrial sectors that account for the vast majority of financial losses. Even short-term interruptions can incur significant costs, due to the nature of industrial and information technology processes: a momentary interruption or transient fault may produce substantial waste of industrial resources and business time, as production lines must be halted and restarted. Likewise, in the information technology and financial sectors, the costs of data loss and operational downtime can be substantial. For vulnerable public agencies and private-sector businesses, the costs of data loss may remain constant regardless of total downtime. Similarly, even short outages can have a great effect on refineries, as evidenced by an outage at Suncor’s Commerce City refinery in 2007. The power disruption was brief, but it caused the refinery to take much of its machinery offline to perform damage check before restarting. This shutdown ultimately resulted in a production loss of 50,000 barrels of gasoline and 30,000 barrels of diesel and jet fuel.

An emergency or disaster, either natural or human-caused, may disable key electric and liquid fuels generation/production, distribution, and delivery facilities resulting in local, statewide, and possibly regional (e.g., western United States) blackouts and/or brownouts. Additionally, the fuel supply system used for generation may be interrupted.

Finally, widespread blackouts or gas shortages could result in public alarm and anxiety depending on the timing of the event (i.e., winter/summer) and potential duration (i.e., days/weeks/months).

The consequences of major power outages are summarized in Table 3-250.

**TABLE 3-250 ENERGY DISRUPTION EMAP IMPACT SUMMARY**

Consideration	Description
<b>Impact on the Public</b>	General disruption in daily life; potential life-threatening impacts to vulnerable populations especially reliant on power (the elderly, the hospitalized, the infirm, etc.).
<b>Impact on the Economic Condition of the State</b>	Situation-specific; disruption in statewide commerce is possible, depending on area and length of outage.
<b>Impact on the Environment</b>	None.
<b>Impact on Property, Facilities, and Infrastructure</b>	Potential disruption in ability for infrastructure to perform specific services.
<b>Impact on the Public Confidence in Government</b>	Public will expect the situation to be resolved quickly.
<b>Impact on Responders</b>	Operations requiring energy sources may be severely impacted; disruptions in the provision of services may occur.
<b>Impact on Continuity of Operations to Include the Continued Delivery of Public Services</b>	Operations requiring energy sources may be severely impacted; disruptions in the provision of services may occur.

Consideration	Description
<b>Cascading Hazards</b>	While power failures are unlikely to cause other hazards, they can exacerbate the impact of those hazards; for example, an extended loss of power during periods of extreme cold or extreme heat could lead to severe effects on the public, resulting in a need to open shelters or cooling centers.

Data Source: 2016 Colorado Energy Assurance Emergency Plan

One of the planning scenarios analyzed for the 2016 Colorado Threat and Hazard Identification and Risk Assessment (THIRA) and State Preparedness Report (SPR) was a widespread power outage lasting several days resulting from a major winter storm. Some of the impacts identified for this worst-case scenario planning were:

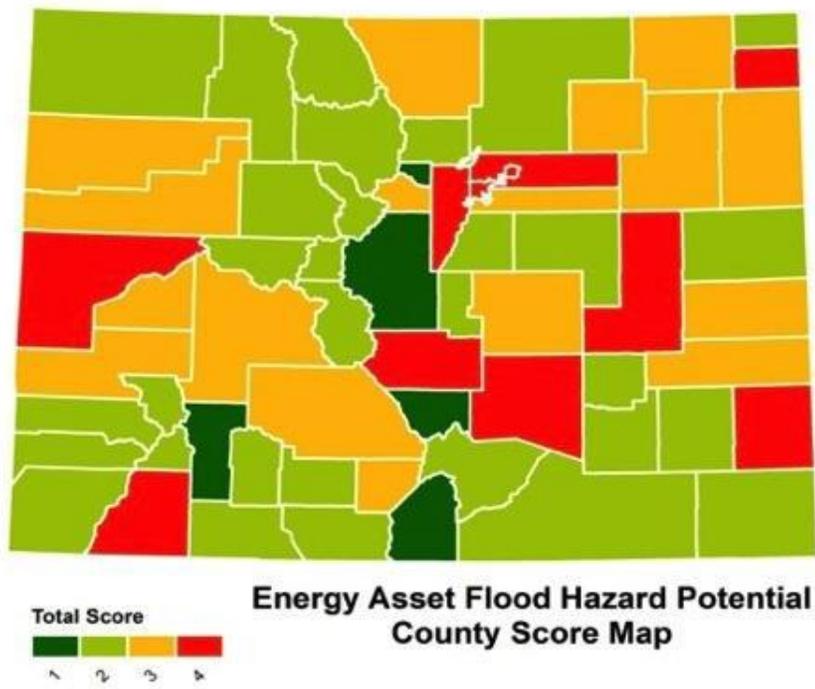
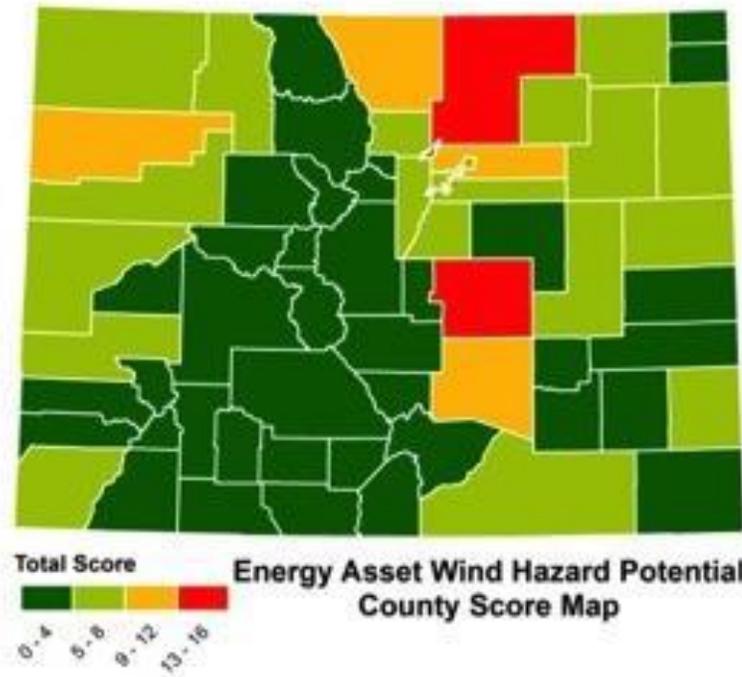
- The outage disrupted 1300 power/energy facilities, over 700 communications facilities, more than 50 transportation systems, and over 1000 healthcare facilities.
- Loss of electrical power impacts food storage, resulting in the need for consumer protection measures as soon as possible after the event has been stabilized.
- Loss of electrical power will require reliance on battery power for radio communications, which may become depleted over time.
- Accurate damage assessments and restoration estimates may not be available for decision-makers for several days.
- For the general public, the loss of power will bring about severe isolation, despair, and uncertainty within 24 hours.

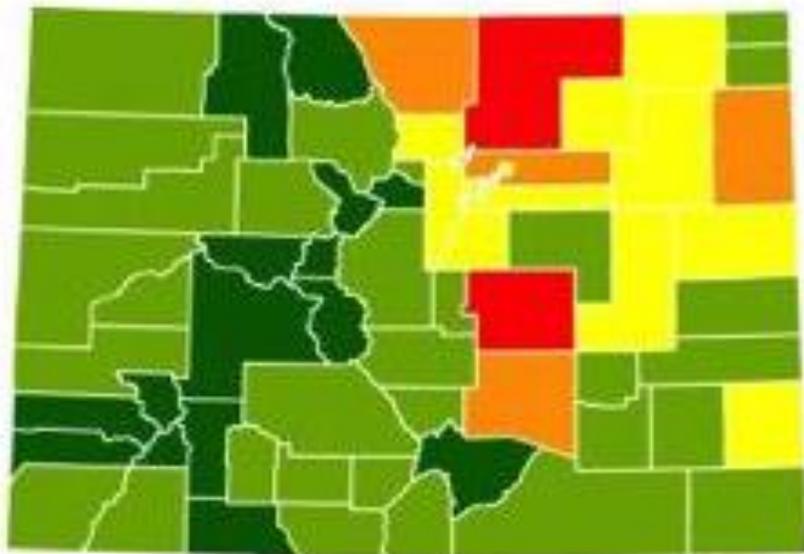
## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

The vulnerability and potential for loss of a county to power failure depends on both the type and quantity of energy sector assets located in that county, and on the types of natural and human-caused hazards they are susceptible to.

Figure 3-148 shows a series of maps created as part of the 2016 Colorado Energy Assurance Emergency Plan by identifying the location of major energy sector assets by county, and then overlaying them on hazard maps for the hazards most likely to impact energy infrastructure. They give a good estimate of what counties are most vulnerable to significant power outages.

FIGURE 3-148 COLORADO ENERGY ASSET VULNERABILITY TO HAZARDS BY COUNTY

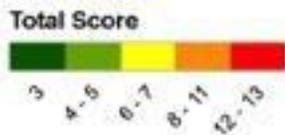
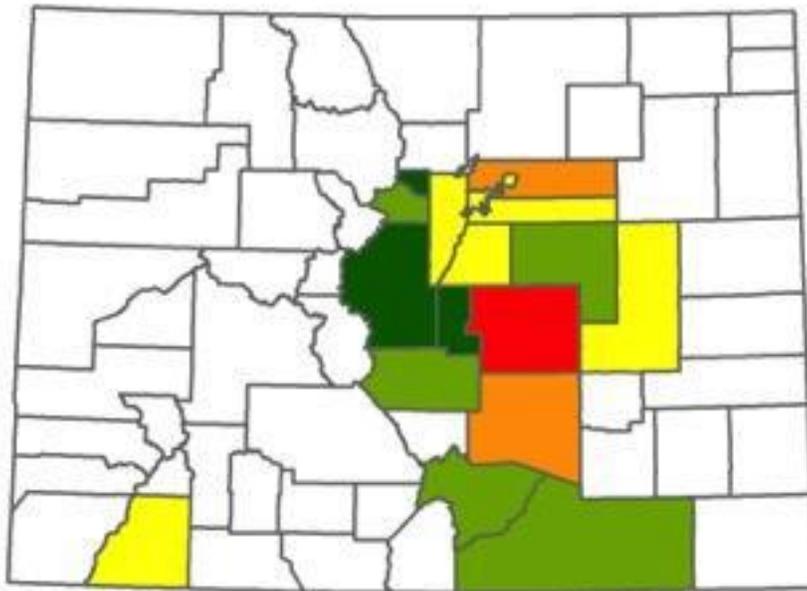




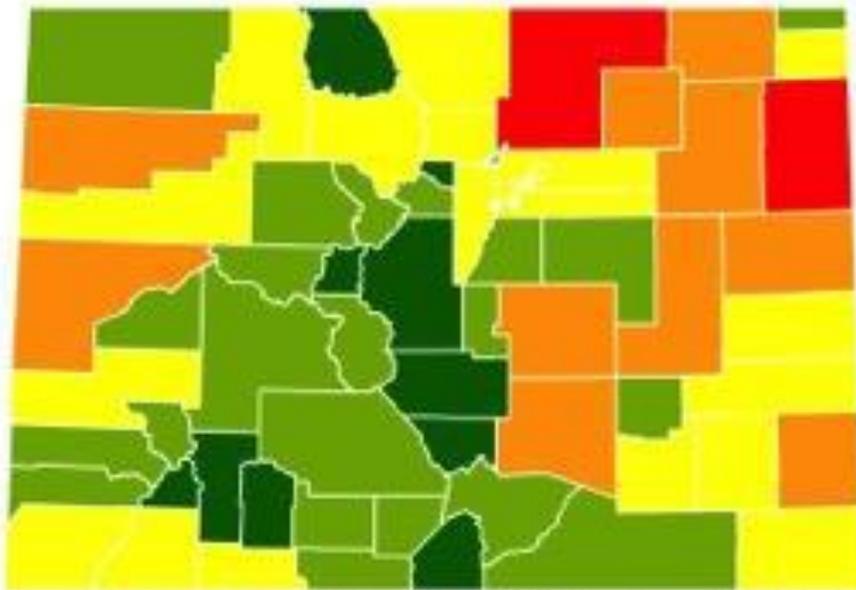
**Energy Asset Tornado Hazard Potential  
County Score Map**

**Total Score**

1-4	5-7	8-10	11-15
-----	-----	------	-------



**County Energy Asset Inventory Ranking in Counties w/ Annual Avg. of >6 Flashes per Sq. Mile**



**Energy Asset Wildfire Hazard Potential County Score Map**

Data Source: 2016 Colorado Energy Assurance Emergency Plan

As of 2017, the only Colorado county to have profiled Power Failure in their Hazard Mitigation Plan is Denver. However, six Colorado municipalities have completed Local Energy Assurance Plans, which includes a hazard assessment and mitigation planning: Aspen, Aurora, Denver, Durango, Lakewood, and Wheat Ridge.

## 8. FUTURE DEVELOPMENT

Future developments will continue to be vulnerable to power failures. This vulnerability may be mitigated somewhat by the introduction of new technologies such as smart grid technologies, distributed generation, and micro-grids.

## 9. CLIMATE CHANGE

Climate change projections show an increase in the frequency and severity of many of the hazards that impact the energy sector, thus potentially leading to an increase in the frequency of power failures. Higher average temperatures can be expected to put increased demand on the energy sector during summer months, while colder-than-normal temperatures can increase load during winter months.

## 10. RISK TO STATE ASSETS

As noted above, all critical infrastructure sectors are heavily power-dependent. These dependencies are described in more detail in Table 3-251.

TABLE 3-251 IMPACT OF ENERGY DISRUPTIONS ON ESSENTIAL PUBLIC SERVICES

Essential Services	Electric	Natural Gas/Oil
<b>Banking &amp; Finance</b>	Financial transactions, security	Fuel for heat, generators, and facilities
<b>Telecommunications</b>	Switches and communication facilities, SCADA systems, repair crew communication	Fuel for heat, generators, and facilities
<b>Transportation</b>	Signal and control systems, fuel and goods shipment, electric powered public transportation	Fuel and lubricants for vehicles and facilities, transport of fuel, and shipment of goods
<b>Water</b>	Control systems, lift systems, and facilities. Transportation of water, cooling and emission controls, water transport for emergency response	Fuel for treatment, heat, pumps, lift stations, and facilities.
<b>Government</b>	Facility HVAC, lighting, telecommunications, emergency response and protective services (EMS, police, fire)	Gas-fired HVAC, fuel/water pumping and processing
<b>Emergency and Protective Services</b>	Base-to-field communications, recharging of field equipment, re-routing of individuals to facilities with electrical service	Gas-fired power generation and similar impacts to electric power system

Essential Services	Electric	Natural Gas/Oil
Sanitation	Pumping and treatment	Gas-fired electrical systems, pumping, and treatment

Data Source: 2016 Colorado Energy Assurance Emergency Plan

According to the Colorado State Office of Risk Management (ORM), from 2008 through 2017, the State of Colorado recorded 12 power failures having significant impacts on state facilities, costing the state more than \$310,000 (these figures do not include loss of productivity).

## 11. RESOURCES

- 2016 Colorado Energy Assurance Emergency Plan (CEAEP)
- 2016 Colorado Threat and Hazard Identification and Risk Assessment (THIRA) and State Preparedness Report (SPR)
- Colorado Energy Office (CEO)
- Colorado Public Utilities Commission (PUC)
- Colorado State Office of Risk Management (ORM)
- US Department of Energy, Electric Disturbance Events (OE-417) Annual Summaries, [www.oe.netl.doe.gov/OE417\\_annual\\_summary.aspx](http://www.oe.netl.doe.gov/OE417_annual_summary.aspx) accessed 2-20-2018.
- US Department of Energy (DOE), State of Colorado Energy Sector Risk Profile

# RADIOLOGICAL RELEASE



## 1. DEFINITION

When atoms become unstable, the nuclei have excess energy, which is released in the form of electromagnetic (EM) waves or small particles. This is what is known as radiation. Visible light, microwaves, and radio waves are all examples of lower-level EM radiation, and are largely harmless. More energetic EM radiation can ionize atoms or molecules, altering their chemical properties.

Radiological releases generally refer to events involving the accidental release of radioactive materials. These types of incidents are typically the result of equipment malfunction or human error, and are not malicious in nature, which is a key distinction between a release and an attack. Following a radiological release, the primary concerns are the extent of radiation and the inhalation and ingestion of radioactive materials.

There are two types of radiological releases that can occur: stationary and mobile. Stationary events are the result of incidents at a facility such as a hospital or power plant. Mobile events happen during the transport of nuclear materials, and an accident takes place, resulting in the release of its radioactive cargo.

Nuclear accidents can result in acute health problems to include death, burns, severe impairment, and chronic health effects such as cancer, as well as persistent psychological effects.

Nuclear energy and waste is heavily regulated by the federal government through the United States Nuclear Regulatory Commission (NRC). The NRC was created as an independent agency by Congress in 1974 to ensure the safe use of radioactive materials for beneficial civilian purposes while protecting people and the environment. The NRC has five main components that make up its regulatory process:

1. Developing regulations and guidance for applicants and licensees,
2. Licensing or certifying applicants to use nuclear materials or operate nuclear facilities, or decommissioning that permits license termination,
3. Overseeing licensee operations and facilities to ensure that licensees comply with safety requirements,
4. Evaluating operational experience at licensed facilities or involving licensed activities, and
5. Conducting research, holding hearings to address the concerns of parties affected by agency decisions, and obtaining independent reviews to support our regulatory decisions.

Table 3-252 shows the hazard summary for radiological releases.

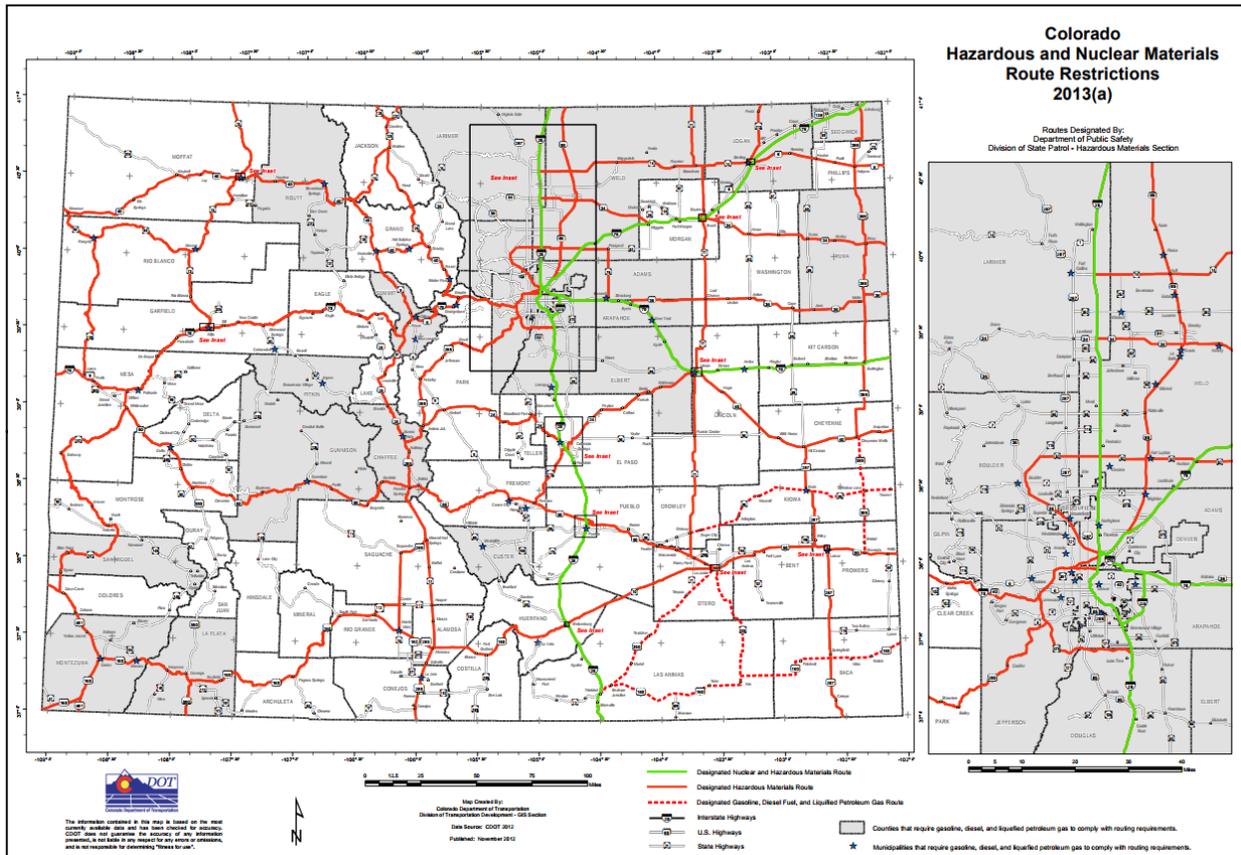
**TABLE 3-252 HAZARD SUMMARY**

<b>Consideration</b>	<b>Impact</b>	<b>Description</b>
<b>Location</b>	Local	Radiological releases will be confined to a relatively small area.
<b>Previous Occurrence</b>	Sporadic	These events do not happen frequently
<b>Probability</b>	Occasional	Incidents are unpredictable. Because there have been events in the past, there can be events expected in the future
<b>Extent</b>	Moderate	Few injuries or deaths are likely to arise as the result of radiological release. Some long-term illnesses may occur.

## 2. LOCATION

Colorado has several Designated Nuclear and Hazardous Materials Routes, including Interstate 25, Interstate 70, and Interstate 76 (Figure 3-149). When transporting nuclear materials, carriers are required to remain on designated nuclear routes. The route along Interstate 25 passes through several highly populated areas, such as Denver, Colorado Springs, and Pueblo.

FIGURE 3-149 DESIGNATED NUCLEAR ROUTES IN COLORADO



Source: Colorado State Patrol, 2013

### 3. EXTENT (MAGNITUDE/STRENGTH)

Radiation is the main danger during radiological incidents. Gamma rays can result in acute and long-term illness, with significant enough doses leading to death. The Gray (Gy), which is the standard unit for measuring radiation, is equal to one joule of energy released per kilogram of matter. While any radiation absorption can be dangerous, any exposure of 8 Gy or greater will result in certain death within a few days or weeks. Table 3-253 shows the effects of acute radiation illness.

TABLE 3-253 ACUTE RADIATION ILLNESS CHART

Phase	Symptom	Whole-body absorbed dose (Gy)				
		1–2 Gy	2–6 Gy	6–8 Gy	8–30 Gy	>30 Gy
<b>Immediate Effects</b>	Nausea and vomiting	5–50%	50–100%	75–100%	90–100%	100%
	Time of onset	2–6 hours	1–2 hours	10–60 minutes	< 10 minutes	< 5 Minutes
	Duration	< 24 hours	24–48 hours	< 48 hours	< 48 hours	Patients die within 48 hours
	Diarrhea	None	None to mild (< 10%)	Moderate to Severe (> 10%)	Severe (> 95%)	Severe (100%)
	Time of onset	—	3–8 hours	1–3 hours	< 1 hours	< 1 hours
	Headache	Slight	Mild to moderate (50%)	Moderate (80%)	Severe (80–90%)	Severe (100%)
	Time of onset	—	4–24 hours	3–4 hours	1–2 hours	< 1 hours
	Fever	None	Moderate increase (10–100%)	Moderate to severe (100%)	Severe (100%)	Severe (100%)
	Time of symptom onset	—	1–3 hours	< 1 hours	< 1 hours	< 1 hours
	Central nervous system function	No impairment	Cognitive impairment 6–20 h	Cognitive impairment > 24 h	Rapid incapacitation	Seizures Tremor, Ataxia, Lethargy
<b>Latent period</b>		28–31 days	7–28 days	< 7 days	None	None
<b>Overt Illness</b>	Clinical Manifestations	Mild to moderate leukopenia	Moderate to severe leukopenia	Severe leukopenia	Nausea	Patients die within 48 hours
		Fatigue	Purpura	High fever	Vomiting	
		Weakness	Hemorrhage	Diarrhea	Severe diarrhea	
			Infections	Vomiting	High fever	
			Epilation after 3 Gy	Dizziness and disorientation	Electrolyte disturbance	
				Hypotension	Shock	
				Electrolyte disturbance		
<b>Mortality</b>	Without care	0–5%	5–95%	95–100%	100%	100%
	With care	0–5%	5–50%	50–100%	100%	100%
	Death	6 – 8 weeks	4 – 6 weeks	2 – 4 weeks	2 days – 2 weeks	1 – 2 days

Source: Merck Manuals Online, 2018

According to the US Nuclear Regulatory Commission, nuclear accidents and incidents are classified under three categories:

- **Criticality Incidents:** Involve nuclear assemblies, research, production or power reactors, and chemical operation. Worldwide, these incidents have resulted in fatalities, radiation exposure, and release of radioactivity into the environment.
- **Loss-of-Coolant:** Accidents result when a reactor coolant system experiences a breach large enough that coolant inventory can no longer be maintained by the normally operating makeup system.
- **Loss-of-Containment:** Accidents involve the release of radioactivity. Points of release for this type of incident can be containment vessels at power facilities or damaged packages during transportation.

Because Colorado does not have any active nuclear power plants, the most common type of radiological release is Loss-of-Containment. These will typically occur during the transportation of nuclear materials from one site to another.

## 4. PROBABILITY

As radiological events are human-caused, there is no way to accurately predict or estimate when such an incident might occur. By following proper regulations and guidelines, nuclear power plant operators, transporters of nuclear material, and those who otherwise deal with radioactive matter on a regular basis can help to prevent accidents from occurring.

Radiological releases happen extremely infrequently. There have not been a sufficient number to provide an estimate for how often these may happen.

## 5. PREVIOUS OCCURRENCES

Though there are no active uranium mines or mills, the State of Colorado has a long history of uranium mining and processing that has had an impact on the natural environment. The Environmental Protection Agency (EPA) has two Superfund sites as a result of uranium mining. These include the Uravan Mineral Belt and a mill site in Canon City.

**Rocky Flats Plant Fires and Leakage, 1957-1969** - The Rocky Flats Plant, located northwest of Denver, was a former nuclear weapons production facility. The Plant had a history of issues, including two damaging fires, as well as the leakage of radioactive material into the ground soil.

The first fire occurred on September 11, 1957, when a plutonium fire ignited a glovebox. This released plutonium into the atmosphere and caused nearly \$818,000 in damages (\$7,131,000 in 2017 dollars).

From the late 1950s until the early 1960s, 55-gallon drums of waste oil and solvents that had been contaminated with plutonium and uranium were stored outdoors at the 903 Area. Hydrochloric acid (HCl), a byproduct of the waste, burned through the barrels, causing the contaminated liquids to leak into the ground. In the late 1960s, the barrels were removed, leaving the ground exposed to the elements. Wind blew some of the soil away, causing off-site contamination. While the barrels themselves were moved to Idaho for burial, a large asphalt pad was placed atop the site, resulting in the name “903 Pad.”

Another large fire occurred on May 11, 1969, started by the spontaneous combustion of plutonium shavings. Though this was not as significant an event as the 1957 fire, it caught the attention of local health officials who performed tests of the surrounding area. They determined that the public southeast of Rocky Flats had been contaminated (Moore, 2007). The incidents at Rocky Flats are considered the worst radiological accidents in Colorado.

### Transportation Accidents

In addition to the stationary releases, there have been a number of mobile incidents involving radioactive materials. The US Department of Transportation (USDOT) keeps track of all hazardous materials incidents; they have recorded 30 incidents involving nuclear materials since 1971, as shown in Table 3-254. Of those, 20 have occurred in Denver County. The last incident on record in the State of Colorado occurred in Park County on August 16, 2010. An open-top truck carrying low-grade radioactive waste rolled over on US 285 south of Jefferson.

These incidents are listed by category:

- **LSA** – Low Specific Activity, non-fissile materials
- **NOS** – Materials Not Otherwise Specified
- **EP** – Expected Package, limited quantity of materials
- **TA** – Type A packages, low quantities of radioactive materials

**TABLE 3-254 PAST OCCURRENCES OF RADIOACTIVE TRANSPORTATION SPILLS**

Date of Incident	Incident City	Incident County	Commodity Type
8/4/1971	Denver	Denver	LSA
7/29/1972	Denver	Denver	NOS
12/5/1972	Denver	Denver	LSA
8/15/1973	Denver	Denver	NOS
11/17/1973	Denver	Denver	LSA
8/17/1974	Denver	Denver	NOS
2/23/1975	Denver	Denver	NOS
3/25/1977	Colorado Springs	El Paso	NOS
6/2/1977	Denver	Denver	LSA
6/23/1977	Denver	Denver	NOS
7/23/1977	Pueblo	Pueblo	LSA
9/27/1977	Springfield	Baca	LSA

Date of Incident	Incident City	Incident County	Commodity Type
1/3/1979	Denver	Denver	NOS
3/3/1979	Denver	Denver	NOS
4/4/1979	Denver	Denver	NOS
3/17/1980	Denver	Denver	NOS
2/2/1981	Denver	Denver	NOS
1/23/1982	Denver	Denver	NOS
5/25/1982	Denver	Denver	EP
6/8/1982	Denver	Denver	NOS
7/1/1982	Denver	Denver	NOS
9/10/1982	Denver	Denver	NOS
12/26/1982	Denver	Denver	NOS
8/31/1989	Canon City	Fremont	LSA
3/3/1992	Whitewater	Mesa	NOS
11/13/1997	Grand Junction	Mesa	LSA
1/25/2005	Fort Collins	Larimer	Type A
12/10/2008	Henderson	Adams	Type A
8/16/2010	Jefferson	Park	LSA

US DOT HAZMAT Portal, January 2018

## 6. IMPACT ANALYSIS

No specific, statewide loss estimation exists for the hazard of a radiological event. Radiation exposure is a low probability in Colorado. Potential costs could be for response, health care, restoration, remediation, and post de facto litigation. Direct costs related to transportation accidents could include materials, carrier damage, property damage, response, and remediation/cleanup.

Radiological materials are strictly controlled at both the federal and state levels. The state's Department of Transportation details the remediation of hazardous materials, including radioactive contaminants. The clean-up of any radiological material must be reported, as well as if the spill impacted soils or waters.

A radiological release has the potential to be highly disruptive, particularly if it were to occur within an urban area or on a busy highway. However, these would be temporary and the radiological materials would be removed by trained hazardous materials teams. Table 3-255 shows the impact summary for a radiological release.

TABLE 3-255 RADIOLOGICAL RELEASE EMAP IMPACT SUMMARY

Consideration	Description
<b>General Public</b>	The general public may panic if they believe they have been affected by a radiological release.
<b>First Responders</b>	First responders to a radiological release will be some of the first people to be affected by radiation and contamination. They may become sick over time if exposed to high enough levels.
<b>Property</b>	Only property in the immediate area of a radiological incident would be affected. Remediation would be minimal.
<b>Facilities and Infrastructure</b>	Infrastructure will not be impacted long-term. Roadways and transportation routes will be temporarily slowed or shut down during remediation.
<b>Economic</b>	Radiological releases will not have a large effect on the economy.
<b>Environment</b>	Radiological releases can pollute the environment and cause nearby plants and animals to get sick. Radioactive material that gets into the air or water supply can affect humans further away from the incident site.
<b>Continuity of Government and Services</b>	Government continuity will not be heavily affected by a radiological release unless it occurs within the immediate vicinity. Even then, after remediation, it would be only for a short time.
<b>Confidence in Government</b>	There is an expectation that governmental authorities will have the resources to successfully respond to a radiological attack and maintain general public safety. If an attack were carried out, followed by a chaotic and disorderly response, public confidence in government would be badly shaken.
<b>Critical Assets</b>	Radiological releases will not have an effect on critical state assets

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

Large inventories of radioactive materials are handled at only a few fixed facilities within the state, and shipments of large quantities of radioactive materials are relatively infrequent as compared to shipments of hazardous materials that pose comparable risks. Operations at fixed facilities and transportation of radioactive material are highly regulated by the Department of Energy (DOE) and NRC to minimize the chance of occurrence of a significant release and provide mitigation if a release occurs. Planning for mitigation of accidental releases is performed to avoid or reduce:

- Death, acute or chronic debilitation, or increased risk of cancer
- Damage or destruction of agricultural products – animals and crops
- Degradation of environmental resources

- Devaluation or loss of use of public and private property
- Costs associated with emergency response, including cleanup

Table 3-256 shows radiological releases by county. Very few counties have experienced a hazardous materials incident involving radiological materials. Those that have include Adams, Baca, Denver, El Paso, Fremont, Larimer, Mesa, and Park Counties. Most of these have only experienced a single event, with Mesa experiencing two, but Denver has seen the highest number of any county with 20 total incidents. It should be noted that the last such incident in Denver County was in 1982. There have not been any in the county since that time.

Since 2007, there have only been two incidents, one in 2008 in Adams County, and then in 2010 in Park County.

**TABLE 3-256 HAZMAT RELEASES INVOLVING RADIOLOGICAL MATERIALS BY COUNTY**

<b>County</b>	<b>No. of Incidents</b>
<b>Adams</b>	1
<b>Alamosa</b>	0
<b>Arapahoe</b>	0
<b>Archuleta</b>	0
<b>Baca</b>	1
<b>Bent</b>	0
<b>Boulder</b>	0
<b>Broomfield</b>	0
<b>Chaffee</b>	0
<b>Cheyenne</b>	0
<b>Clear Creek</b>	0
<b>Conejos</b>	0
<b>Costilla</b>	0
<b>Crowley</b>	0
<b>Custer</b>	0
<b>Delta</b>	0
<b>Denver</b>	20
<b>Dolores</b>	0
<b>Douglas</b>	0
<b>Eagle</b>	0
<b>El Paso</b>	1
<b>Elbert</b>	0
<b>Fremont</b>	1
<b>Garfield</b>	0
<b>Gilpin</b>	0
<b>Grand</b>	0
<b>Gunnison</b>	0
<b>Hinsdale</b>	0

<b>County</b>	<b>No. of Incidents</b>
Huerfano	0
Jackson	0
Jefferson	0
Kiowa	0
Kit Carson	0
La Plata	0
Lake	0
Larimer	1
Las Animas	0
Lincoln	0
Logan	0
Mesa	2
Mineral	0
Moffat	0
Montezuma	0
Montrose	0
Morgan	0
Otero	0
Ouray	0
Park	1
Phillips	0
Pitkin	0
Prowers	0
Pueblo	1
Rio Blanco	0
Rio Grande	0
Routt	0
Saguache	0
San Juan	0
San Miguel	0
Sedgwick	0
Summit	0
Teller	0
Washington	0
Weld	0
Yuma	0
<b>Total</b>	<b>29</b>

US DOT HAZMAT Portal, January 2018

Though no county-level hazard mitigation plan directly profiles radiological releases, five counties that profile hazardous materials incidents in their top four hazards include some mention of radioactivity as part of this larger hazard profile. These include Douglas, Grand,

Huerfano, Park, and Archuleta Counties. No plan has any mitigation actions specifically relating to radioactive hazardous materials incidents. There are also no damage estimates from radioactive incidents.

## **8. FUTURE DEVELOPMENT**

There are currently no nuclear power plants in the State of Colorado, nor are there any plans to develop any in the immediate future. Radiation exposure is not currently understood nor expected to influence any other natural hazards. From a human-caused perspective, it is possible that a large-scale radiological event could initiate civil disturbances.

As population increases, the demand for radiological materials may increase as well, creating increased production and transport. Even if the amount of radiological release incidents remain consistent over time, increased population and housing growth may expose more people.

## **9. CLIMATE CHANGE**

Due to the nature of Radiological Releases being a human-caused hazard, they are not susceptible to climate change.

## **10. RISK TO STATE ASSETS**

Highways, aircraft, and rail lines are used to move radioactive materials around the state. Transportation of highly radioactive materials is regulated by the Department of Energy, Nuclear Regulatory Commission, and the Department of Transportation. Requirements can include use of single purpose licensed shipping casks designed for either truck or rail transport. Casks are designed to withstand extreme forces including drop tests and direct hits from freight trains.

According to the United States Nuclear Regulatory Commission, there are no operating nuclear power reactors and no facilities currently undergoing decommissioning in Colorado. The only nuclear reactor is one used for testing by the United States Geological Survey in Denver.

There are many factors that determine the risk of state assets to radiological releases, which makes it difficult to determine vulnerability. Damage to state assets due to a hazardous material incident would depend on factors such as the severity of the incident, the proximity to the incident, the chemical released, time of day, weather, etc. A hazardous material (HAZMAT) incident may cause structural damage to state assets as well as impact the health of personnel. If environmental contamination occurs remediation efforts could be costly, however the cost is typically the responsibility of the spiller. Quick response to a HAZMAT incident may help minimize the damages. According to the DHSEM CHIRRP, the Colorado State Patrol (CSP) is responsible for oil and hazardous materials response, including coordinating response and recovery actions to prepare for, prevent, minimize, or mitigate a threat to public health, welfare, or the environment.

## 11. RESOURCES

- Colorado Energy Office (CEO); <https://www.colorado.gov/pacific/energyoffice/nuclear>. Accessed January 2018.
- Colorado Division of Homeland Security and Emergency Management (DHSEM) Colorado Hazard and Incident Response and Recovery Plan (CHIRRP), 2016
- Democracy and Public Health and Rocky Flats. Moore, LeRoy. 2007
- Park County Hazard Mitigation Plan (HMP), 2015
- Procedures for Hazardous Material Spills That Occur on State and Federal Highways Within Colorado as a Result of a Highway Transportation Incident, 2006
- State of Colorado Emergency Response Guide (ERG), 2014
- U.S. Nuclear Regulatory Commission (NRC)

# CHEMICAL, BIOLOGICAL, RADIOLOGICAL, AND NUCLEAR ATTACK



## 1. DEFINITION

A chemical, biological, radiological, and nuclear (CBRN) attack is the malicious use of chemical, biological, radiological, or nuclear materials or weapons with the intention to cause significant harm or disruption.

### 1.1 CHEMICAL ATTACK

FEMA states that a chemical attack is the use of any chemical agents that are poisonous vapors, aerosols, liquids, and solids that have toxic effects on people, animals, or plants. They can be released by bombs or sprayed from aircraft, boats, and vehicles. They can be used as a liquid to create a hazard to people and the environment. Some chemical agents may be odorless and tasteless. They can have an immediate effect (a few seconds to a few minutes) or a delayed effect (2 to 48 hours). While potentially lethal, chemical agents are difficult to deliver in lethal concentrations. Outdoors, the agents often dissipate rapidly depending on weather conditions. Chemical agents also are difficult to produce.

A chemical attack could come without warning. Signs of a chemical release include people having difficulty breathing, experiencing eye irritation, losing coordination, becoming nauseated, or having a burning sensation in the nose, throat, and lungs. Also, the presence of many dead insects or birds may indicate a chemical agent release.

### 1.2 BIOLOGICAL ATTACK

A biological attack is the use of biological toxins or infectious agents with the intent to kill or incapacitate humans, animals, or plants. It is useful to distinguish between two kinds of biological agents:

- Transmissible agents that spread from person to person (e.g., smallpox, Ebola) or animal to animal (e.g., foot and mouth disease).
- Agents that may cause adverse effects in exposed individuals but that do not make those individuals contagious to others (e.g., anthrax, botulinum toxin).

In addition to agents that affect human health, a biological attack also includes agents that could affect only animal or plant life but thereby threaten food supplies or the economy of Colorado communities. An attack *against people* could be used to cause illness, death, fear, societal disruption, and economic damage. An attack *on agricultural plants and animals* would primarily cause economic damage, loss of confidence in the food supply, and possible loss of life.

Secondary effects of these attacks, which could severely stress the state include: lack of

adequate shelter, food, water, health and medical facilities and personnel, mortuary services, disruption of communication systems, and power outages.

A strategic biological attack could have devastating and far-reaching consequences. The use of these agents is rare, used most prevalently during World War I but also on a finite number of occasions in the United States by terrorist groups or individual attackers, both domestic and international. Unfortunately, the location, timing, extent, and even nature of such attacks are extremely difficult to predict. However, because of the potential devastation and significant secondary effects caused by this type of attack, the extent is rated catastrophic.

Because many biological attacks depend on highly infectious disease, biological attacks should be considered in combination with evaluations of pandemics, which are discussed in greater detail in the pandemic hazard profile in this Plan.

### **1.3 RADIOLOGICAL ATTACK**

The United States Department of Homeland Security (U.S. DHS) defines a Radiological Attack as the spreading of radioactive material with the intent to do harm. This is contrary to a Radiological Release (included in a separate hazard profile), which is an accidental release incident. A Radiological Attack is most likely to use what is called a “dirty bomb,” a device that uses conventional explosives to disperse radioactive materials within a small, targeted area. These types of explosives are also known as Radiological Dispersal Devices (RDD). Terrorist organizations, such as al-Qaeda and ISIS, have demonstrated ambition to use weapons of mass destruction and sourcing of radiological material to manufacture dirty bombs. Attacks from terrorist organizations using dirty bombs are often harder to deter than those of nation-states because dirty bombs are similar to an explosive attack; however, the magnitude of losses from a dirty bomb attack would be less than an attack from a nation-state.

### **1.4 NUCLEAR ATTACK**

Nuclear attack can be defined as an attack in which nuclear weaponry is used to inflict crippling damage on a place and the people living there. Nuclear weapons are weapons of mass destruction, which means they can produce far ranging destruction in a very short time-frame, while also having lasting impacts (Birks and Sherry, 1986).

Colorado lies within range of nuclear attack from multiple nation-states. Since World War II, several nations have developed nuclear weapons technology, and some nations have or are in the process of developing nuclear weapons that could reach Colorado. This makes nuclear attack a hazard of concern for the State of Colorado.

Table 3-257 describes the hazard profile summary for CBRN attacks.

TABLE 3-257 HAZARD SUMMARY TABLE

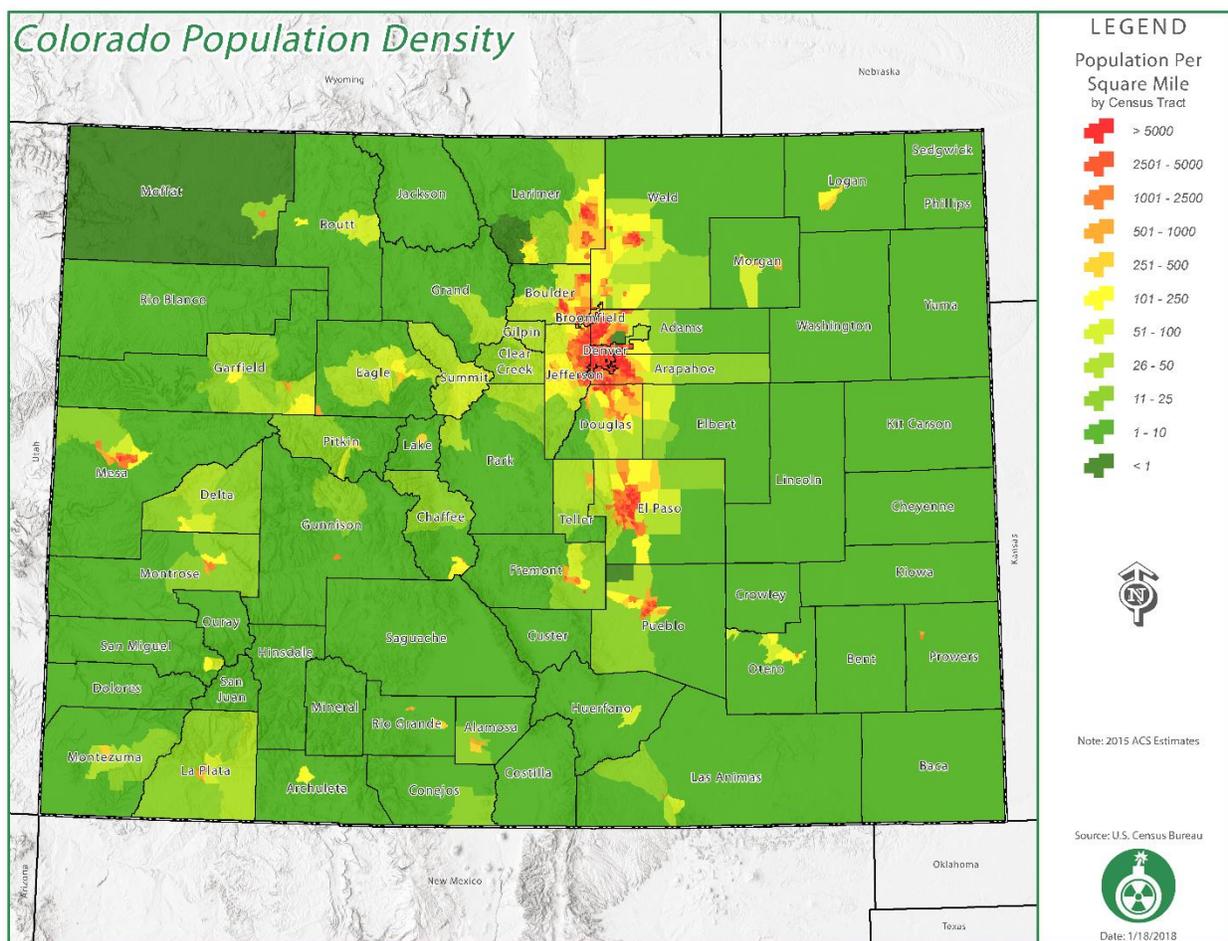
Consideration	Impact	Description
<b>Location</b>	Regional	Unpredictable but likely to affect urban and higher density areas or sites, or persons of renown or strategic importance to the state or nation. Direct impacts are typically limited to the immediate area, but long-term impacts can have a wide range effect. In a radiological attack, radioactive contamination will be blown downwind of the blast area.
<b>Previous Occurrence</b>	Sporadic	Rare, typically during wartime or as result of terrorist actions. There have not been any nuclear or radiological attacks in the State of Colorado.
<b>Probability</b>	Occasional	Attempts occur infrequently but are likely to continue to occur into the future. Future global conditions may result in CBRN attacks becoming more common. There are many military-grade chemical agents that exist and could be used in an attack, but the manufacture or acquisition, risk of discovery, and difficulty of effective deployment act as deterrents.
<b>Extent</b>	Catastrophic	Destroyed or damaged property that threatens structural stability, mass fatalities and/or casualties, impact to critical lifelines, impact to government's ability to provide service. Likely to overwhelm state and local resources and require federal assistance for full recovery. Remediation of radioactive or chemical contamination will result in significant clean-up efforts.

## 2. LOCATION

A CBRN attack is typically a pre-meditated, targeted attack on a specific place or group. The location targeted by an attack depends on the motive of the attacker (DHSEM THIRA, 2016). Since CBRN attacks are most often linked to warfare or terrorist actions, they are likely to target prominent public figures, highly urban or iconic locations, or sites of strategic or military importance. Consequently, areas of higher risk include densely populated cities and counties along the Front Range; the Denver metro area which is a densely populated transportation and economic hub of the Rocky Mountain West; Denver's government centers, including the Denver Federal Center located in Lakewood, which holds 26 "off-site" federal government agencies and is often referred to as the "Washington DC." of the west because it is the most densely packed federal area outside of Washington, DC; and military facilities such as Buckley Air Force Base, Cheyenne Mountain Air Force Station (CMAFS), Peterson Air Force Base, Fort Carson, Schriever Air Force Base, the Air Force Academy, the Pueblo Chemical Depot, and Rocky Mountain Arsenal. Large venue events, such as a sporting event attended by tens of thousands of people might be considered a desirable target. Again, such events typically occur in densely populated areas since those areas are able to provide the infrastructure support (hotels, eateries, etc.) for large numbers of people.

Additionally, major farms and food distributors, many located on the Eastern Plains, may also be at higher risk of certain types of CBRN attacks. Sparsely populated rural counties are less desirable targets for publicity-seeking terrorists, though this does not make these areas immune. It is expected that the probability of an attack is directly related to population density or more likely to an event that is occurring or to a specific location of importance to the attacker. Figure 3-150 shows Colorado's population density on a statewide map. Larimer, Boulder, Denver, Arapahoe, El Paso, Douglas, and Adams Counties all have very densely populated urban areas.

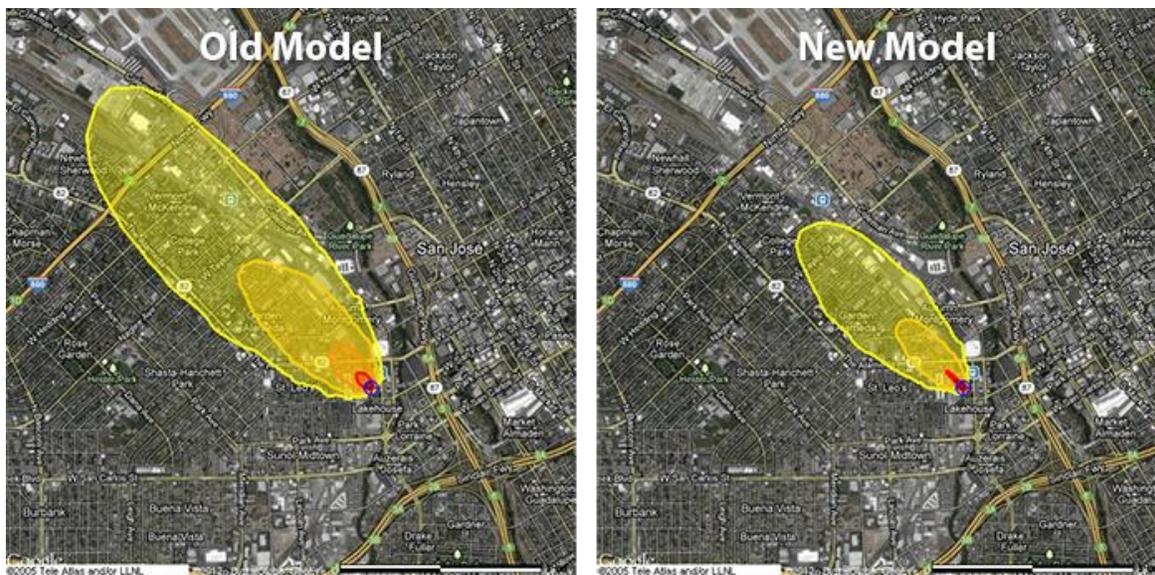
**FIGURE 3-150 COLORADO POPULATION DENSITY**



While a radiological attack may occur in any part of the state, it can generally be assumed that the larger cities are more at risk than smaller ones since an attack of this type would only affect a few city blocks. Figure 3-151 shows the dispersion pattern of a RDD detonation in an urban area. The “New Model” on the right accounts for larger ballistic particles that do not travel as far as previously thought, according to the “Old Model.” The model predicts near-source ground contamination (red) and downwind concentrations (orange and yellow). The worst effects will be felt nearest the detonation site, and the “New Model” predicts increased near-source ground

contamination, but significantly reduced downwind concentrations compared to the “Old Model” (Lawrence Livermore National Laboratory, 2018).

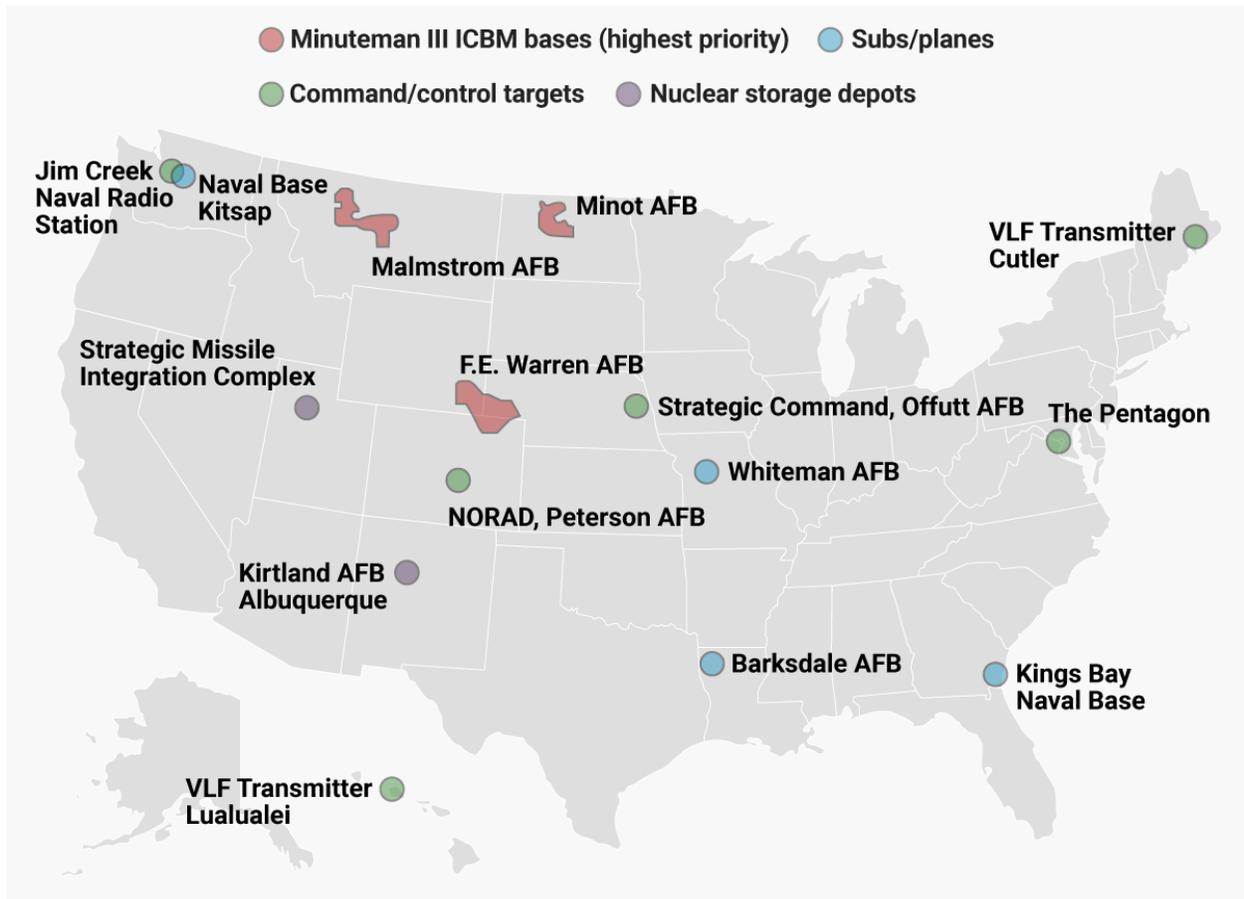
**FIGURE 3-151 RADIOLOGICAL DEVICE DISPERSAL MODELS**



Source: Lawrence Livermore National Laboratory, 2018

In the event of a nuclear attack, there are likely nuclear strike targets that could be anticipated. As identified in Figure 3-152, anticipated targets include locations where United States military supplies and personnel are located. Two such targets are located in or near Colorado. These targets are the F.E. Warren Air Force Base near Cheyenne, Wyoming; and the United States Northern Command (USNORTHCOM) and the North American Aerospace Defense Command (NORAD), located at Peterson Air Force Base near Colorado Springs, which are identified on the map below. Destroying military supplies and personnel at these targets would hinder the United States’ defense. USNORTHCOM was established after the September 11, 2001 terrorist attacks and provides command and control of Department of Defense (DOD) homeland defense efforts and to coordinate defense support of civil authorities (USNORTHCOM, 2018). The Commander of USNORTHCOM is also the concurrent Commander of NORAD. NORAD is the command headquarters for the North American Aerospace Defense. The destruction of both USNORTHCOM and NORAD would be detrimental to homeland defense, coordination, and response in the United States.

FIGURE 3-152 LIKELY MILITARY NUCLEAR STRIKE TARGETS IN THE UNITED STATES



Source: Stephen Schwartz, Business Insider, 2017

### 3. EXTENT (MAGNITUDE/STRENGTH)

The extent of a CBRN attack varies based on the type of attack.

#### 3.1 CHEMICAL ATTACK

Chemical attacks can cause injury or fatalities if they have been inhaled or absorbed through the skin. The Department of Homeland Security (DHS) states that the harm caused by these attacks ultimately depends on: 1) their degree of toxicity, 2) the concentration of the chemical, 3) the route of exposure, and 4) the duration of the exposure. Symptoms of exposure to most toxic chemicals would appear in minutes to hours. Different chemicals have varying effects on the body. Depending on the chemical agent, symptoms can appear either minutes or hours after exposure. Figure 3-153 describes the effects and treatment of chemical weapons developed for military use.

**FIGURE 3-153 EFFECTS AND TREATMENT OF SOME CHEMICAL WEAPONS DEVELOPED FOR MILITARY USE**

	Nerve Agents		Blister Agents (injure skin, eyes, and airways)		Blood Agents (cause blood changes and heart problems)		Choking Agents	
<b>Examples</b>	Sarin	VX	Mustard	Lewisite	Hydrogen Cyanide	Cyanogen Chloride	Chlorine	Phosgene
<b>Odor</b>	Odorless		Garlic or Mustard	Geraniums	Burnt almonds		Bleach	Mown hay
<b>Persistency*</b>	Non-persistent (min. to hrs.)	Persistent (>12 hrs.)	Persistent		Non-persistent		Non-persistent; vapors may hang in low areas	
<b>Rate of Action</b>	Rapid for vapors; liquid effects may be delayed		Delayed	Rapid	Rapid		Rapid at high concentrations; delayed at lower concentrations	
<b>Signs and Symptoms</b>	Headache, runny nose, salivation, pinpointing of pupils, difficulty in breathing, tight chest, seizures, convulsions, nausea, and vomiting		Red, burning skin, blisters, sore throat, dry cough; pulmonary edema, eye damage, nausea, vomiting, diarrhea. Symptoms may be delayed 2 to 24 hrs		Cherry red skin/lips, rapid breathing, dizziness, nausea, vomiting, convulsions, dilated pupils, excessive salivation, gastrointestinal hemorrhage, pulmonary edema, respiratory arrest		Eye and airway irritation, dizziness, tightness in chest, pulmonary edema, painful cough, nausea, headache	
<b>First Aid</b>	Remove from area, treat symptomatically, Atropine and pralidoxime chloride (2-PAM chloride), diazepam for seizure control		Decontaminate with copious amount of water, remove clothing, support airway, treat symptomatically		Remove from area, assist ventilations, treat symptomatically, administer cyanide kit		Remove from area, remove contaminated clothing, assist ventilations, rest	
<b>Decontamination</b>	Remove from area, remove clothing, flush with soap and water, aerate							

\*How long a chemical remains at toxic levels

Source: The National Academies and the U.S. Department of Homeland Security, 2004

The area affected depends on various factors including type and amount of the chemical agent, means of dispersal, local topography, and local weather conditions in an open-air environment. The area directly exposed to the chemical agent will be affected with the most lethal or immediate life-threatening results. Severity of symptoms will lessen further away from the site of original exposure. In a closed space, a volatile chemical will disperse to fill the space. The smaller the closed space, the greater the concentration of the chemical exposed. If the attack is in the form of a toxic cloud it will spread mostly with the speed and direction of the wind, but the concentration of the chemical would be greatly diminished at distances far from the source.

Chemicals can also be placed in food to make them highly toxic, sometimes without altering the appearance or taste of the food. If food sources were to be infiltrated with chemicals, impacts could be harmful to large populations.

Similarly, chemicals can be introduced into water, contaminating the water distribution system. Due to the nature of water systems, chemicals have the potential to spread rapidly throughout drinking water sources. While there are methods of treating large volumes of potentially contaminated water, impacts could be harmful to a widespread population (The National Academies and the U.S. Department of Homeland Security, 2004).

### 3.2 BIOLOGICAL ATTACK

The U.S. Centers for Disease Control and Prevention (CDC) has identified a list of animal and plant agents of concern, which include certain bacteria, viruses, and biotoxins, and which are

the most plausible and of greatest threat if utilized. These are identified in Table 3-258 by level of threat.

**TABLE 3-258 DISEASES/AGENTS LISTED BY THE CDC AS POTENTIAL BIOTERROR THREATS**

Priority Level	Category A: Highest	Category B: 2nd Highest	Category B: 3 <sup>rd</sup> Highest
<b>Definitions</b>	1) can be easily disseminated or transmitted from person to person; 2) result in high mortality rates and potential for major public health impact; 3) might cause public panic and social disruption; and 4) require special action for public health preparedness.	1) are moderately easy to disseminate; 2) result in moderate morbidity rates and low mortality rates; and 3) require specific enhancements of CDC's diagnostic capacity and enhanced disease surveillance.	Emerging pathogens that could be engineered for mass dissemination in the future because of: 1) availability 2) ease of production and dissemination; 3) potential for high morbidity and mortality rates and major health impact.
<b>Bacteria</b>	Anthrax, Botulism, Plague, Tularemia	Brucellosis, Clostridium perfringens, Glanders, Melioidosis, Psittacosis, Q fever, Typhus fever, food safety threats, water safety threats	
<b>Viruses</b>	Smallpox	Viral encephalitis	Nipah virus, Hantavirus
<b>Biotoxin</b>	Botulism	Ricin toxin, Staphylococcal enterotoxin B	

Source: CDC, 2018

Table 3-259 shows the level of impact of biological diseases that have strong potential to be weaponized, based on data from the United States Army Medical Research Institute of Infectious Diseases (USAMRIID) Medical Management of Biological Casualties Handbook.

**TABLE 3-259 IMPACT OF PROBABLE WEAPONIZED BIOLOGICAL DISEASES**

Disease	Human Transmittable	Latency Period (days)	Illness Duration	Lethality	Vaccine Efficacy
<b>Anthrax</b>	No	1 to 6	3 to 5 days (usually fatal if untreated)	High	2 dose efficacy against up to 1,000 LD50 in monkeys
<b>Brucellosis</b>	No	5 to 60	weeks to months	<5% untreated	No vaccine

Disease	Human Transmittable	Latency Period (days)	Illness Duration	Lethality	Vaccine Efficacy
<b>Cholera</b>	Rare	<1 to 5	>1 week	Low w/treatment, high without	No data on aerosol
<b>Glanders</b>	Low	10 to 14	death in 7-10 days in septicemic form	>50%	No vaccine
<b>Pneumonic Plague</b>	High	2 to 3	1 to 6 (usually fatal)	Low w/treatment, high without	3 doses not protective against 118 LD50 in monkeys
<b>Tularemia</b>	No	2 to 10	>2 weeks	Moderate	80% protection against 1-10 LD50
<b>Q Fever</b>	Rare	10 to 40	2-14 days	Very low	94% protection against 3,500 LD50 in guinea pigs
<b>Smallpox</b>	High	7 to 17	4 weeks	High	Vaccine protects against large doses in primates
<b>Venezuelan Equine Encephalitis</b>	Low	2 to 6	days to weeks	Low	TC 83 protects against 30-500 LD50 in hamsters
<b>Viral Hemorrhagic Fevers</b>	Moderate	4 to 21	7 to 16 days (often fatal)	High, depending on strain	No vaccine
<b>Botulism</b>	No	1 to 5	months (often fatal within days)	Low w/treatment, high without	3 dose efficacy 100% against 25-250 LD50
<b>Staph Enterotoxin B</b>	No	3 to 12 hours	hours	<1%	No vaccine
<b>Ricin</b>	No	18 to 24 hours	10 to 12 days	High	No vaccine
<b>T-2 Mycotoxins</b>	No	2 to 4 hours	days to months	Moderate	No vaccine

Source: USAMRIID, 2014

### 3.3 RADIOLOGICAL ATTACK

Radioactive materials are commonly used throughout a host of different professions, including manufacturing, health, and research. In each industry, different radioactive materials are used. The U.S. DHS breaks them down into three separate categories based on the type of radiation they emit: Gamma, Beta, and Alpha. These types of radiation have different qualities that allow them to be used in the array of industries and fields:

**Gamma and X-Rays:** Travel long distances in air and can pass through the body exposing internal organs; it is also a concern if gamma emitting material is ingested or inhaled.

**Beta radiation:** Travels only a few yards in the air. In sufficient quantities, it can cause skin damage. Beta-emitting material is an internal hazard if ingested or inhaled.

**Alpha radiation:** Travels only a few inches in the air and cannot penetrate skin. It is hazardous only if ingested or inhaled.

The materials and their uses are discussed in Table 3-260. Exposure to these materials for long periods of time can result in illness.

**TABLE 3-260 TYPES OF RADIOACTIVE MATERIALS BY INDUSTRY**

Isotope	Industries
<b>Gamma Emitters</b>	
<b>Cobalt-60</b>	Cancer therapy, industrial radiography, industrial gauges, food irradiation
<b>Cesium-137</b>	Cancer therapy, industrial radiography, industrial gauges, food irradiation, well logging
<b>Iridium-102</b>	Industrial radiography and medical implants for cancer therapy
<b>Beta Emitters</b>	
<b>Strontium-90</b>	Radioisotope thermoelectric generators which are used to make electricity in remote areas
<b>Alpha Emitters</b>	
<b>Plutonium-238</b>	Research and well logging and in Radioisotope Thermoelectric Generators (RTGs) for space missions
<b>Americium-241</b>	Industrial gauges and well logging

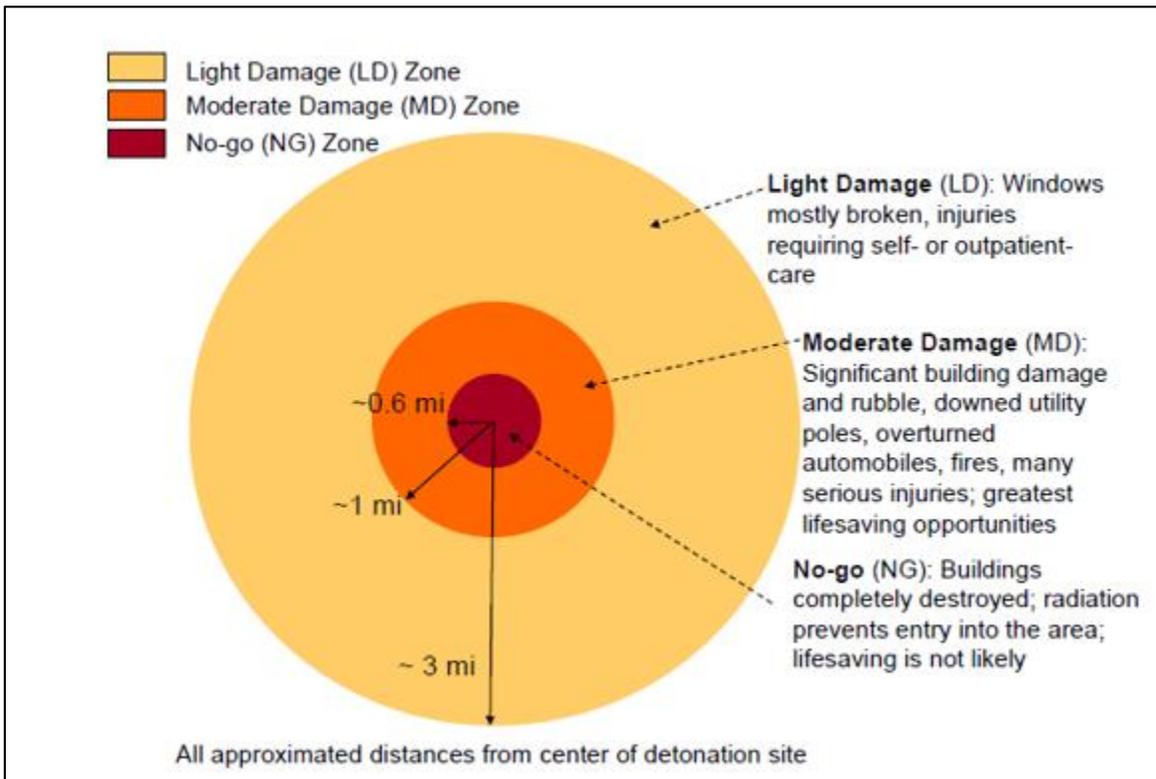
Source: Department of Homeland Security Radiological Attack Fact Sheet, 2003

### 3.4 NUCLEAR ATTACK

A nuclear attack could have the most devastating and far reaching consequences out of all the possible disasters and hazards. This is because nuclear detonations produce powerful blasts, heat, outputs of radiation, radioactive fallout, and electro-magnetic pulse (Colorado Energy Assurance Emergency Plan, 2016). An attack would have direct effects, indirect effects, and secondary effects.

Direct effects include intense heat, blast energy, and high-intensity nuclear radiation. These effects generally will be limited to the immediate area of the detonation (up to 22 miles), depending on weapon size, altitude of burst, and atmospheric conditions. Figure 3-154 represents the direct effects of a 10 kiloton nuclear explosion.

FIGURE 3-154 DAMAGE ZONES FOR A 10 KT NUCLEAR EXPLOSION



Source: Homeland Security Council Interagency Policy Coordination Subcommittee for Preparedness and Response to Radiological and Nuclear Threats, 2009

The most prominent indirect effect of a nuclear attack is radioactive fallout. Radioactive fallout is the residual radioactive material that is propelled into the atmosphere following a nuclear attack. This material forms into radioactive dust, ash, clouds and potentially rain, which all have the potential to disperse farther and have a greater reaching impact than the range of the actual initial explosion. These environmental impacts generated by the detonation of a bomb would alter the physical environment and atmosphere dramatically. Impacts of this atmospheric change would be long-term (Birks and Sherry, 1986).

There would also be secondary effects caused by a nuclear attack. These effects are related to the destruction of state assets such as critical infrastructure, transportation systems, communication systems, and more caused by the attack. These impacts could include a shortage of adequate shelter, food, water, health, and other necessities for survival (Birks and Sherry, 1986).

## 4. PROBABILITY

CBRN attacks in Colorado are extremely rare, but still have a chance of occurring. It is difficult to determine the probability of a CBRN attack due to the human-caused nature of the hazard.

#### **4.1 CHEMICAL ATTACK**

Chemical attacks are rare in practice. While they are theoretically effective, few attempts to use chemical weapons have been made. Most previous attempts have failed (CDOT THIRA).

According to the Colorado Energy Assurance Emergency Plan (CEAEP) a chemical attack has the lowest risk out of all human-caused hazards profiled. This risk assessment takes into consideration geographic extent, future probability, previous occurrences, general impact, and energy sector impact. The CEAEP profiled the following other hazards: cyber-attack, electromagnetic pulse, major transportation disruption, physical attack, nuclear attack, explosive attack, biological attack, and dam failure. Relative to the risk of other hazards, the probability of a chemical attack occurrence is assessed as being low.

While there are many military-grade chemical agents that exist and could be used in an attack, there are many obstacles acting as deterrents to chemical weapon use. Some analysts believe that chemical weapons would be unattractive to use for attack due to the challenge of manufacture or acquisition and risks of discovery, combined with the difficulty of effective deployment and potential for public or law enforcement backlash (CEAEP).

#### **4.2 BIOLOGICAL ATTACK**

Historically, the United States sees a handful of biological attacks or attempted attacks every few years, and the odds that the State of Colorado will see an attack in any given year is low. The presence of several strategically important military response and training facilities make it probable that the state is a greater target than many areas of the United States. However, the state does not include any of the largest metropolitan areas or most visible economic or political flagships in the country, which are the most frequent targets of these types of attacks. Exact probabilities are not possible to determine based on the complex array of natural and human factors.

#### **4.3 RADIOLOGICAL ATTACK**

Because Radiological Attacks are human-caused, there is no way to predict when or where they might happen. There is not sufficient evidence to predict when they may occur.

The James Martin Center for Nonproliferation Studies (CNS), under the Nuclear Threat Initiative (NTI), keeps track of incidents involving radiological materials, as shown in Table 3-261. The United States has a substantially higher rate for incidents, followed by Canada, as compared to other countries. The NTI CNS 2016 Annual Report suggests that this could be due to the fact that both the United States and Canada are two of the six countries that engage in systematic public reporting of individual events.

TABLE 3-261 INCIDENTS INVOLVING RADIOLOGICAL MATERIALS

Countries	Case Number (Each for grouped countries)	Percent of Total
<b>United States</b>	412	60.3%
<b>Canada</b>	54	7.9%
<b>France</b>	41	6.0%
<b>Russia</b>	19	2.8%
<b>Ukraine</b>	15	2.2%
<b>Australia/Belgium/Japan</b>	10 (30 total)	1.5%
<b>Italy/Mexico/United Kingdom</b>	7 (21 total)	1.0%
<b>Georgia</b>	6	0.9%
<b>China/Kazakhstan/Poland</b>	5 (15 total)	0.7%
<b>Brazil/Chile/Moldova/South Korea</b>	4 (16 total)	0.6%
<b>Argentina/Israel/Lebanon/Peru/South Africa/Spain/Vietnam</b>	3 (21 total)	0.4%
<b>Algeria/Colombia/Costa Rica/Finland/India/Iran/Iraq/Lithuania/Macedonia/Slovakia/ Sri Lanka</b>	2 (24 total)	0.3%
<b>Austria/Belarus/Germany/Guatemala/Ireland/Latvia/Malta/ Nepal/Nigeria/Sierra Leone/Turkey</b>	1 (12 total)	0.1%
<b>TOTAL</b>	683	100.0%

Source: NTI CNS Database, 2017

#### 4.4 NUCLEAR ATTACK

The use of nuclear weapons against Colorado is unlikely. The Colorado Energy Assurance Emergency Plan identifies nuclear attack as a high impact, low probability event. However, as long as, nuclear weapons exist, there is always a chance that they could be used.

Nuclear attack by a nation-state is unlikely due to the enacted military doctrine known as Mutual Assured Destruction (MAD). This doctrine reflects the idea that both sides face comparable vulnerabilities. Therefore, it is in all nation's best interest to refrain from nuclear attack (Gaddis, 1982). MAD is dependent upon rational actors, which likely includes Iran and North Korea.

The threat of all-out nuclear war has been significantly reduced with the dissolution of the former Soviet Union. However, there is still the potential for a nuclear attack. Several scenarios still exist that might subject a jurisdiction to widespread radioactive contamination or high-levels of radiation exposure. According to a report to the Senate Select Committee on Intelligence given by Dennis C. Blair in 2009, along with nations that are already known to have nuclear capability, there are five other nations that have declared their nuclear capability and another five that are suspected of having developed nuclear weapon technology. Additionally, 15 nation states have either had weapons or programs to develop nuclear weapons but have reportedly abandoned their efforts (Blair, 2009). Since this report was given, one of the suspected nations, North Korea, has been confirmed as having nuclear technology. As their nuclear capability has advanced, tensions have grown creating more fear of a risk of nuclear attack.

While nations have nuclear capability, or have the potential to develop nuclear capability, most have now signed the Nuclear Nonproliferation Treaty. This is an international treaty that represents the only existing binding commitment in a multilateral treaty to the goal of disarmament by the nuclear-weapon states. Its objective is to prevent the spread of nuclear weapons and weapons technology (United Nations Office for Disarmament Affairs, n.d.).

Nuclear Attacks by terrorist organizations is highly dependent on the ability of the non-state actors to gather the necessary radiological materials and recruit rogue scientists to build a nuclear weapon. While building a nuclear device is an identified goal of organizations such as al-Qaeda and ISIS; the chances of these organizations obtaining a nuclear weapon are small. These organizations are more likely to obtain the resources and capabilities to build a dirty bomb.

Despite nuclear detonation being unlikely due to the existing methods of management, if it were to occur it could be detrimental.

## 5. PREVIOUS OCCURRENCES

CBRN attacks have occurred during wartime, as described below, as well as in more targeted attacks across the world.

**World War I (1915–1918):** Chemical and conventional weapons were used. The first poison gas, chlorine, was used by the Germans against Allied troops in 1915. The effects of the gas were devastating, causing severe choking attacks within seconds of exposure. The British subsequently retaliated with chlorine attacks of their own, although reportedly more British suffered than Germans, because the gas blew back into their own trenches. Phosgene was later used in the war because it caused less severe coughing, resulting in more of the agent being inhaled. Then, in September 1917, mustard gas was used in artillery shells by the Germans against the Russians. Mustard gas caused serious blisters, both internally and externally, several hours after exposure. In all, there were 1,240,853 gas-related casualties and 91,198 deaths from gas exposure during World War I.

Additionally, there were attempts to utilize anti-agricultural and livestock biological agents, including use of anthrax and destructive funguses for wheat harvests. However, none of these agents were widely used, unlike chemical agents which were widely used by both German and Allied troops. The Geneva Protocol of 1925 prohibited the use of chemical weapons and biological weapons, but said nothing about experimentation, production, storage, or transfer; later treaties did cover these aspects.

**World War II (1939–1945):** Atomic (nuclear), chemical, and conventional weapons were used. Use of chemical weapons in World War II was not as prevalent as in World War I and was primarily limited to the Japanese Imperial Army. During the war, the Japanese used various chemical-filled munitions including artillery shells, aerial bombs, grenades, and mortars against

Chinese military forces and civilians. Chemical agents used included phosgene, mustard, lewisite, hydrogen cyanide, and diphenyl cyanarsine.

Twentieth-century advances in microbiology enabled the first pure-culture biological agents to be developed by World War II. Similarly, biological agents such as anthrax, tularemia, brucellosis, and botulism toxins were researched and weapons developed, including schematics for dissemination of the pathogens through aerial-spray attacks or the mail system. Use of these weapons was not widely spread, although there is evidence they were used against both Chinese soldiers and civilians by the Japanese in several campaigns. Research into both types of biological agents and weaponization of those agents continued into the 1950's, including major programs operated by Britain, the United States, and Israel.

In 1945 the war ended abruptly when the United States dropped two atomic bombs on Japan. The first was on Hiroshima. The bomb obliterated the entire city and killed approximately 66,000 people. The second was on Nagasaki, and it destroyed about half the city and killed an estimated 39,000 people.

**Cold War Period (1947-1991):** The Cold War was also significant to the history of nuclear weapons in the United States. The nuclear arms race that existed between the United States and the Soviet Union led to the rapid advancement of nuclear technology. In 1949 the Soviet Union tested its first nuclear bomb, which led to the beginning of the nuclear arms race. In 1952 the United States tested the first hydrogen bomb, which raised the stakes in the race. In 1962 the Cuban Missile Crisis led to a tense stand-off between the United States and the Soviet Union when Soviet missiles were discovered in Cuba. In 1986 leaders of both nations met to discuss the abolition of nuclear weapons, and in 1987 the Intermediate-Range Nuclear Forces Treaty was signed.

**Vietnam War (1964–1973):** Chemical and conventional weapons were used. Chemical weapons used during the Vietnam War are believed to have only involved tear agents used by the United States and possibly psychedelic agents, also by the United States. Although not directly used as warfare agents, toxic herbicides such as Agent Orange were commonly used as defoliants by the United States. Long-term exposure to Agent Orange, which contained the contaminant dioxin, caused illness, major health problems, and disease in humans.

**Iran-Iraq War (1980-1988):** In 1983, Iraq launched its first of 10 documented chemical attacks against Iran. The largest of these attacks was in February 1986, when mustard gas and the nerve agent tabun were used, impacting up to 10,000 Iranians. Although the exact number of chemical attacks implemented by Iraq during the war is unknown, the Iranian government estimates that more than 60,000 soldiers had been exposed to mustard gas and the nerve agents sarin and tabun by the time the war ended in 1988. Based on these data, the Iraqi chemical attacks during the Iran-Iraq war were the largest since World War I.

## 5.1 CHEMICAL ATTACK

Chemical attacks have been used in many isolated incidents in the United States since the 1970s. The Global Terrorism Database reports on these incidents, providing information on more than 150,000 global and domestic terrorism incidents at <https://www.start.umd.edu/gtd/>. Table 3-262 shows brief descriptions of chemical attack incidents that have occurred in the United States between 1974 and 2015 (2015 is the last year for available data).

TABLE 3-262 CHEMICAL ATTACKS IN THE UNITED STATES

Date	City	Perpetrator Group	Fatalities	Injured	Agent	Target Type
6/13/1974	New York City	Unknown	0	0	Unknown	Business
6/13/1974	New York City	Unknown	0	0	Unknown	Business
6/13/1974	New York City	Unknown	0	0	Unknown	Business
6/13/1974	New York City	Unknown	0	0	Acid	Business
1/1/1976	Unknown	Arabs (suspected)	0	0	Nerve Gas	Government (General)
6/9/1976	Hyattsville	White Extremists	0	Unknown	Chemical Mace	Private Citizens and Property
6/10/1977	Seattle	George Jackson Brigade	0	0	Sulfuric Acid, Potassium Chlorate, Gasoline	Business
February 1974	Cincinnati	Anti-Abortion Extremists	0	0	Unknown	Abortion Related
9/2/1986	New York City	Jewish Defense League	0	32	Tear Gas	Business
26/11/1986	New York City	Jewish Defense League	Unknown	Unknown	Unknown	Business
9/19/1988	Los Angeles	Up the IRS, Inc.	0	0	Unknown	Government (General)
3/26/1998	Los Angeles	Unknown	0	0	Cyanide	Government (General)
7/9/1998	Guaynabo	Unknown	0	0	Acid	Telecommunication
3/22/2000	Ogden	Unknown	0	3	Unknown	Government (General)

Date	City	Perpetrator Group	Fatalities	Injured	Agent	Target Type
4/3/2000	Kansas City	Unknown	0	3	Unknown	Government (General)
2/17/2010	Clearwater	Unknown	0	0	Acid	Business
8/12/2012	Lombard	Unknown	0	0	Acid and Other Chemicals	Educational Institution
5/5/2014	Weirton	Anti-Government Extremists	0	0	Cleaning Chemicals	Government (General), Police
10/3/2014	New York City	Unknown	0	1	Pepper Spray	Private Citizens and Property, Journalists and Media
3/20/2015	New Orleans	Unknown	1	2	Molotov Cocktails and Insecticide	Airports and Aircraft

Source: Global Terrorism Database, January 2018

Additionally, there is growing evidence that terrorist groups have been perusing the advancement of chemical weapon technology. There are indications that both Al-Qaeda and ISIS have been using low-grade chemical weapons such as sulfur mustard and sarin gas in Syria and Iraq, and that they are working to advance these weapons. United States allied intelligence officers have identified several sites where they suspect chemical weapons to be held. To date there have been no United States casualties due to chemical attack, but some Iraqi troops have been treated for chemical weapon related injuries. As terrorist groups advance their access to chemical weapon technology, the threat of chemical weapon attack on the United States becomes more significant.

## 5.2 BIOLOGICAL ATTACK

Various forms of biological warfare have been practiced throughout history. Before the 20th century, the use of biological agents took three major forms:

- Deliberate contamination of food and water with poisonous or contagious material
- Use of microbes, biological toxins, animals, or plants (living or dead) in a weapon system
- Use of biologically inoculated fabrics and persons

In the last century, sophisticated bacteriological and virological techniques allowed the production of significant stockpiles of weaponized bio-agents. In addition to using biological weapons during previous wartimes, the following describe previous use of biological attacks.

In 1984, followers of the religious cult of Bhagwan Shree Rajneesh poisoned 10 salad bars in Wasco County, Oregon with salmonella, in hopes of incapacitating enough voters to ensure the success of their associates in upcoming elections. A total of 751 citizens contracted salmonellosis, but no cases were fatal.

Although several isolated attacks involving biological agents have occurred over the last few decades, a series of incidents in the United States gaining nationwide exposure occurred between early October and December 2001, when five people died from anthrax infection, and at least 13 others contracted the disease in Washington, DC, New York City, Trenton, New Jersey, and Boca Raton, Florida. Anthrax spores were found in many government buildings and postal facilities in these and other areas. Most of the confirmed anthrax cases were tied to contaminated letters mailed to media personalities and U.S. senators. Thousands of people were potentially exposed to the spores and took preventive antibiotics. Numerous mail facilities and government buildings were shut down for investigation and decontamination. In the wake of these incidents, federal, state, and local emergency response agencies across the United States responded to thousands of calls to investigate suspicious packages, unknown powders, and other suspected exposures. Fortunately, almost all of these incidents turned out to involve no actual biohazard.

Suspicious of an ongoing Iraqi biological warfare program were not substantiated in the wake of the March 2003 invasion of that country. Later in 2003, however, Muammar Gaddafi was persuaded to terminate Libya's confirmed biological warfare program.

The Global Terrorism Database provides information on more than 150,000 global and domestic terrorism incidents at <https://www.start.umd.edu/gtd/>. The following are brief descriptions of selected biological incidents that have occurred in the United States between 2004 and 2015 (2015 is the last year for available data).

- **February 2, 2004:** In Washington, DC, ricin was discovered in a United States Senator's Office. Fortunately, there were no reports of illness or injury. No group claimed responsibility.
- **March 14, 2005:** Trace amounts of potential anthrax were found at a Department of Defense mail facility in Washington, DC. Workers were given antibiotics as a precautionary measure. No injuries or damages were reported and no group claimed responsibility.
- **October 2009:** At least 40 Islamic militants associated with Al-Qaeda in the land of the Islamic Mahgreb (AQLIM) were reportedly killed by accidental release of pneumonic plague bacteria at a clandestine laboratory in Algeria. Supports assessments that Al-Qaeda affiliates like AQLIM have demonstrated interest and likely are actively pursuing biological weapons development.

- **January 7, 2011:** An envelope addressed to Homeland Security Secretary Janet Napolitano ignited at a postal sorting facility in Washington D.C. The envelope was not opened and therefore did not cause any casualties or property damage. No group claimed responsibility for the attack.

### **5.3 RADIOLOGICAL ATTACK**

There have been no incidents of radiological attacks in the State of Colorado in the past. There have, however, been incidents that have had similar effects to what might have occurred had there been a purposeful attack. The Colorado Department of Transportation THIRA notes one incident in particular where radioactive material was stolen in Goiânia, Brazil. This led to numerous people being exposed to radiation, and several deaths.

*On September 13, 1987, medical equipment was stolen from an abandoned hospital in Goiânia, Brazil. The thieves were seeking metal for salvage and were unaware that they had taken a powerful radioactive source. The protective casing for the equipment's cesium chloride source was cracked open with a hammer and the deadly material dispersed through homes and businesses. The victims, some of whom were children, and none of whom were aware of the danger, handled the radioactive cesium and in some cases painted it on their bodies or ate it.*

*The danger was not recognized for more than two weeks, when doctors identified the radioactive material. When the incident was made public, local medical facilities were then overwhelmed by approximately 130,000 persons seeking medical care. Eventually, 249 victims were found to be contaminated four of whom died. Extensive clean-up work required widespread radioactive monitoring, demolition of a number of buildings, excavation of contaminated soil, and disposal of large amounts of radioactive waste.*

*The Goiânia accident represents nearly a worst case example of radioactive contamination. The material involved was especially dangerous and the danger was undetected for several weeks. Victims had ongoing close contact with the radioactive material, including ingestion. A dirty bomb attack would likely be detected immediately, and a much timelier and more effective response conducted. Despite the seriousness of this incident, there were only four deaths, although cleanup was difficult and expensive. Public fear of radiation led to large numbers of unexposed but concerned persons demanding medical treatment.*

Though there have been no radiological attacks recorded, there have been numerous other criminal uses of radioactive materials. Worldwide, between 2013 and 2016, there were between 329 and 342 unique incidents involving materials that were stolen or otherwise went missing that could plausibly be used as part of a RDD, as shown in Table 3-263. In 2016 alone, there were an estimated 68 incidents involving plausible RDD materials.

TABLE 3-263 INCIDENTS OF STOLEN OR MISSING PLAUSIBLE RDD MATERIALS

Material of Principal RDD Concern	Incidents, 2016 Alone	Incidents, 2013-2016
Cesium-137	39-40	191-194
Americium-241	30-32	154-159
Iridium-192	8	41-42
Radium-226	5-6	32-36
Cobalt-60	2	26
Strontium-90	8	21
Californium-252	0	4
Selenium-238	1	3
Plutonium-238	0	2-4
Plutonium-239	0	0-2
Ytterbium-169	0	1
Thulium-170	0	0
<b>Subtotal</b>	<b>93-97</b>	<b>474-491</b>
<b>Total Unique Cases</b>	<b>68-70</b>	<b>329-342</b>

Source: NTI CNS Database, 2017

#### 5.4 NUCLEAR ATTACK

While no nuclear weapons have been used on the United States, and nuclear threat has decreased since the Cold War, there is still the potential threat of future occurrence.

## 6. IMPACT ANALYSIS

### 6.1 CHEMICAL ATTACK

Impact of a chemical attack depends on the form of chemical used. Chemical weapons and toxins can be used to hinder public health. The impact of a chemical attack relies on factors such as concentration of the chemical, volatility of the chemical, location in which the chemical is released, and how the chemical is dispersed. A dose high enough could injure or kill many people (The National Academies and the U.S. Department of Homeland Security, 2004).

Regular government functionality depends on the situation. Functionality may take a couple of days to repair depending on the nature and target of the attack. Trust in the government would most likely depend on government's capability of responding to an attack. Emergency response would be largely dedicated to cleanup.

#### Direct Effects

Chemical agents are commonly divided into several categories, and depending on the categories the direct effect can vary. The categories include choking, blister, nerve and riot control agents (Organisation for the Prohibition of Chemical Weapons, n.d.). No matter what category an agent falls under, they can be dispersed directly onto a population, producing an immediate effect. Impacts of an attack can be non-persistent (lasting minutes to a couple of

hours) to persistent (lasting several hours to several days). Severity of injuries depends on the type and amount of the agent used and duration of exposure.

#### Indirect Effects

Indirect effects of chemical weapons can be geographically widespread and vary in intensity - depending on weapon size, type of chemical agent, and wind patterns. The main risk involves the migration of these chemicals in the ground and water supply, which can ultimately impact the entire food chain.

### **6.2 BIOLOGICAL ATTACK**

Impacts of biological attack are dependent upon a series of complex factors. The agent selected for use, quality and weaponization, dispersal method, weather, early warning, and health care and emergency management response can all affect the level of impact wrought by a biological attack. A strategic biological attack on Colorado or the United States in which a highly infectious, virulent, and persistent agent with high fatality rates was introduced to a major population via effective dispersal devices, could have devastating and far-reaching consequences. The use of these weapons against the United States is unlikely; the potential for traditional war-related attacks, using conventional weapons, is a scenario that is more likely to occur, based on currently available information, however, even attacks of that variety are rare. Attackers are likely to have either very specific targets, such as women's clinics, or desire large publicity from the attacks.

It is not possible to calculate a specific vulnerability for each county in Colorado. However, because of the desire for publicity following attacks, it is more likely that counties with greater population densities would be the target of attacks. The potential damage that can occur in the event of such an attack is huge, particularly to human health.

The population is vulnerable to two separate categories of impacts associated with biological attacks: direct and indirect.

#### Direct Effects

Biological agents are infectious microbes used to produce illness or death. They can be dispersed as aerosols or airborne particles directly onto a population, producing an immediate effect (a few seconds to a few minutes for chemical agents) or a delayed effect (several hours to several days for biological agents). Severity of injuries depends on the type and amount of the agent used and duration of exposure. Because some biological agents take time to grow and cause disease, an attack using this type of agent may go unnoticed for several days.

A biological attack could also take the form of agroterrorism, directed at causing societal and economic damage through the intentional introduction of a contagious animal disease or fast-spreading plant disease that affects livestock and food crops and disrupts the food supply chain.

Such an attack, would not only require the agriculture industry to destroy livestock and food crops, but also affect consumer confidence in the food supply resulting in tremendous economic

damage for potentially an extended period. The food supply could be severely affected not only for the State of Colorado and surrounding regions, but the national and world market, since the United States exports large quantities of food to other nations. Recently, the federal government recognized the vulnerability of the agricultural/food supply industry and potential debilitation from a terrorist incident, and acted to protect the resources through presidential decision directives (PDDs) and encouraged complementary state and local actions.

#### Indirect Effects

Indirect effects of biological weapons are usually limited to downwind areas. They can be geographically widespread and vary in intensity - depending on weapon size, type of chemical or biological agent, and wind patterns. The spread of these agents can contaminate food and water supplies, destroy livestock, and ravage crops.

Agroterrorism's indirect effects are loss of breeding stock to replenish herds and flocks, loss of seed crops, and possible loss of land use for a long period of time depending on the disease involved. Agroterrorism has a high probability of creating an economic disaster for states highly vested in food production, and potentially the entire nation.

### **6.3 RADIOLOGICAL ATTACK**

Radiological weapons do not create a nuclear explosion, but rather rely on common explosives such as dynamite or gunpowder. The explosion then propels scraps or materials that have been contaminated with radiation into the local vicinity. Most dirty bombs and RDDs have a localized effect. There are several factors that play a part in their overall dispersion:

- Amount and type of material
- Means of dispersal
- Physical and chemical form of material
- Local topography, building placement, and landscape
- Local weather conditions

It is difficult to design an RDD that would deliver radiation doses high enough to cause immediate health effects or fatalities to a large number of people. Homeland Security experts typically agree that the most likely uses of RDDs are two-fold: contaminate facilities or places in order to disrupt life and work, and to cause anxiety in those who think they may have been exposed or may face future attacks.

The induction of fear into a populace is one of the main ideas and goals of terrorism. The dissemination of information through educational programs is one of the best ways to counteract the anxieties that people may feel after an incident. The U.S. DHS has several practical steps that can be taken for those who are near a radiological attack site, or feel that they have otherwise been exposed:

1. Stay away from any obvious plume or dust cloud.

2. Cover their mouth and nose with a tissue, filter, or damp cloth to avoid inhaling or ingesting the radioactive material.
3. Walk inside a building with closed doors and windows as quickly as can be done in an orderly manner and listen for information from emergency responders and authorities.
4. Remove contaminated clothes as soon as possible; place them in a sealed container such as a plastic bag. The clothing could be used later to estimate a person's exposure.
5. Gently wash skin to remove possible contamination; people should make sure that no radioactive material enters the mouth or is transferred to areas of the face where it could be easily moved to the mouth and ingested. For example, don't eat, drink, or smoke.

#### **6.4 NUCLEAR ATTACKS**

A single nuclear weapon detonation could cause widespread destruction, as well as extensive casualties. It could affect the entire population near the impacted area. Some areas would experience direct weapons effects, while other areas would experience indirect weapons effects and impacts from secondary effects as mentioned previously.

Substantial damage could be incurred by state, local, and federal facilities, and the damage to infrastructure would be enormous with lost power, water, sewer, gas, and communications. Homes, businesses, and infrastructure would suffer extensive damage in such an event, and roads and bridges could be destroyed.

The regular functionality and continuity of government would be severely hampered. Emergency response would be largely dedicated to responding to the attack, although the resources for response may be hindered in the attack.

The Colorado Department of Transportation Threat and Hazard Identification and Risk Assessment discusses some threats and hazards that impact Colorado in terms of nuclear attack. Some potential impacts of nuclear attack include widespread infrastructure failures, hazardous material incidents, transportation crashes, energy emergencies, structural fires, oil/gas pipeline failures, wildfire events, dam failures, and flooding. Furthermore, the widespread homelessness that a nuclear attack would cause could have a serious impact upon public health. A nuclear attack would have profound consequences for all of Colorado.

Table 3-264 provides information on the potential impact that a CBRN attack would have on Colorado.

TABLE 3-264 CBRN ATTACK EMAP IMPACT SUMMARY

Consideration	Description
<b>General Public</b>	Adverse impact expected to be severe for unprotected personnel, and moderate to light for trained and protected personnel. A CBRN attack would cause great fear among the general populace, especially in the early days. Public outcry would demand that local, state, and federal politicians do something to ensure this type of event would not happen again. For a nuclear attack, many casualties would occur within the damage zones. The general public would be exposed to radiation and other impacts of fallout.
<b>First Responders</b>	Adverse impact expected to be severe for unprotected personnel, and moderate to light for trained and protected personnel. A nuclear attack would pose extensive risks and challenges. First responders would be exposed to radiation and other impacts of fallout. First responders in the area may also become victims, causing reliance on first responders from other areas, increasing response time to an incident.
<b>Property</b>	Property could be contaminated by the chemical during a biological or chemical attack. Cleanup may be necessary. Property may be neglected or damaged because of secondary economic and social impacts. During a radiological attack, property directly surrounding the blast site would be damaged moderately or severely. It is unlikely that any buildings would be completely destroyed. The cleanup process would be extensive, owing largely to the radioactive contamination. During a nuclear attack, property would be destroyed or altered.
<b>Facilities and Infrastructure</b>	Damage to facilities and infrastructure from a biological or chemical attack is likely to be moderate to light, although cleanup may be necessary. A radiological attack would result in nearby structures damaged by the initial blast. Roads may be cordoned off for several hours or days while cleanup takes place, necessitating rerouting for traffic. A nuclear attack would cause facilities and infrastructure to be destroyed or damaged depending on their location relative to the point of the explosion. The combination of overpressure and wind created by an attack is extremely destructive to structures.
<b>Economic</b>	Local economy and finances adversely affected, possibly for an extended period of time. Secondary impacts resulting from potential anti-personnel impacts include compulsory costs of quarantine, protective equipment, prophylaxis, medical treatment, and decreased staffing capabilities resulting in lost productivity.
<b>Environment</b>	May cause extensive damage, creating denial or delays in the use of some areas. Remediation required. A nuclear attack would cause significant environmental damage. The physical environment and the atmosphere would be altered dramatically. Smoke from fires would darken the sky. Vegetation would not survive.

Consideration	Description
<b>Continuity of Government and Services</b>	Personnel infection in the incident may require lines of succession execution and disarray in procedures. Disruption of communication lines and facilities may extensively postpone services. The regular functionality and continuity of government would be severely hampered from a nuclear attack.
<b>Confidence in Government</b>	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective. For a biological attack, efforts to limit disease spread such as quarantine orders may provoke public anger and panic directed at government. However, a nuclear attack may cause anger towards the attacker, increasing popular support of the government (CDOT THIRA).
<b>Critical Assets</b>	Minimal likely impact to water treatment facilities, government buildings, public safety facilities and equipment, unless contaminated by a chemical. Healthcare services may experience overcrowding, strain, lost resources, and damage in a major event. A nuclear attack would result in critical assets being destroyed or damaged, making response difficult and limited.

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

### 7.1 CHEMICAL ATTACK

The perceived risk and associated concern of terrorism has increased. Events such as the terrorist attacks on the World Trade Center buildings in New York City and the Pentagon in Washington D.C., along with the 2001 anthrax attack, have increased awareness of the United States' vulnerability to future terrorist chemical attacks. Government facilities, public infrastructure, and cities with a high population density are likely targets within jurisdictions in Colorado. The population targeted by a chemical attack would be extremely vulnerable, and there is a possibility for casualties and injuries from a potential attack.

### 7.2 BIOLOGICAL ATTACK

As discussed previously, it is difficult to quantify potential losses in terms of the jurisdictions most threatened by biological attack events due to limited historical data, and the many variables and human elements that come into play. There have been limited historical occasions when biological attacks have been successfully executed in the United States by which to judge. Further, specific amounts of estimated losses for previous occurrences are not available due to the complexity and multiple variables associated with these types of hazards. However, potential losses can be high, primarily in the direct harm to human life, and disruption of critical life lines such as food and water distribution and access, economic outputs, and panic. Secondary effects of this disruption could include public safety hazards, public panic, overruns on public health facilities and resources, and lingering economic and social disorder.

Therefore, for the purposes of this Plan, the loss estimates will be based on a hypothetical scenario. Please note that a hypothetical scenario is included for illustrative purposes as a sample methodology for local jurisdictions to estimate potential losses. Analysis of vulnerable populations is aided by a program developed by Johns Hopkins University in 2006 called Electronic Mass Casualty Assessment and Planning Scenarios (EMCAPS) <http://www.hopkins-cepar.org/EMCAPS/EMCAPS.html> which utilizes scenarios. This scenario also draws from a similar assessment conducted as part of the 2016 Colorado State Preparedness Report (SPR).

### Biological Attack Scenario

The hypothetical attack scenario will all be staged at a baseball game at Coors Field in Denver. The Coors Field Stadium is situated on less than one square mile and has a seating capacity of over 50,000 persons. Surface area and parking structures are located adjacent to the stadium.

Canisters containing aerosolized pneumonic plague bacteria are opened in public bathrooms. The perpetrators are not noticed during the event, and successfully deploy the aerosols and escape unnoticed. Each release location will directly infect 110 people; hence, the number of release locations dictates the initial infected population. The secondary infection rate is used to calculate the total infected population. This particular weapon of mass destruction (WMD) attack method would not cause damages to buildings or other infrastructure, only to human populations.

One week after the sporting event, local area hospitals and clinics notice a significant spike in patients with fever, chills, and exhaustion. Antiviral drugs, which are typically applied for flu and other illnesses with similar symptoms, don't seem to be effective against these cases, and hospitals are struggling to identify this mysterious outbreak. Hospitals outside of Colorado are also noting cases. Case tracking begins at local public health agencies, and it is identified that all those who are ill attended the large sporting event in Denver. Local public health agencies are working in coordination with health care facilities to identify people who attended the sporting event. Plague is treatable, and this strain ultimately proves responsive to available antibiotics. However, facilities are barely able to handle the current influx of patients and must import antibiotics from other areas, stressing nationwide supplies and leading to shortages. By the week following the sporting event, local hospitals have reached capacity.

The epidemiological evidence indicates that there is human-to-human transmission of this disease, and hospitals begin to enforce their applicable protocols related to controlling the spread of the disease including the use of personal protective equipment (PPE). CDPHE and Local Public Health Agencies have put out an alert for people to wash their hands often, cover coughs/sneezes, and stay home if ill. All along the Front Range and in surrounding states doctor visits and hospitalizations continue to rise. Social distancing is the prevention method being recommended by state health officials. Meanwhile, dozens of businesses in and around the state are closed due to lack of healthy staff, resulting in millions of dollars in lost revenue. Colorado requests Strategic National Stockpile (SNS) assets from the Managed Inventory. The Governor's Expert Emergency Epidemic Response Committee (GEEERC) advises controlled

traffic flow measures are being used to protect some areas of the state, which are implemented for seven days. Other states are also activating their department operations centers (DOCs) in preparation for cases they are handling within their borders.

Three weeks after the first cases of the attack, the level of new cases declines and the worst impacts of the attack are over. All told, the plague infects close to 20,000 residents with 1,400 fatalities, most within the Denver metro area, yet thousands dispersed throughout the region and nation. Economic losses in terms of suspended business activity from illness, controlled traffic, and medical expenses reach nearly a billion dollars. This scenario illustrates the types and severity of impact that could result from a single, well-executed terrorist biological attack.

Assumptions: (1) The population density at the stadium on game day is high. (2) The population density of the stadium city is high (5,724 persons/sq mi). (3) The number of dispersion devices is 30. Devices are assumed to be placed in crowded seating areas. (4) Pneumonic plague has a 1-15 percent mortality rate in treated cases and a 40-60 percent mortality rate in untreated cases. (5) The rate of “worried well” is equal to nine times the number of infected cases.

Likely losses from this scenario are described in Table 3-265.

**TABLE 3-265 BIOLOGICAL ATTACK SCENERIO LIKELY LOSSES**

<b>Description</b>	<b>Impacts</b>
<b>Initial Infected Populations</b>	3,300 persons
<b>Secondary Infected Population</b>	16,629 persons
<b>Total Plague Cases</b>	19,929 persons
<b>Total Deaths (Treated Cases 7%)</b>	1,395 persons
<b>Total “Worried Well” Cases (nine times the number of infected cases)</b>	179,361 persons

### **7.3 RADIOLOGICAL ATTACK**

No radiological weapon has ever been used in an actual attack. However, based on U.S. government tests of dirty bomb designs, the health effects of this type of weapon would likely be quite limited. It is difficult to create enough contamination to make victims seriously ill and even more difficult to cause deaths through radiation, except for irradiated shrapnel entering victims. It is likely that more people would be killed by the normal explosives in a dirty bomb than would be seriously hurt by the effects of radiation. However, cleaning up an area once it has been contaminated by radioactive materials would be extremely difficult and expensive. In addition, radioactive threats tend to cause a great deal of fear in the general public. This makes radiological weapons potentially very useful for terrorists: they create little actual destruction, but considerable terror and disruption.

Radiological weapons are considered a serious threat because components for a dirty bomb have legitimate civilian uses and can be stolen by terrorists or criminals. Hospitals, food processing plants, and research centers all possess radioactive materials that would be of use

in making a weapon. There is a proven black market in radioactive materials, particularly involving sources stolen from Eastern European countries. Plans for radiological weapons have been discovered in the hands of several potential terrorists, including U.S. domestic terrorists (CDOT THIRA).

#### **7.4 NUCLEAR ATTACK**

Despite the threat of nuclear attack diminishing over the past several years, the perceived risk and associated concern of the use of weapons of mass destruction has increased. Events such as the terrorist attacks on the World Trade Center buildings in New York City and the Pentagon in Washington D.C. have increased awareness of the United States' vulnerability to future terrorist attacks, including nuclear attacks.

Evidence of perceived risk and associated concern presented itself in the January 13, 2018 false emergency alert sent to cell phones throughout Hawaii stating, "Ballistic missile threat inbound to Hawaii. Seek immediate shelter. This is not a drill." While this alert was accidentally sent, the fear felt by locals was evident. The vulnerability of the population to a nuclear attack if it were to occur is great, so a response of fear and helplessness was warranted (The New York Times, 2018). It is likely that emergency alert systems will be checked nationally, to ensure a false alarm does not happen again.

Likely targeted areas identified in Figure 3-150 are vulnerable, but losses would vary. The F.E. Warren Air Force Base is located within a few miles of Cheyenne, Wyoming, and reaches into northern Colorado and southwest Nebraska. An attack could impact over 60,000 people that live in the region. Peterson Air Force Base, home to NORTHCOM and NORAD, is located directly outside of Colorado Springs, Colorado, which has a significantly larger population where over 460,000 people could be impacted.

#### **7.5 LOCAL HAZARD MITIGATION PLAN ANALYSIS**

Based on a 2017 review of local hazard mitigation plans, 11 counties consider terrorism attacks in their local hazard mitigation plan, four of them deeming it of medium significance, four of low significance, and three with no indicator of significance as indicated below:

- Archuleta County - low significance
- City and County of Broomfield - medium significance
- Eagle County - medium significance
- El Paso County - low significance
- Garfield County - low significance
- Hinsdale County - medium significance
- Montrose County - no significance ranking
- San Miguel County - low significance
- City of Aurora - no significance ranking
- City of Boulder - no significance ranking
- Colorado Springs - medium significance

Specific types of terrorist attacks are rarely broken out in the local hazard mitigation plans. Of these jurisdictions, only Hinsdale County mentions that Lake San Cristobal is vulnerable to a bio-terrorism attack. Additionally, The City of Colorado Springs, the City of Boulder, San Miguel County, and Hinsdale County have hazard profiles that mention radiological terrorism within their mitigation plans, however, there are no specific mitigation actions relating to radiological attacks. Several jurisdictions do identify potentially vulnerable infrastructure to terrorism attacks, such as ski resorts, agricultural premises, dams, or military facilities. Additionally, environmental motives for terrorist attacks have been profiled as a top concern in Archuleta, Eagle, and Garfield Counties, as well as the Northwest Regional THIRA due to conflict over unaltered environment and proposed developments.

It should be noted that 26 additional jurisdictions evaluated pandemic disease, with four jurisdictions, Broomfield, Eagle, and Pueblo Counties, as well as the University at Colorado in Boulder, ranking it among the their top four most significant hazards. Risk from pandemic disease is related to overall risk from biological attacks.

## 8. FUTURE DEVELOPMENT

Unfortunately, areas of dense population and large public venues may make attractive targets for CBRN attacks. As parts of the state become more densely populated, greater numbers of large public events are held, and more potential may exist for these venues to become targets of an attack. One of the current trends in development for large cities is a revitalization of downtown and core urban areas. This leads to more people living closer to civic buildings and public locations that would be more likely to be the targets of an attack. It is expected that this trend will continue and more people will choose to live in urban settings as time progresses. However, human-caused hazards can have multiple variables involved, and increases in development is not necessarily always a factor in determining risk.

## 9. CLIMATE CHANGE

As CBRN attacks are a human-caused hazard, they are not directly subject to climate change. However, as time passes, relationships between countries across the globe may evolve from adversarial conditions to friendship and back; these relationships can be strained by a variety of factors, including energy shortages, water availability, and changing weather patterns. Climate change is likely to aggravate many of these factors, increasing volatility of relations on the national stage, and in turn increasing the risk of attacks on the state and nation. Additionally, climate change and changes in weather and micro-climate can affect the magnitude and strength of chemical agents dispersed in an open-air environment. The area affected depends on numerous factors including the type and amount of chemical agent, means of dispersal, local topography, and local weather conditions. The behavior of a chemical agent depends on variables such as wind, temperature, air stability, humidity and precipitation (Departments of the

Army, the Air Force, and the Marine Corps, 1986). As variables in climate become more extreme, the impacts of a chemical attack become less predictable.

## **10. RISK TO STATE ASSETS**

All state assets should be considered at risk to a potential CBRN attack. State-owned buildings are generally regarded as high-profile targets for terrorism. The risk of an attack being targeted at a state asset may be high due to the value associated with the asset.

### **10.1 CHEMICAL ATTACK**

High trafficked assets may be targeted by an attack, such as mail sorting facilities or public institutions.

### **10.2 BIOLOGICAL ATTACK**

Biological agents cannot damage infrastructure and facilities directly, but a major biological attack can have catastrophic anti-personnel or anti-livestock impacts with secondary impacts as a result. Potential anti-personnel impacts include compulsory costs of quarantine, protective equipment, prophylaxis, medical treatment, and decreased staffing capabilities resulting in lost productivity. High persistence agents may result in potential staffing issues, staff treatment costs, lost productivity, and in less likely cases, compulsory decontamination of impacted facilities, thus in turn causing general operations, maintenance, and repair of facilities to be delayed. Medical and healthcare facilities would likely experience very high volumes of traffic and activity, and require intensive usage of resources in a short period of time. The mix of volume and intensity could cause strain of these facilities, especially technologies, equipment, and supplies.

Hostile actors are most likely to take initiative in deliberately targeting military and political assets. Such a specific target, major enough to cause secondary impacts on facilities, would necessitate a highly sophisticated biological attack. Therefore, general impacts to the public or other personnel-intensive, government services, and health-care facilities are still most at risk.

### **10.3 RADIOLOGICAL ATTACK**

Radiological attacks are not likely to severely damage the infrastructure around them, as they tend to use lower-grade explosives. Hospitals would likely experience a short-term increase in traffic as they deal with the immediate aftermath. Some patients would have to be monitored for several days in order to ensure that they are not experiencing any effects from radiation poisoning. If so, they will need to be treated.

### **10.4 NUCLEAR ATTACK**

If a nuclear attack were to occur, the assets within the vicinity of the attack would be extremely vulnerable to destruction or damage. Federal assets in Colorado, including many military installations, are also at significant risk, therefore also making the state assets within their vicinity more vulnerable to risk.

Nuclear attacks cause the greatest damage to structures within close vicinity to the detonation of the bomb. According to the Homeland Security Council Interagency Policy Coordination Subcommittee for Preparedness and Response to Radiological and Nuclear Threats (2009), physical destruction of structures following a nuclear explosion at different overpressures is described as follows:

1. Buildings sustain minor damage — damage corresponds to overpressures in the range of approximately 0.15 to about 2 psi
2. Most buildings are moderately damaged — damage corresponds to overpressures between 2 and 5 psi
3. Buildings are badly damaged or destroyed — damage corresponds to overpressures around 5 to 8 psi
4. Only heavily reinforced buildings remain standing, but are significantly damaged and all other buildings are completely destroyed — damage corresponds to 10 psi or greater

Structural damage also depends on a structure's vicinity to the nuclear attack. As Figure 1-2 illustrates, there are variations in impacts between the light damage zone, the moderate damage zone, and the no-go zone. To protect state and federal assets in Colorado, the Colorado Hazard and Incident Response and Recovery Plan (CHIRRP) identifies targeted actions for addressing this risk. The main strategy identified is to use detection technologies and screening processes to interdict before an attack. It is proposed that the design and deployment of the Global Nuclear Detection Architecture and other similar programs should happen at a national level.

Nested under the state's Division of Homeland Security & Emergency Management (DHSEM) is the Colorado Preventative Radiological/Nuclear Detection (PRND) Program, established in March 2014. The mission of the PRND Program is to protect state residents, visitors, the economy, critical infrastructure, and natural resources against threats posed by the unauthorized use of radiological or nuclear materials.

The PRND Program allows for a state-level reporting mechanism of radiological data. There is broad participation across the state's many law-enforcement, fire, and emergency management agencies in the program.

## 11. RESOURCES

- Birks, John. & Stephens, Sherry. 1986. Possible Toxic Environments Following a Nuclear War. National Academy Press. <https://www.nap.edu/read/940/chapter/10>. Accessed January 2018.

- Blair, Dennis, Director of National Intelligence. February 12, 2009. Annual Threat Assessment of the Intelligence Community for the Senate Select Committee on Intelligence. Link to Book. Accessed January 2018.
- Center for Disease Control and Prevention (CDC). 2018. Public Health Response to a Nuclear Detonation.
- Colorado Department of Public Health and Environment (CDPHE)
- Colorado Department of Transportation (CDOT) Threat and Hazard Identification and Risk Assessment (THRIA), 2017
- Colorado Division of Homeland Security & Emergency Management (DHSEM) Hazard and Incident Response and Recovery Plan (CHIRRP), 2016
- Colorado Division of Homeland Security & Emergency Management (DHSEM) Threat and Hazard Identification and Risk Assessment (THIRA)
- Colorado Energy Assurance Emergency Plan (CEAEP), 2016
- Departments of the Army, the Air Force, and the Marine Corps. November 3, 1986. Field Behavior of NBC Agents. <https://fas.org/irp/doddir/army/fm3-6.pdf>.
- Ehley, Brianna. January 5, 2018. CDC Briefing to Focus on Preparing for Nuclear War. <https://www.politico.com/story/2018/01/04/nuclear-war-cdc-briefing-266633>. Accessed January 2018.
- FEMA. Fact Sheet: Chemical Attacks. [https://www.fema.gov/media-library-data/20130726-1621-20490-6631/chemicalfactsheet\\_final.pdf](https://www.fema.gov/media-library-data/20130726-1621-20490-6631/chemicalfactsheet_final.pdf). Accessed January 2018.
- Gaddis, John Lewis. 1982. Strategies of Containment: A Critical Appraisal of Postwar American National Security Policy. <https://www.amazon.com/exec/obidos/ASIN/0195030974/nuclearfilesonli>. Accessed January 2018.
- Global Terrorism Database; <http://www.start.umd.edu/gtd/search/>. Accessed January 2018.
- Governor's Expert Emergency Epidemic Response Committee (GEEERC)
- Homeland Security Council Interagency Policy Coordination Subcommittee for Preparedness and Response to Radiological and Nuclear Threats. January 16, 2009. Planning Guidance for Response to a Nuclear Detonation. <https://info.publicintelligence.net/NukePlanning.pdf>. Accessed January 2018.
- Lawrence Livermore National Laboratory, 2018; <https://narac.llnl.gov/research-and-development/radiological-dispersion-device-modeling>. Accessed January 2018.
- National Atmospheric Release Advisory Center (NARAC); <https://narac.llnl.gov>. Accessed January 2018.
- Nuclear Threat Initiative (NTI); [http://www.nti.org/media/documents/global\\_incidents\\_and\\_trafficking\\_2016.pdf](http://www.nti.org/media/documents/global_incidents_and_trafficking_2016.pdf). Accessed January 2018.

- Organisation for the Prohibition of Chemical Weapons. (n.d). Types of Chemical Agent. <https://www.opcw.org/about-chemical-weapons/types-of-chemical-agent/>. Accessed February 2018.
- Preventative Radiological and Nuclear Detection (PRND) Program Strategy; <https://www.colorado.gov/pacific/dhsem/atom/60536>. Accessed January 2018.
- State of Colorado Preventative Radiological and Nuclear Detection Program Strategy
- The National Academies and the U.S. Department of Homeland Security. Chemical Attack: Warfare Agents, Industrial Chemicals and Toxins; [https://www.dhs.gov/sites/default/files/publications/prep\\_chemical\\_fact\\_sheet.pdf](https://www.dhs.gov/sites/default/files/publications/prep_chemical_fact_sheet.pdf). Accessed January 2018.
- The New York Times. January 13, 2018. Hawaii Panics After Alert About Incoming Missile is Sent in Error. <https://www.nytimes.com/2018/01/13/us/hawaii-missile.html>. Accessed January 2018.
- U.S. Centers for Disease Control and Prevention (CDC)
- U.S. Department of Agriculture (USDA)
- U.S. Department of Homeland Security (U.S. DHS) Radiological Attack Spreadsheet, 2003
- U.S. Northern Command. (n.d.). About USNORTHCOM. <http://www.northcom.mil/About-USNORTHCOM/>. Accessed February 2018.
- United Nations Office for Disarmament Affairs (UNODA). (n.d). Treaty on the Non - Proliferation of Nuclear Weapons (NPT). <https://www.un.org/disarmament/wmd/nuclear/npt/>. Accessed January 2018.

# CYBER ATTACK



## 1. DEFINITION

A cyber-attack is deliberate exploitation of computer systems, technology-dependent enterprises, and networks. Cyber-attacks use malicious code to alter computer operations or data. The vulnerability of computer systems to attacks is a growing concern as people and institutions become more dependent upon networked technologies. The Federal Bureau of Investigation's (FBI) Cyber Division (n.d.) states that "cyber intrusions are becoming more commonplace, more dangerous, and more sophisticated," with implications for private- and public-sector networks.

The 2016 Colorado Hazard and Incident Response and Recovery Plan (CHIRRP) describes cyber-attacks as follows: "State of Colorado characterizes information system security or cyber incidents as any event violating State of Colorado security policy, standards, procedures, guidelines, processes or security best practice that may be detected as unexplained network or system behavior resulting in the loss of sensitive data or any instance where State of Colorado's reputation might suffer." This may include unauthorized disclosures of information, increased access to informational assets, corruption of information, denial of service, and theft of state information technology or telecommunications assets, services, or resources.

According to the CHIRRP, "A significant cyber incident may take many forms: an organized cyber - attack, an uncontrolled exploit such as a virus or worm, a natural disaster with significant cyber consequences, or other incidents capable of causing extensive damage to critical infrastructure or key IT assets." In general, cyber disruptions are classified as either intentional or unintentional. Unintentional disruptions are more common and occur when a portion of a system fails, whether as a result of coding mistakes, physical failure of hardware, or even solar storm activity. Intentional disruptions are typically the result of a directed attack with malicious intent. Intentional disruptions are the most worrisome to governments as they pose the potential to cause irreparable harm to the function and capability of critical systems or supporting systems that are used in daily operations. Accordingly, this section will focus on intentional attacks.

There are many types of cyber-attacks. Among the most common is a direct denial of service, or DDoS attack. This is when a server or website will be queried or pinged rapidly with information requests, overloading the system and causing it to crash.

Malware, or malicious software, can cause numerous problems once on a computer or network, from taking control of users' machines to discreetly sending out confidential information. Ransomware is a specific type of malware that blocks access to digital files and demands a payment to release them. The FBI states that hospitals, school districts, state and local governments, law enforcement agencies, and small and large businesses are among the entities affected by ransomware.

Cyber spying or espionage is the act of illicitly obtaining intellectual property, government secrets, or other confidential digital information, and often is associated with attacks carried out by professional agents working on behalf of a foreign government or corporation. According to cybersecurity firm Symantec’s latest Internet Security Threat Report, in 2016 “...the world of cyber espionage experienced a notable shift towards more overt activity, designed to destabilize and disrupt targeted organizations and countries.”

Major data breaches - when hackers gain access to large amounts of personal, sensitive, or confidential information - have become increasingly common. The Symantec report says more than seven billion identities have been exposed in data breaches over the last eight years. In addition to networked systems, data breaches can occur due to the mishandling of external drives, as has been the case with losses of some state employee data.

The most severe type of attack is cyber terrorism, which aims to disrupt or damage systems in order to cause fear, injury, and loss to advance a political agenda. Table 3-266 describes the hazard profile summary for cyber-attacks.

**TABLE 3-266 HAZARD PROFILE SUMMARY**

<b>Consideration</b>	<b>Impact</b>	<b>Description</b>
<b>Location</b>	Statewide	Cyber-attacks are not bounded by any geographical feature and can target any networked computer or system. A single incident may involve multiple geographic areas.
<b>Previous Occurrence</b>	Sporadic	There is no pattern for when cyber-attacks may occur. Incidents may happen at any time with little warning.
<b>Probability</b>	Expected	Multiple data breaches targeting Colorado businesses, organizations, and institutions are reported every year. Attacks are becoming more common, and the threat is expected to continue to increase.
<b>Extent</b>	Moderate (Variable)	Depends on the nature of the disruption, ranging from actions targeting a single user to data breaches affecting billions of customers worldwide. Attacks may target critical services.

## 2. LOCATION

Cyber disruption events can occur and/or impact virtually any location in the state where computing devices are used. The CHIRRP notes that incidents may involve a single location or multiple geographic areas. A disruption can have far-reaching effects beyond the location of the targeted system; disruptions that occur outside Colorado may impact people, businesses, and institutions within the state.

The Privacy Rights Clearinghouse, a nonprofit organization based in San Diego, maintains a timeline of data breaches reported in the United States since 2005. Among hacking incidents

with a specific location provided, nine targeted systems in Denver. This was the most of any city in Colorado and also represented the largest total number of records exposed. It was followed by the City of Boulder with six breaches.

### **3. EXTENT (MAGNITUDE/STRENGTH)**

The extent or magnitude/severity of a cyber disruption event is variable depending on the nature of the event. A disruption affecting a small, isolated system could impact only a few functions/processes. Disruptions of large, integrated systems could impact many functions/processes, as well as many individuals that rely on those systems.

There is no universally accepted scale to explain the severity of cyber-attacks. The strength of a DDoS attack is sometimes explained in terms of a data transmission rate. One of the largest DDoS disruptions ever, which brought down some of the internet's most popular sites on October 21, 2016, peaked at 1.2 terabytes per second.

Data breaches are often described in terms of the number of records or identities exposed. The largest data breach ever reported occurred in August 2013, when hackers gained access to all three billion Yahoo accounts. The hacking incidents associated with Colorado in the Privacy Rights Clearinghouse database are of a smaller scale, ranging from just 32 records to approximately 60,000, along with several cases in which an indeterminate number of records may have been stolen. While each of these breaches involved networked systems in Colorado, it is important to note that not all the affected records pertained to Colorado residents. For example, the breach affecting 60,000 records targeted a Denver-based company, but the incident involved credit card readers at 10 locations across the United States, none of which were in Colorado. Conversely, some of the largest international data breaches have likely affected more than 60,000 Colorado residents.

### **4. PROBABILITY**

The possibility of an intentional disruption affecting the state exists at all times, but it is difficult to quantify the exact probability due to such highly variable factors as the type of attack and intent of the attacker.

Symantec reports there were a total of 1,209 data breaches worldwide in 2016, 15 of which involved the theft of more than 10 million identities. While the number of breaches has remained relatively steady, the average number of identities stolen has increased to almost one million per incident. The report also found that one in every 131 emails contains malware, and the company's software blocked an average of 229,000 web attacks every day. Since 2005, Colorado companies and agencies reported an average of more than three data breaches per year, according to Privacy Rights Clearinghouse's records. Recent cyber-attack trends seem to indicate that these types of events will continue to increase in the coming years.

The 2016 Colorado Energy Assurance Emergency Plan (CEAEP) states, “While less sophisticated incidents of cybercrime and casual hacking are extremely frequent, sophisticated cyber-attacks capable of seriously disrupting critical infrastructure and services have been comparatively rare and could be considered a High Impact/Low Probability (HILP) event.”

## 5. PREVIOUS OCCURENCES

Privacy Rights Clearinghouse’s records contain 41 hacking events from 2005 to 2017 with the State of Colorado or a Colorado city listed as the primary location. A total of more than 334,000 records were affected in these breaches, although the number of records remains undetermined for 14 incidents. Table 3-267 lists the 10 largest of these events based on the number of records impacted. They include multiple thefts of personal information for staff and current, former, and prospective students in the University of Colorado system, incidents targeting Colorado-based companies that process credit cards, and email and network breaches of health care providers.

**TABLE 3-267 LARGEST DATA BREACHES TARGETING COLORADO ENTITIES, 2005-2017**

Date Reported	Target	Total Records	Description
<b>July 21, 2005</b>	University of Colorado, Boulder	49,000	Prospective students, current students, staff, faculty, and University health care service recipients may have had their data exposed in a campus server breach. The information included names, Social Security numbers, addresses, student ID numbers, birth dates, and lab test information.
<b>August 2, 2005</b>	University of Colorado, Denver	36,000	Hackers accessed files containing names, photographs, Social Security numbers, and University meal card information of current and former students and staff members.
<b>August 19, 2005</b>	University of Colorado, Denver	49,000	A hacker may have gained access to personal information, including current and former student names, Social Security numbers, addresses, and phone numbers.
<b>December 15, 2006</b>	University of Colorado, Boulder	17,500	A server in the Academic Advising Center was subject to a hacking attack. Personal information exposed included names and Social Security numbers for individuals who attended orientation sessions.
<b>May 22, 2007</b>	University of Colorado, Boulder	45,000	A hacker launched a worm that attacked a University computer server used by the College of Arts and Sciences. Information exposed included Social Security numbers of enrolled students.
<b>July 17, 2007</b>	Western Union, Greenwood Village	20,000	Credit card information, names, addresses, and phone numbers were hacked from a database.
<b>April 22, 2014</b>	Centura Health, Englewood	12,286	Hackers gained access to emails containing patient information through a sophisticated phishing scam.

Date Reported	Target	Total Records	Description
<b>October 13, 2015</b>	Service Systems Associates Inc., Denver	60,000	Point-of-sale software contained malware that compromised payment card information of individuals who visited zoo gift shops operated by the company, including locations in Texas, Michigan, California, Hawaii, Florida, and Pennsylvania.
<b>June 17, 2016</b>	Allergy, Asthma & Immunology of the Rockies, Glenwood Springs	6,851	Evidence of ransomware discovered on clinic computer system containing patient records.
<b>July 3, 2017</b>	PVHS-ICM Employee Health and Wellness, Fort Collins	10,143	Evidence of ransomware discovered on clinic computer system containing patient records.

Source: Privacy Rights Clearinghouse, 2018

Recent, massive data breaches with a national or international scope also have affected Colorado residents. The theft of consumer data from the credit-reporting agency Equifax in 2017 affected most Americans who have a credit report. A 2015 breach of 37.5 million medical records from Anthem Inc. directly affected businesses and institutions that offered health insurance through the company, including the University of Colorado and Colorado State University systems. Personal information of more than 50,000 federal employees in Colorado, as well as contractors, may have been stolen in a 2015 attack on the U.S. Office of Personnel Management.

The 2016 U.S. presidential election saw several examples of new forms of high-profile, targeted, subversive attacks intended to influence politics and sow discord. In one instance, Russian-affiliated hackers targeted the election systems of 21 states, including Colorado. The U.S. Department of Homeland Security notified the state in September 2017 of activity in the weeks leading up to the 2016 election. The Colorado Secretary of State's Office announced that the state's election systems had been scanned for weaknesses, but there is no evidence that the system was breached or that any voter information was compromised.

Additionally, in February 2018, the Colorado Department of Transportation (CDOT) server was breached. The following narrative describes the incident.

Between February 21st and the 23rd, malware began encrypting CDOT workstations and servers. This was a ransomware attack which denied user access to their e-mail, electronic files, data, and computer applications. This attack impacted approximately 3,800 laptops (~50% infected), 200 desktops, 354 servers (~40% infected), and a host of other electronic devices and applications. Each device needed to be individually assessed and have multiple security patches applied.

Upon the completion of an initial situational assessment, the CDOT Executive Director activated a Departmental Incident Management Team on February 26th, with the sole

responsibility of being the central entity to direct all internal activities related the ransomware virus incident. This included: the reassignment of departmental resources (as needed); establish prioritized lists of actions to be taken; coordination with the Office of Information Technology (OIT) on technical measures to confine and eradicate the virus as well as restore the network; and provide a public information message for staff, vendors, the media and the public. There were no previous incidents (nationwide) to draw upon to assist in identifying our actions to respond to or recover from an event of this scale or scope.

On February 28th, the CDOT network had been assessed as clean and authorization was given for non-infected workstations to be brought back on-line following a second assessment and remediation. By March 1st, new infections had been detected along with unexplained activity on the network. All recovery efforts were halted and additional computer security resources were requested. The entire network was shut down, which included commercial vendors as well as the Colorado National Guard Cyber Team and other federal assets. The Recovery process restarted on March 7th.

While the technological side of the incident was being resolved, the prioritization of business functions continued. The first priority was to enable the appropriate software package(s) to process invoices and payments. Then, a move onto the other 55 computer applications that the department utilizes on a daily basis. By March 11th, small portions of the network were turned on to staff.

On March 19th, the formal recovery phase began with the goal of reconstituting the entire network.

## 6. IMPACT ANALYSIS

The impact of a cyber-attack can vary from insignificant to highly destructive. The intent of a disruptor could range from something as minor as leaving a message to a major issue with sensitive data collection or control of a critical facility.

Though a cyber disruption can have limited impacts within a system's own operations, it also can have extended cascading affects throughout multiple systems. The system that is disrupted and the source of the disruption are major factors in the impact.

The 2016 CHIRRP states: "Large-scale cyber incidents may overwhelm government and private-sector resources by disrupting the Internet and/or taxing critical infrastructure IT systems. Complications from disruptions of this magnitude may threaten lives, property, the economy, the state's ability to deliver critical services, and national security."

Cyber-attacks can have a significant cumulative economic impact. Symantec reports that in the last three years, businesses have lost \$3 billion due to spear-phishing email scams alone. A major cyber-attack has the potential to undermine public confidence and build doubt in their

government’s ability to protect them from harm. Table 3-268 includes an overall summary of the impacts of cyber-attacks.

**TABLE 3-268 CYBER ATTACK EMAP IMPACT SUMMARY**

<b>Consideration</b>	<b>Description</b>
<b>General Public</b>	A cyber-attack could disable the vast majority of systems which control critical infrastructure, traffic control systems, and basic activities. It could also impact personal data and accounts.
<b>First Responders</b>	Cyber-attacks have the potential to interfere with emergency-response communication and activities. Many agencies rely on technology to notify and route responders to the scene of the incident.
<b>Property</b>	While some attacks affect only data, physical damage to hardware is possible. Sabotage of utilities and infrastructure could result in system failures that damage property on a scale equal with natural disasters.
<b>Facilities and Infrastructure</b>	Facilities and infrastructure may become unusable as a result of a cyber-attack.
<b>Economic</b>	Could greatly affect the economy. In an electronic-based commerce society, any disruption to daily activities can have disastrous impacts to the economy. It is difficult to measure the true extent of the impact.
<b>Environment</b>	Could impact the environment if a release of a hazardous material was triggered. Accidents involving hazardous materials can also occur due to disruption of traffic-control devices.
<b>Continuity of Government and Services</b>	Agencies that rely on electronic backup of critical files are vulnerable. The delivery of services can be impacted since governments rely, to a great extent, upon electronic delivery of services.
<b>Confidence in Government</b>	The government’s inability to protect confidential personal data would impact confidence in the state. An attack would raise questions regarding the security of using electronic systems for government services.
<b>Critical Assets</b>	A cyber-attack may target utility systems and critical infrastructure.

## 7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION

All areas of the state are considered prone to this hazard. Vulnerability and potential losses depend on many factors, including what critical facilities and business interests exist within the jurisdiction and how robust their cybersecurity protections are.

Based on a 2017 review of local hazard mitigation plans, 11 counties consider terrorism attacks in their local hazard mitigation plan, four of them deeming it of medium significance, four of low significance, and three with no indicator of significance as indicated below:

- Archuleta County - low significance
- City and County of Broomfield - medium significance
- Eagle County - medium significance
- El Paso County - low significance
- Garfield County - low significance
- Hinsdale County - medium significance
- Montrose County - no significance ranking
- San Miguel County - low significance
- City of Aurora - no significance ranking
- City of Boulder - no significance ranking
- Colorado Springs - medium significance

Of these jurisdictions, none profile cyber-attacks separately from other terrorism hazards, however regional THIRAs profile the significance of a cyber-attack to counties and services in their regions. The Northeast, Northwest, South Central, and West Regional THIRAs all profile cyber-attacks separate from other types of terrorist attacks and recognize several sectors that could be negatively impacted by a cyber-attack, such as SCADA systems, traffic systems, power grids, air traffic control, and banking.

## **8. FUTURE DEVELOPMENT**

As infrastructure and facilities are upgraded while new development occurs, planners will need to keep in mind the potential for disruption to essential services due to cyber-attacks.

## **9. CLIMATE CHANGE**

Cyber-attacks are considered a human-caused/technological hazard and are not impacted by changes in weather patterns or climate.

## **10. RISK TO STATE ASSETS**

State agencies depend on properly functioning electronic communication, data transmission, and data storage to fulfill their functions. Virtually all government utilities, critical infrastructure, and facilities are networked to allow remote access and monitoring, allowing for greater efficiency, coordinated operations, and cost savings; however, this creates the possibility that systems such as power plants, water supply systems, and fuel lines could be targeted in a cyber-attack. As the 2016 CHIRRP notes, “Damage to these systems could create great hardship and civil unrest.” The 2017 Colorado Department of Transportation (CDOT) Threat and

Hazard Identification and Risk Assessment (THIRA) likewise states, “A cyber-attack could disable the vast majority of systems which control critical infrastructure, traffic control systems, and basic activities.”

A worst-case scenario would involve hackers remotely gaining control of utilities or infrastructure. Such an event would have wide-ranging impacts. Attackers are likely to have either very specific targets, or desire wide-spread publicity that would lead toward the targeting of popular, iconic, or critical systems.

Of particular concern would be a coordinated strike on such energy infrastructure as a smart grid system, substation controller, supervisory control and data acquisition (SCADA) system, or intelligent electronic device (IED). The CEAEP outlines what an intruder could do once they had gained access to one of these systems:

- Shut down the SCADA system, either immediately or in a delayed manner
- Steal or alter metering and management data gathered by the SCADA system
- Shut down a substation, or any portion of a subsystem controlled by the compromised IED, either immediately or in a delayed manner
- Change protection device settings to degrade reliability of the IED and, subsequently, the electric service provided by the substation
- Gather control and protection information that could be used in a subsequent attack
- Change or perturb the data in such a manner as to trigger an inappropriate action by an IED
- Plant malicious code that could later trigger a delayed or coordinated attack
- Use the SCADA system as a backdoor into the corporate IT system to obtain customer credit and personal identity information used in electronic theft
- Pipelines, generating facilities, substations and transformers, and other major components can be severely damaged or destroyed, with secondary impacts distributed across respective networks.

Losing direct control of any type of utility could have far-reaching impacts to the safety of the public as well as the functionality of any related systems. This domino effect could negatively influence the daily life activities of the public and could take government services completely offline. Public safety could be put at risk; for example, if an electric utility is the target, individuals that rely on power for health-related treatments could be at risk. Prolonged outages would result in loss of automated traffic control and other power-dependent safety measures. Other utility outages, such as loss of communications, would cause additional cascading impacts.

Due to the variables involved, it is not possible to generate quantitative loss estimates for cyber disruption incidents. A utility outage as described above could produce the same impacts as a worst-case natural hazard. The magnitude of losses for this event could reach upwards of millions to billions of dollars. Large scale injuries or deaths could be expected to occur.

This is a newly developing threat, so as more resources are devoted to countering the hazard, the risk of a disruption would hopefully decrease. Mitigation opportunities for this hazard include continued diligence of the state's Office of Information Technology (OIT), as well as for other government and private sector entities to continue to monitor, block, and report cyber-attacks, and continually assess the vulnerability of systems.

## 11. RESOURCES

- Colorado Department of Transportation (CDOT) Threat and Hazard Identification and Risk Assessment (THIRA)
- Colorado Energy Assurance Emergency Plan (CEAEP)
- Colorado Hazard and Incident Response and Recovery Plan (CHIRRP)
- Federal Bureau of Investigation (FBI) Cyber Division
- Internet Security Threat Report
- Privacy Rights Clearinghouse Chronology of Data Breaches

# EXPLOSIVE ATTACK



## 1. DEFINITION

Explosive Attack can be defined as an attack in which a bomb and or destructive device is used to destroy, incapacitate, harass, or distract. These devices are used by criminals, vandals, terrorists, suicide bombers, and insurgents. Explosive devices used in an explosive attack can come in many forms ranging from a pipe bomb to a sophisticated device capable of causing massive damage and loss of life (The National Academies and the U.S. Department of Homeland Security).

A terrorist attack on the United States remains a significant threat, and explosive devices are the most commonly used weapon by terrorists due to their accessibility and destructive capacity (Colorado Division of Homeland Security & Emergency Management (DHSEM)). Explosive device attacks are the most prevalent in United States history, making up more than half of all U.S. terrorist attacks (National Consortium for the Study and Responses to Terrorism).

“Colorado is at risk for terrorism (domestic and international) and national security incidents including small scale explosives or large improvised explosives” (CHIRRP). The accessibility, as well as the frequency of explosive attack, makes this a hazard of concern in Colorado.

Table 3-269 describes the hazard profile summary for explosive attack.

TABLE 3-269 HAZARD PROFILE SUMMARY

Consideration	Impact	Description
<b>Location</b>	Local	An attack is typically targeted at a specific place or group.
<b>Previous Occurrence</b>	Sporadic	There have been periodic explosive attacks in Colorado. Many documented explosive attacks occurred in the 1970s. Occurrences have decreased in recent decades.
<b>Probability</b>	Likely	Accessibility to explosives makes an attack likely.
<b>Extent</b>	Moderate (Varies)	Damage is local. However, the type of explosive device and the means by which it reaches its target has broad implications for the extent of damage it can cause to its target.

## 2. LOCATION

An explosive attack is typically a pre-meditated, targeted attack on a specific place or group. The location targeted by an attack depends on the motive of the attacker.

Attacks have often been targeted at buildings in urban environments. There are several reasons why buildings in densely populated areas are attractive targets. One reason is that urban buildings tend to be tall structures with high concentrations of occupants, allowing for high

impact from a single targeted strike. Another reason is that they tend to be valuable assets, and an attack can cause extensive property loss (New York City Police Department).

Any infrastructure that is important to the function of society could be a target of an attack. This includes critical infrastructure, transportation systems, bridges, and more.

Attacks may also be targeted at places that represent specific groups. This could include religious institutions, organizations that represent specific views or values, etc.

### 3. EXTENT (MAGNITUDE/STRENGTH)

The extent of damage caused by an explosive attack depends on many factors including the size, construction, composition, application, and placement of the explosive (CEAEP, 2016). Figure 3-155 predicts the damage of different explosives based on size and construction of the explosive.

FIGURE 3-155 CAPACITY OF DIFFERENT EXPLOSIVES

Threat	Threat Description	Explosive Capacity	Building Evacuation Distance	Outdoor Evacuation Distance
	Small Package/letter	1 lb	40 ft	900 ft
	Pipe Bomb	5 lb	70 ft	1,200 ft
	FedEx Package	10 lb	90 ft	1,080 ft
	Vest/Container Bombs	20 lb	110 ft	1,700 ft
	Parcel Package	50 lb	150 ft	1,850 ft
	Compact Car	500 lb	320 ft	1,900 ft
	Full Size Car/Minivan	1,000 lb	400 ft	2,400 ft
	Van/SUV/Pickup Truck	4,000 lb	640 ft	3,800 ft
	Delivery Truck	10,000 lb	860 ft	5,100 ft

Source: U.S. Technical Support Working Group, the National Academies and the U.S. Department of Homeland Security, 2003

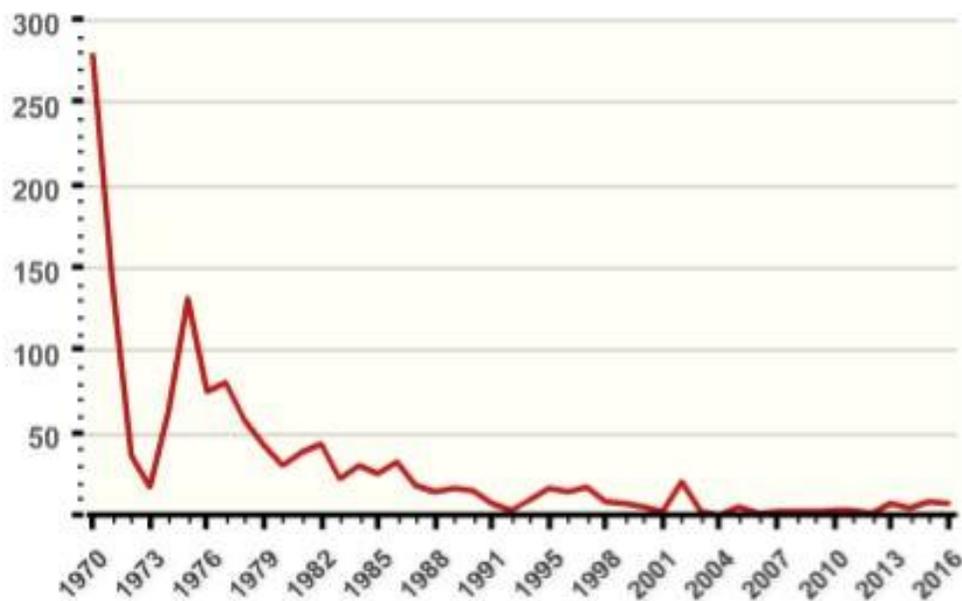
The location of the explosion influences the extent of the damage caused by an attack. If an explosion is near a building, public transportation, or other facility there could be extensive damage done to structures and infrastructure. Windows may be blown out, walls could be destroyed, facility systems could be shut down, exit routs could be destroyed, and more. An explosive attack may cause disruption in services such as electricity, water, communications, and transportation (The National Academies and the U.S. Department of Homeland Security).

An explosion can also create health impacts. The high-pressured blast caused by an explosion can send debris flying and lift people off the ground. The extent of people injured will vary depending on situational factors such as the physical environment, the size of the blast, the amount of shielding between victims and the blast, the occurrence of fires, the occurrence of structural damage, and the location of the explosion. There are four injuries that are common to explosion; which include overpressure damage, fragmentation injuries, impact injuries, and thermal injuries (The National Academies and the U.S. Department of Homeland Security). Some health effects caused by explosions such as eye injuries and abdominal injuries may not be apparent initially (Colorado Division of Homeland Security & Emergency Management).

#### 4. PROBABILITY

Past use of explosives indicate that the likeliness of an explosive attack is probable. Explosive use has historically been significant. In 2010 the National Consortium for the Study of Terrorism and Responses to Terrorism (START) compiled a report on the use of explosives for attacks. This report concluded that between 1970 and 2008 explosives were used in 45% of all attacks worldwide, and more than half of all terrorist attacks in the U.S. Recently the amount of explosive attacks has been much lower than in the past. Figure 3-156 illustrates the decline in amount of explosive attacks.

FIGURE 3-156 EXPLOSIVE ATTACK INCIDENTS IN THE UNITED STATES (1970-2016)



Source: Global Terrorism Database, January 2018

Despite the decline in use of explosive attacks, there is still the threat of explosives being used for an attack. The accessibility of explosives makes this form of attack a threat.

Recent notable bombing attacks that have occurred in the U.S. that have resulted in casualties or injuries include: 2016 New York and New Jersey bombings (29 injured) and the 2015 Boston Marathon bombing (2 fatalities and 132 injured).

## 5. PREVIOUS OCCURENCES

There have been many previous explosive attacks in Colorado. Throughout the 1970s, explosives were used as a primary method of attack. Between 1970 and 1978 there were 18 explosive attacks in Colorado. These attacks were concentrated in Boulder and Denver. Since then, there have only been two other recorded instances of explosives being used for an attack. In 2002 anti-government extremists in Pueblo and Salida used explosives to attack both government and private property. Most recently, in 2015 there was an explosive attack in Colorado Springs, where a man placed an explosive device at a private property. The attack was isolated and the motive for the attack is still unknown (FBI, 2018).

Table 3-270 details previous occurrences of explosive attacks in Colorado.

**TABLE 3-270 PREVIOUS EXPLOSIVE ATTACKS IN COLORADO**

Date	City	Perpetrator Group	Fatalities	Injured	Target Type
1/31/1970	Denver	Unknown	0	0	Police
2/6/1970	Denver	Black Nationalists	0	0	Transportation
2/24/1970	Denver	White Extremists	0	0	Private Citizens & Property
2/27/1970	Boulder	Student Radicals	0	0	Educational Institution
3/1/1970	Boulder	Student Radicals	0	0	Military
3/1/1970	Boulder	Left-Wing Militants	0	0	Police
3/3/1970	Denver	Left-Wing Militants	0	0	Private Citizens & Property
3/4/1970	Denver	Left-Wing Militants	0	0	Private Citizens & Property
3/5/1970	Denver	Left-Wing Militants	0	0	Private Citizens and Property

Date	City	Perpetrator Group	Fatalities	Injured	Target Type
2/24/1974	Boulder	Chicano Radicals (suspected)	0	0	Government (General)
March 1974	Boulder	Chicano Radicals (suspected)	0	0	Educational Institution
March 1974	Boulder	Chicano Radicals (suspected)	0	0	Educational Institution
2/3/1975	Denver	Continental Revolutionary Army	0	4	Government (General)
4/28/1975	Denver	Unknown	0	0	Business
4/28/1975	Denver	Unknown	0	0	Government (General)
8/8/1975	Denver	Unknown	0	0	Government (General)
12/23/1975	Denver	Continental Revolutionary Army	0	0	Government (General)
3/22/1978	Denver	New World Liberation Front (NWLFF)	1	0	NGO
5/6/2002	Pueblo	Anti-Government Extremists	0	0	Government (General), Private Citizens & Property
5/6/2002	Salida	Anti-Government Extremists	0	0	Government (General), Private Citizens & Property
1/6/2015	Colorado Springs	Unknown	0	0	Business, Private Citizens & Property

## 6. IMPACT ANALYSIS

An explosive attack could cause destruction, as well as casualties and injuries. Substantial damage could be incurred by state, local, and federal facilities, and the damage to infrastructure could be significant. There could be loss of power, water, sewer, gas, communications, and more. Homes, businesses, and infrastructure could suffer extensive damage if such an event were targeted at these locations.

Regular government functionality depends on the situation. Functionality may take several days to repair depending on the nature and target of the attack. Trust in the government would most likely depend on the government’s capability of responding to an attack. Emergency response would be largely dedicated to responding to the attack.

Table 3-271 provides information on the potential impact that an explosive attack would have on Colorado.

**TABLE 3-271 EXPLOSIVE ATTACK EMAP IMPACT SUMMARY**

<b>Consideration</b>	<b>Description</b>
<b>General Public</b>	May experience physical effects caused by the explosion or psychological effects from being involved in a traumatic event.
<b>First Responders</b>	May experience physical effects caused by the explosion or psychological effects from being involved in responding to a traumatic event.
<b>Property</b>	Could be damaged if the target of an attack or within range of the explosive.
<b>Facilities and Infrastructure</b>	Could be damaged if targeted by or within range of the explosive. Ability to restore function could take up to days or weeks after the attack. The “...infrastructure in some areas or sectors will sustain damage from explosives” (CHIRRP, 2016).
<b>Economic</b>	Costs associated with the damage done by the attack and potential losses due to decreased tourism and travel to certain areas following an attack.
<b>Environment</b>	Would be damaged from the impacts of the explosive.
<b>Continuity of Government and Services</b>	May take several days to repair depending on the nature and target of the attack.
<b>Confidence in Government</b>	Would depend on the capability of response to the event.
<b>Critical Assets</b>	Could be damaged if targeted by or within range of the explosive attack. Impact could be critical depending on the function and importance of the asset.

## **7. VULNERABILITY AND POTENTIAL LOSSES BY JURISDICTION**

A well implemented and targeted explosive attack can cause extensive losses. In Colorado and across the U.S., explosive attacks have been on the decline since 1970. Even though occurrences are less frequent today; they are still likely to occur. Nationally, high visibility attacks, such as the terrorist attacks on the World Trade Center buildings in New York City and the Pentagon in Washington, D.C. have increased awareness of the United States’ vulnerability to explosive attacks.

Based on a 2017 review of local hazard mitigation plans, 12 counties consider terrorism or explosive attacks in their local hazard mitigation plan, four of them deeming it of medium significance, five of low significance, and three with no indicator of significance as indicated below:

- Archuleta County - low significance
- City and County of Broomfield - medium significance
- Eagle County - medium significance
- El Paso County - low significance
- Garfield County - low significance
- Hinsdale County - medium significance
- Montrose County - no significance ranking
- Ouray County - low significance
- San Miguel County - low significance
- City of Aurora - no significance ranking
- City of Boulder - no significance ranking
- Colorado Springs - medium significance

While eco-terrorism is the main concern for most of these counties due to the unaltered natural beauty that exists, threat of explosive attack is also a concern. In Archuleta County in 2009 an individual's house was foreclosed, prompting him to manufacture pipe bombs with the intent to use the explosives at the nearest Wells Fargo in an act of revenge. The Farmington, NM Bomb Squad was called in to handle the event. The individual ended up killing himself, and no other people were physically harmed in the incident. In 2011, a bomb threat was received in the area of the county court house (Archuleta County Multi-Hazard Mitigation Plan). In Ouray County, explosive attack is an imminent threat due to the active mines located within the county. If an attack were to be targeted at these mines, impacts could be detrimental (Ouray County Multi-Hazard Mitigation Plan).

Many other counties reference terrorism as it is assessed in the regional Threat and Hazard Identification and Risk Assessment (THIRA) plans. The CDOT THIRA addresses the common use of explosives by terrorists and violent criminals. The availability, flexibility, and ease of use make explosives a threat. An attack can be countered by careful law enforcement work to identify and interfere with an attack before it occurs.

## **8. FUTURE DEVELOPMENT**

Population growth and development contribute to increased exposure of people and property to the potential impacts of an explosive attack. Continuing development will likely increase the overall vulnerability of infrastructure to an explosive attack. As population increases in Colorado, more people are potentially prone to the impacts of a possible explosive attack.

## 9. CLIMATE CHANGE

Due to the human-caused nature of an explosive attack, this hazard is not related to climate change.

## 10. RISK TO STATE ASSETS

State assets are at risk to the impacts of an explosive attack. The risk of an attack being targeted at a state asset may be high due to the value associated with the asset. While all state assets are at risk to impact, the vulnerabilities of each asset differ depending on the facility construction and standoff distances (Colorado Energy Assurance Emergency Plan (CEAEP)).

Explosive attacks cause the greatest damage to the target, but could also damage structures and infrastructure within close vicinity to the explosion. To address the potential hazard of an explosive attack, the CHIRRP identifies the importance of using bomb squad teams for providing adequate protection of assets and resources.

According to the CEAEP, an explosive attack can be targeted at hindering access to energy. Explosives may be used to damage or destroy grid components, assets, or facilities to disrupt energy sector operations. To counteract this, some high-risk assets such as government buildings, can be physically hardened to limit the potential damage of an attack. Some high-risk assets such as airports, can also be equipped with explosives screening devices (CDOT THIRA, 2017).

## 11. RESOURCES

- Archuleta County Multi-Hazard Mitigation Plan
- Colorado Department of Transportation (CDOT) Threat and Hazard Identification and Risk Assessment (THIRA)
- Colorado Division of Homeland Security & Emergency Management. Bombs and Explosives. <https://www.colorado.gov/pacific/dhsem/bombs-and-explosives>. Accessed January 2018.
- Colorado Energy Assurance Emergency Plan (CEAEP)
- Colorado Hazard and Incident Response and Recovery Plan (CHIRRP), 2016
- FBI. February 20, 2015. Man Responsible for Placing Explosive-Type Device at Colorado Springs Building Arrested. <https://www.fbi.gov/contact-us/field-offices/denver/news/press-releases/man-responsible-for-placing-explosive-type-device-at-colorado-springs-building-arrested>. Accessed January 2018.
- Global Terrorism Database. <http://www.start.umd.edu/gtd/search/>. Accessed January 2018.
- National Consortium for the Study of Terrorism and Responses to Terrorism (START). 2010. Explosives Used in Most U.S. Terrorist Attacks Overall, but Rarely in Recent

Attacks.

[http://www.start.umd.edu/sites/default/files/files/media/pr/Package\\_Bombs\\_Press\\_Release.pdf](http://www.start.umd.edu/sites/default/files/files/media/pr/Package_Bombs_Press_Release.pdf). Accessed January 2018.

- New York City Police Department. The Threat to Buildings from Explosive Devices. [http://www.nyc.gov/html/nypd/downloads/pdf/counterterrorism/engineeringsecurity\\_010\\_threat\\_to\\_buildings\\_from\\_exp\\_dev.pdf](http://www.nyc.gov/html/nypd/downloads/pdf/counterterrorism/engineeringsecurity_010_threat_to_buildings_from_exp_dev.pdf). Accessed January 2018.
- Ouray County Multi-Hazard Mitigation Plan
- The National Academies and U.S. Department of Homeland Security. News and Terrorism Communicating in a Crisis: Improvised Explosive Devices Attack. [https://www.dhs.gov/xlibrary/assets/prep\\_ied\\_fact\\_sheet.pdf](https://www.dhs.gov/xlibrary/assets/prep_ied_fact_sheet.pdf). Accessed January 2018.

## **RISK ASSESSMENT SUMMARY**

The risk assessment as presented in the 2018 State Plan identifies and describes natural, technological, and human-caused hazards identified as threatening Colorado’s people, property, infrastructure, economy, and environment. Based on a summary of historic events and models looking forward, the assessment presents an estimate of statewide vulnerability, including that of state and local assets in the broadest sense. The assessment is not absolute, but serves as a critical tool in guiding Colorado and its statewide mitigation program in developing appropriate strategies to reduce the risk of hazards.

### **1. HAZARD PROFILE KEY TAKEAWAYS**

Table 3-272 describes key takeaways from the results of the Risk Assessment for each hazard. This table can be used as a quick reference to major results from the Risk Assessment.

TABLE 3-272 HAZARD PROFILES KEY TAKEAWAYS

Hazard		Key Takeaways
Dense Fog		<ul style="list-style-type: none"> <li>Garfield and Mesa Counties have the highest number of events (98 and 96), but data presented by forecast zones makes it difficult to pinpoint the counties with the highest deaths and injuries.</li> <li>Garfield County has the most extreme exposure related to population growth.</li> <li>Transportation related incidents are the most dangerous impacts related to fog.</li> <li>Risk to state assets is minimal.</li> </ul>
Drought		<ul style="list-style-type: none"> <li>Drought is a “top hazard” for the State of Colorado based on impacts, previous occurrences, probability, and climate change.</li> <li>Drought can be linked to other hazards as well, wildfire, for example, due to extremely dry vegetation from drought.</li> <li>The most vulnerable infrastructure/state assets are dams, trans-mountain ditches, and irrigation ditches.</li> <li>A vulnerability analysis on future exposure to drought indicates Routt County as being the most vulnerable. Geographically, vulnerable counties are located throughout the entire state.</li> </ul>
Extreme Heat		<ul style="list-style-type: none"> <li>Extreme heat is most prevalent on the eastern plains and Mesa County.</li> <li>Health impacts of extreme heat are a major concern, particularly for vulnerable populations.</li> <li>Climate change is projected to increase the number of extreme heat days in Colorado and expand the geographic extent to more northern and higher elevation regions across the state.</li> <li>Most jurisdictions statewide profile extreme heat in their plans, but Arapahoe County is the only one that lists it as a top 4 hazard.</li> <li>Many counties in the eastern edge of the Front Range are experiencing rapid population growth and have some of the highest extreme heat risk – these counties have severe future exposure ratings to extreme heat.</li> <li>State assets are at risk to extreme heat in the form of infrastructure damage due to high temperatures as well as increased demand for air conditioning putting a strain on electricity.</li> </ul>

Hazard		Key Takeaways
<b>Flood</b>		<ul style="list-style-type: none"> <li>Flood is a “top hazard” for the State of Colorado based on impacts, previous occurrences, and probability.</li> <li>Almost all counties have experienced damaging flooding events.</li> <li>Based on Hazus analysis, counties along the northern and central Front Range have the highest total estimated flood losses.</li> <li>All counties with a local hazard mitigation plan (HMP) profile flood.</li> <li>Arapahoe and El Paso Counties have severe future exposure to flooding based on population growth and risk.</li> <li>Boulder, Denver, and Crowley counties have the highest value of state assets located in the 100-year floodplain.</li> </ul>
<b>Hail</b>		<ul style="list-style-type: none"> <li>Colorado is one of the most hail-prone states, with damaging hail events occurring most frequently along the Front Range and Eastern Plains.</li> <li>Most years involve at least one catastrophic hailstorm that causes \$25 million or more in insured damage.</li> <li>Hail is profiled in all local HMPs along the Eastern Plains and Front Range.</li> <li>Counties along the northern and central Front Range have severe future exposure ratings for hail based on population growth, previous occurrences, and previous deaths and injuries.</li> <li>A majority of state assets are located along the Front Range and Eastern Plains, which are at risk to damaging hail events.</li> </ul>
<b>Severe Wind</b>		<ul style="list-style-type: none"> <li>Severe wind occurs more frequently along the Front Range and northern Eastern Plains than any other area of the state.</li> <li>Windstorms are one of Colorado’s costliest hazards. From 1996 to 2016, wind events have caused a reported \$40 million in property and crop damage. Wind events have also resulted in 13 deaths and more than 200 injuries in the state since 1987.</li> <li>Most local HMPs profile wind across the state.</li> <li>Counties along the Front Range have the most severe future exposure rating based on population growth and, previous occurrences, and previous deaths and injuries.</li> <li>Counties along the Front Range also have the most state assets at risk to severe wind events.</li> </ul>

Hazard		Key Takeaways
<b>Severe Winter Weather</b> 	<ul style="list-style-type: none"> <li>• Severe winter weather can occur statewide in Colorado, but Western Slope counties have experienced the most severe winter weather events.</li> <li>• Nearly all counties have profiled severe winter weather in their local HMPs.</li> <li>• The highest amount of damages occur along the northern/central Front Range.</li> <li>• Garfield County has the most extreme future exposure rating based on population growth, previous occurrences, and previous deaths and injuries.</li> <li>• Counties along the Front Range have high amounts and value of state assets, as well as high number of past winter weather events.</li> </ul>	
<b>Thunderstorms and Lightning</b> 	<ul style="list-style-type: none"> <li>• Thunderstorms and lightning occur across the entire state, but the most lightning-prone areas are the foothills and plains areas between the Denver metro area and Colorado Springs, and the Raton Plateau south and southeast of Trinidad near the New Mexico.</li> <li>• Weld County has the highest number of historic thunderstorm and lightning events.</li> <li>• The counties with the most deaths from lightning are located along the populated Front Range and foothills, including Denver, Larimer, Boulder, Jefferson, Arapahoe, and El Paso Counties.</li> <li>• Lightning causes significant crop damage in the state.</li> <li>• Thunderstorms and lightning are profiled in nearly all local HMPs throughout the state.</li> <li>• Populated counties along the Front Range have extreme future exposure to thunderstorms and lightning due to population growth, previous occurrences, and previous deaths and injuries. These same counties also have high amounts and values of state assets.</li> </ul>	
<b>Tornadoes</b> 	<ul style="list-style-type: none"> <li>• In Colorado, the primary threat of tornado is east of the Continental Divide along the Front Range and across the Eastern Plains, although they have occurred statewide.</li> <li>• Damages from tornadoes are highest in Weld County</li> <li>• Tornadoes are profiled in all local HMPs in the Eastern Plains and Front Range, as well as many Western Slope communities.</li> <li>• Weld, Adams, and El Paso Counties have extreme future exposure to tornadoes based on population growth, previous occurrences, and previous deaths and injuries. These same counties also have high amounts and values of state assets.</li> </ul>	

Hazard		Key Takeaways
Wildfire		<ul style="list-style-type: none"> <li>• Wildfire is a “top hazard” for the state, and the threat is statewide in Colorado with the forests, grasslands, and WUI all at risk, but risk is highest in the foothill and mountain forests due to more development that increases possibility of loss or harm. These areas are in the central and western areas of Colorado.</li> <li>• WUI risk is highest along the central and northern Front Range.</li> <li>• Wildfire is connected with other hazards, such as drought and extreme heat increasing wildfire potential, and flooding and landslides becoming a higher risk in wildfire burn scar areas.</li> <li>• Wildfire is profiled in all jurisdictions with a local HMP.</li> <li>• In the context of wildfire, increased population growth and development along the WUI has increased human exposure to wildfire in a number of Colorado communities.</li> <li>• Douglas and Garfield Counties rank in the most extreme future exposure risk category based on population growth and their wildfire risk. Many high density Front Range counties located along the foothills, including Larimer, Jefferson, El Paso, and Boulder, rank in the severe or high exposure category.</li> <li>• Climate change is contributing to more frequent high-intensity wildfires in the western United States, and this trend is expected to continue.</li> <li>• Rio Blanco and Garfield Counties stand out as possessing the greatest number and value of state assets in the highest wildfire hazard areas.</li> </ul>
Avalanche		<ul style="list-style-type: none"> <li>• Colorado has experienced the most avalanche fatalities out of every state in the United States.</li> <li>• Avalanche hazards occur predominantly in the mountainous regions of Colorado above 8,000 feet.</li> <li>• Between 1950 and 2016, Pitkin County experienced the greatest number of avalanche-related deaths in the state at 45 fatalities, followed closely by Summit County with 39 fatalities.</li> <li>• Many jurisdictions on the Western Slope profile avalanche as a hazard in local HMPs.</li> <li>• Summit County has extreme future exposure to avalanches based on population growth and previous occurrences/deaths/injuries.</li> <li>• Climate change may be affecting the timing of wet-snow avalanches, and more research is needed to determine the impacts to the state.</li> <li>• Avalanches negatively impact Colorado’s highways and roads.</li> </ul>

Hazard		Key Takeaways
<b>Earthquake</b> 	<ul style="list-style-type: none"> <li>• Most faults are located in the western valleys and plateau region of the state.</li> <li>• Occurrence of earthquakes is relatively infrequent in Colorado.</li> <li>• In recent years, induced seismicity has become an increasingly pertinent issue. Induced seismicity refers to seismic events instigated by human activities.</li> <li>• Based on Hazus analysis, counties along the central and northern Front Range, along with Mesa County, would experience the most total annualized loss from an earthquake.</li> <li>• Most jurisdictions with local HMPs profile earthquake as a hazard, however only Larimer County profiles it as a high hazard.</li> <li>• Arapahoe and Denver Counties have extreme future exposure to earthquakes based on potential annualized losses and population growth.</li> </ul>	
<b>Erosion and Deposition</b> 	<ul style="list-style-type: none"> <li>• Erosion and deposition are occurring continually at varying rates all over Colorado.</li> <li>• Risk of erosion is higher after a wildfire event and other extreme weather events, such as floods.</li> <li>• Less than half of the jurisdictions with local HMPs profile erosion and deposition as a hazard.</li> <li>• El Paso County has the most extreme future exposure to erosion and deposition due to future development and associated risk. Other counties along the central and northern Front Range have severe or high risk.</li> <li>• Erosion and deposition can cause significant damage to roadways.</li> </ul>	
<b>Expansive Soils and Heaving Bedrock</b> 	<ul style="list-style-type: none"> <li>• Expansive soils occur throughout Colorado. Rocks containing swelling clay are generally softer and less resistant to weathering and erosion than other rocks and therefore, more often occur along the sides of mountain valleys and on the plains than in the mountains.</li> <li>• Expansive soils can cause structural damage to buildings and roadways.</li> <li>• Approximately one-third of jurisdictions with a local HMP profile expansive soils and heaving bedrock as a hazard.</li> <li>• Increased frequency and duration of drought due to climate change may cause an increase in the frequency of expansive soil events.</li> <li>• Broomfield County has extreme future exposure to expansive soils due to development and high risk.</li> <li>• Larimer County has the highest value of state assets in areas of high or moderate expansive soil risk.</li> </ul>	

Hazard		Key Takeaways
<b>Landslides, Mud/Debris Flows, and Rockfalls</b>		<ul style="list-style-type: none"> <li>• Landslides, mud/debris flow, and rock fall events largely occur in the mountainous region from the Front Range to the Western Slope, with the threat generally increasing with slope and susceptibility.</li> <li>• Landslides risk increases after wildfire and during extreme precipitation events.</li> <li>• Landslides and rockfall can significantly impact transportation networks.</li> <li>• Nearly all counties along the Front Range and Western Slope with a local HMP profile landslides as a hazard, as well as some counties along the Eastern Plains.</li> <li>• Growth in many areas in mountain counties are constrained by federal lands and this sometimes forces growth onto alluvial fans and hillsides that might be prone to landslides, debris flow, mudslides, or rockfall.</li> <li>• Mesa County has the highest value of state assets with potential landslide exposure.</li> </ul>
<b>Radon, Carbon Monoxide, and Methane Seeps</b>		<ul style="list-style-type: none"> <li>• Seeps can occur statewide.</li> <li>• Impacts to human health are a concern with seeps.</li> <li>• Impacts are reduced with radon testing kits, carbon monoxide alarms, and continued regulation, even with increased development.</li> </ul>
<b>Subsidence and Abandoned Mine Lands</b>		<ul style="list-style-type: none"> <li>• Subsidence, undermined areas, and collapsible soils tend to be problematic along the Front Range, Western Slope, and in the Central Mountains. The Eastern Plains are largely void of this hazard.</li> <li>• Subsidence can result in serious structural damage to buildings, roads, irrigation ditches, underground utilities, and pipelines.</li> <li>• Many jurisdictions with local HMP profile subsidence as a hazard, with Lake County profiling it as a high hazard.</li> <li>• As Colorado's population continues to grow and the need for additional housing increases, more people and property may be affected by subsidence. Site-specific engineering studies are needed to avoid development in subsidence or abandoned mine land areas.</li> <li>• Because there is a significant amount of collapsible soils around the Denver metro area, there are a large number of state assets exposed to this risk.</li> </ul>

Hazard		Key Takeaways
<b>Animal Disease</b>		<ul style="list-style-type: none"> <li>The State of Colorado comprises over 33,800 farms, with over 31,700,000 acres zoned as farmland maintaining a livestock inventory of over 8,800,000 and epidemics result in mass mortality of animals, resulting in devastating economic impacts on industries and communities.</li> <li>Warmer temperatures due to climate change may increase the prevalence of parasites and diseases that affect livestock (i.e., the earlier onset of spring and warmer winters could allow some parasites and pathogens to survive more easily). It may also cause pests to persist year-round.</li> </ul>
<b>Pandemic</b>		<ul style="list-style-type: none"> <li>Pandemics occur not only on a state or regional level, but on a national and global scale. It is likely that most counties in Colorado would be affected, either directly or by secondary impacts.</li> <li>It is difficult to predict when a pandemic will occur.</li> <li>Counties with high population and dense development would likely be the most impacted from a pandemic.</li> <li>A pandemic would impact vulnerable populations, such as young children and the elderly, the most.</li> <li>Pandemics are profiled in approximately half local HMPs.</li> <li>Climate change may impact the location of vector-borne diseases prevalence, as well as the extent and intensity, increasing the overall risk to pandemics.</li> </ul>
<b>Wildlife-Vehicle Collisions (WVCs)</b>		<ul style="list-style-type: none"> <li>WVCs can happen nearly anywhere in Colorado, but Colorado Parks and Wildlife (CPW) cautions drivers to be especially wary when driving through the following areas: Interstate 70 (Floyd Hill, Mt. Vernon, and Eagle), Highway 285 (Morrison), Highway 160 (Durango to Pagosa Springs and Durango to Mancos), Highway 550 (north of Durango and from Montrose to Ouray), Interstate 25 (Castle Rock to Larkspur), Highway 82 (Glenwood Springs to Aspen), Highway 36 (Boulder to Lyons), and Highway 93 (Golden to Boulder).</li> <li>CDOT data on WVCs between 2005 and 2014 indicates that the risk is especially high in 10 counties in particular: La Plata, Jefferson, Douglas, El Paso, Montezuma, Garfield, Eagle, Moffat, Pueblo, and Routt.</li> <li>The expected overall population increase in Colorado will put more people at risk of experiencing a collision with wildlife, either as residents of the most at-risk counties or as tourists who are passing through the area.</li> </ul>

Hazard		Key Takeaways
<b>Pest Infestation</b>		<ul style="list-style-type: none"> <li>• Pest infestations can occur statewide with regional propensity depending on the specific rodent or insect.</li> <li>• The Eastern Plains are most typically impacted by grasshopper infestations as the area coincides with rangeland. Western Colorado is also impacted but to a lesser extent. Higher elevations are largely void of significant grasshopper populations.</li> <li>• The Emerald Ash Borer (EAB) is localized to Boulder County, but it is very likely the EAB will spread to other Front Range and northeast plains urban forests, where ash trees comprise an estimated 15 percent or more of all trees.</li> <li>• Very few jurisdictions profile pest infestation in local HMPs.</li> <li>• Climate change may cause an increase in pest infestations as temperatures increase.</li> </ul>
<b>Infrastructure Failure</b>		<ul style="list-style-type: none"> <li>• Critical infrastructure can be found statewide.</li> <li>• Predicting the precise location of the next infrastructure failure is often difficult and generally dependent on the quality, upkeep, and maintenance of each piece of infrastructure, as well as protective actions that have been taken to mitigate or prevent damage.</li> <li>• Organizations and facilities should determine what infrastructure systems are necessary for them to continue to provide mission-essential services, what mitigation measures can be taken to protect those systems, and what alternate systems they could use in the event of an interruption.</li> <li>• No local HMP identified infrastructure failure as a stand-alone hazard.</li> </ul>

Hazard		Key Takeaways
<p><b>Dam and Levee Failure</b></p> 	<ul style="list-style-type: none"> <li>• There are dams in every county across the State of Colorado. Fifty-five counties report having high hazard dams. Larimer County has the largest number of high hazard dams (54), followed by Boulder (28), El Paso (24), Delta (21), Jefferson (21), and Mesa (20).</li> <li>• All high-hazard dams in Colorado have EAPs in place, which provide for the emergency notification procedures in the event of a dam emergency event.</li> <li>• Nearly all jurisdictions with local HMPs profile dam failure as a hazard.</li> <li>• Increasing population figures and growing urbanization translates to a higher risk for communities located downstream of significant or high hazard dams, and generally located within or near the inundation areas of hydrologic containment structures including levees. Additionally, development downstream of existing low and significant hazard dams will elevate these dams to high hazard.</li> <li>• Development downstream of dams does not only increase exposure to dams in general through growth, but also the exposure to high hazard dams by increasing the hazard itself.</li> <li>• Based on population growth and number of high hazard dams, El Paso and Larimer Counties have extreme future exposure rating to dam failure. These counties also have a high amount and value of state assets.</li> </ul>	
<p><b>Hazardous Materials Release</b></p> 	<ul style="list-style-type: none"> <li>• Sources of hazardous materials are located statewide in Colorado in the form of fixed facilities as well as pipelines and highways that facilitate hazardous materials transportation.</li> <li>• Transportation related hazardous material incidents are more common than fixed facility incidents.</li> <li>• The increase in oil and gas development combined with large increases in population and development put Weld County at risk for future exposure to hazardous material incidents, however, improved technologies and continued regulation can help to minimize this risk.</li> <li>• Hazardous materials release was profiled in approximately half local HMPs.</li> </ul>	

Hazard		Key Takeaways
<b>Mine Accidents</b>		<ul style="list-style-type: none"> <li>• Colorado's abandoned and operating mines are primarily located along the Front Range, Western Slope, and southwestern corner.</li> <li>• Mining accidents have dropped significantly within modern safety regulations, but future accidents are possible.</li> <li>• A small number of counties identified mine accidents as a potential hazard in their local HMP.</li> <li>• Hazardous materials releases from mines pose the biggest threat to future development in Colorado. As the population and demand for housing continues to grow along the Front Range, Western Slope, and southwestern Colorado, more people and properties may be exposed to toxic mine waste water spills.</li> </ul>
<b>Power Failure</b>		<ul style="list-style-type: none"> <li>• Power failures can occur in any populated area of Colorado.</li> <li>• The most common causes of power outages in Colorado are human error, equipment failure (to include excavation and vehicle accidents), and natural causes (to include weather events and wildlife disruptions).</li> <li>• As of 2017, the only Colorado county to have profiled Power Failure in their Hazard Mitigation Plan is Denver. However, six Colorado municipalities have completed Local Energy Assurance Plans, which includes a hazard assessment and mitigation planning: Aspen, Aurora, Denver, Durango, Lakewood, and Wheat Ridge.</li> </ul>
<b>Radiological Release</b>		<ul style="list-style-type: none"> <li>• Colorado has several Designated Nuclear and Hazardous Materials Routes, including Interstate 25, Interstate 70, and Interstate 76.</li> <li>• Radiological releases happen extremely infrequently.</li> <li>• As radiological events are human-caused, there is no way to accurately predict or estimate when such an incident might occur. By following proper regulations and guidelines, nuclear power plant operators, transporters of nuclear material, and those who otherwise deal with radioactive matter on a regular basis can help to prevent accidents from occurring.</li> </ul>

Hazard		Key Takeaways
<b>Chemical, Biological, Radiological, and Nuclear (CBRN) Attack</b>		<ul style="list-style-type: none"> <li>• Since CBRN attacks are most often linked to warfare or terrorist actions, they are likely to target prominent public figures, highly urban or iconic locations, or sites of strategic or military importance.</li> <li>• CBRN attacks in Colorado are extremely rare, but still have a chance of occurring.</li> <li>• Eleven jurisdictions with local HMPs profile terrorist attacks as a hazard.</li> <li>• As parts of the state become more densely populated, greater numbers of large public events are held, and more potential may exist for these venues to become targets of an attack.</li> <li>• State assets could be a potential target of a CBRN attack.</li> </ul>
<b>Cyber Attack</b>		<ul style="list-style-type: none"> <li>• Cyber disruption events can occur and/or impact virtually any location in the state where computing devices are used.</li> <li>• Both local and national breaches can affect the State of Colorado.</li> <li>• Virtually all government utilities, critical infrastructure, and facilities are networked to allow remote access and monitoring, allowing for greater efficiency, coordinated operations, and cost savings; however, this creates the possibility that systems such as power plants, water supply systems, and fuel lines could be targeted in a cyber-attack.</li> </ul>
<b>Explosive Attack</b>		<ul style="list-style-type: none"> <li>• Explosive attacks have been targeted at buildings in urban environments.</li> <li>• There have been 20 recorded explosive attacks in Colorado since 1970, and it is probable more explosive attacks will occur in Colorado.</li> <li>• Continuing development will likely increase the overall vulnerability of infrastructure to an explosive attack.</li> </ul>

## 2. STATEWIDE SIGNIFICANT RISKS

The 2018 State Plan risk assessment affirms Colorado's experience with natural, technological, and human-caused hazards and related disasters since the last Plan update, indicating that wildfire, flood and drought remain the most significant hazards in Colorado. Over the last decade, Colorado has experienced a prolonged and severe drought, unprecedented explosive and destructive wildfires, and catastrophic flooding, including the most destructive wildfire in Colorado history and the September 2013 floods, which was one of Colorado's costliest disasters. Additionally, these hazards are interrelated and can potentially cause cascading effects that influence the severity of the hazard. For example, severe drought can cause an increase in abnormally dry vegetation, which provides more fuel for a high-intensity wildfire. The burn-scar from the wildfire may then contribute to increased debris flows and more intense flooding after storms. These events result in death and injury along with hundreds of millions of dollars in losses related to damaged and destroyed property and critical infrastructure. Tens of thousands of people were displaced for prolonged periods of time due to these events. Population growth across the State of Colorado also contributes to an increased future risk to these disasters. Across the state, economies were devastated as one event after another kept tourists from visiting affected Colorado destinations.

### **2.1 WILDFIRE**

Significant wildfires are expected to continue in Colorado. These events result in death, injury, health complications, prolonged evacuation and road closures, property and structural loss, disruption of critical services, negative impacts to local and regional economies, and environmental degradation. In mountainous areas, wildfires result in cascading impacts that are challenging to overcome, including an increased propensity for flash flooding and heightened threat of landslides and mud/debris flows.

### **2.2 FLOOD**

Flooding in Colorado will continue as both flash events in the mountains and foothills, with overbanking in the valleys and plains. As one of Colorado's most deadly and costly natural hazards, negative impacts to public and private property and infrastructure will continue with secondary health concerns of mold, contaminated drinking water, and impacts to lifelines such as drinking water and wastewater treatment facilities.

### **2.3 DROUGHT**

Drought is a nearly continuous hazard in Colorado with various areas across the state experiencing abnormally dry conditions any time of year. Drought continues to have devastating impacts to agricultural land and farm economies across the state. Colorado also depends on precipitation to store and supply water for residential, industrial, commercial, and agricultural uses. Lack of moisture, statewide or localized, continues to result in extraordinarily low moisture levels in vegetation that contribute to high-intensity wildfires in Colorado. Additionally, drought negatively impacts tourism in Colorado, which is a major source of revenue year-round for many

Colorado communities. Drought conditions and low water levels can impact activities such as white-water rafting, fishing, and hunting. In addition, reduced snowpack can severely impact Colorado's ski industry, which contributes \$4.8 billion to Colorado's economy according to a study released by Colorado Ski Country USA and Vail Resorts (The Coloradoan, 2015).

### 3. MOST VULNERABLE JURISDICTIONS

This section is designed to summarize the hazards facing Colorado on a localized level. Local governments and tribes must continually assess the hazards threatening their communities and prioritize development of response capabilities and mitigation efforts. Assessment and efforts change along with population, land use, finances, and the local environment. Coloradans become vulnerable to hazards when they live, work, or visit an area where these events occur. Individuals and communities that prepare for the occurrence of a hazard are less vulnerable to its consequences than those that do not.

The vulnerability of Colorado's population is rooted in a relationship between the occurrence of hazard events, the proximity of people and property to these occurrences, and the degree that a community and its members are committed and prepared to cope with these occurrences and mitigate their effects.

The continued population growth in regions across Colorado increases the likelihood that vulnerability will increase. Many of the areas currently under development are high hazard areas. Compounding this problem, many public agencies responsible for land use, emergency planning, and mitigation are understaffed and operating with limited budgets.

Colorado's tourist population presents another vulnerability concern. Many jurisdictions economically depend on tourists each year. Most of these visitors travel to mountain locations and are, for the most part, unaware of the potential hazards associated with these areas. The preparedness, planning, and mitigation efforts undertaken by mountain communities must consider these visitors.

There is a close correlation between settlement patterns, population growth, and the cost of disasters. When a disaster strikes a densely populated area, the costs are usually greater than in those incurred in a sparsely populated region. As a community grows, competition for remaining land increases. This results in a tendency to allow development in areas where hazards exist.

Mitigation, through processes that guide development, lessens damage caused by hazard events and generates a monetary benefit by reducing funds spent on disaster response and recovery. Not all hazards can be avoided through mitigation efforts so a community must continually plan for response and recovery. Public awareness of hazards to which they may be exposed and education on preparedness is important in every community's emergency and overall planning efforts. A hazard analysis is a living document that requires routine review and update as a community and its hazards change.

In addition to hazard profiles, local hazard mitigation plans were evaluated to provide insight as to how local jurisdictions view the degree of vulnerability to hazard events. Many plans included planning priorities for the various hazards or provided a risk ranking of high, medium, or low. The State Hazard Mitigation Plan update process is closely integrated with local jurisdiction and tribal planning efforts. Similar to the process used to develop the 2013 State Plan, the 2018 Plan update includes an analysis and data roll-up of risk assessment information from 69 local hazard mitigation plans (one region, 61 counties, five cities, and two tribes)

### 3.1 RISK RANKING, VULNERABILITY, AND LOSS ESTIMATION

Table 3-273 provides a summary of prevalent hazards listed as high, medium, or low based on risk assessments by local jurisdictions. There is a significant break between the four top ranked hazards and the remaining hazards. These ‘top four’ hazards that stand out with respect to high statewide risk rankings are severe winter weather, wildfire, flood, and drought. Local jurisdictions tended to consider being at risk to weather-based hazards such as tornado, hail, severe wind, and lightning as medium/high along with dam/levee failure, earthquake, and other geologic hazards. A detailed breakdown of rankings by local jurisdiction is provided Table 3-274. All local hazard mitigation plan data is current as of December 2017.

TABLE 3-273 SUMMARY OF LOCAL JURISDICTION HAZARD VULNERABILITY RANKINGS

Hazard	Risk Rank		
	High	Medium	Low
Severe Winter Weather	54	13	2
Wildfire	54	6	9
Flood	41	27	1
Drought	37	27	2
Severe Wind	26	33	8
Severe Thunderstorm	24	37	5
Hail	23	26	12
Tornado	22	20	18
Lightning	21	39	7
Extreme Heat	13	17	24
Landslide/Mud/Debris Flows/Rock Fall/Rockslide	12	20	22
Dam/Levee Failure	11	25	25
Hazardous Materials Release	11	18	1
Pandemic/Epidemiology (Epidemic/Pandemic)	4	23	7
Erosion and Deposition	3	8	17
Avalanche	3	16	15
Sinkholes/Subsidence	2	8	37
Pest Infestation	3	3	0
Expansive Soils and Heaving Bedrock	1	6	14
Earthquake	1	14	51

Hazard	Risk Rank		
	High	Medium	Low
<b>Terrorism</b>	0	4	4
<b>Wildlife Vehicle Collisions</b>	0	1	1
<b>Volcano</b>	0	0	2
<b>Space Weather</b>	0	0	1

Detailed vulnerability rankings by local jurisdiction are presented in Table 3-274. When jurisdictions provided information to directly indicate or derive a high, medium, or low ranking, it is shown in the table as red, yellow, or green. If vulnerability for a specific hazard was not analyzed in a plan, the hazard is shown in white. Jurisdictions highlighted in yellow in the “Jurisdictions” column did not have a hazard mitigation plan at the time of analysis.

TABLE 3-274 HAZARD RISK RANKING BY LOCAL JURISDICTION

<b>Legend:</b> Information is derived from local hazard mitigation plans		H - High
		M - Medium
		L - Low
		Not Analyzed

Jurisdiction	Avalanche	Dam Failure	Drought	Erosion/Deposition	Earthquake	Expansive Soils	Extreme Heat	Flood	Hail	Landslide	Lightning	Subsidence	Thunderstorm	Tornado	Severe Wind	Wildfire	Winter Weather	Public Health	HAZMAT	Terrorism	Volcano	Pest Infestation	Space Weather	Wildlife Collisions
Adams County			M		L			M	H		H	L	H	H	H	L	H							
Alamosa County	M	M	H		L		H	H	M	M	M		M	M	M	M	H							
Arapahoe County			M	L	L		H	M	H		H	L	H	M	M	M	H	M						
Archuleta County	M	H	H		L		L	H	L	H	H	L	M	M	M	L	H	M	H	L	L			L
Baca County		L	H	L	L		M	M	H		H	L	H	H	H	H	H	L	H				H	
Bent County		H	H	M	L		L	H	H		H	L	H	H	M	M	H	L	M				H	
Boulder County	L	H	H		M	L	L	H	L	H	M	M	H	M	H	H	H	M						
City & County of Broomfield		M	M		L	H	L	H	L		M	L		L	M	L	M	M	M	M				
Chaffee County	M	L	H	L	L	L	L	H	L	L	M	L	M	L	M	H	H							
Cheyenne County		L	H		L		L	M	M	L	M	L	M	H	H	H	H	M						
Clear Creek County	L	M	L	L	L	L	L	H	M	M	M	L	M	L	M	H	H						L	
Conejos County	M	L	H		L		H	M	H	L	M		H	M	H	H	H							
Costilla County		L	H		L		H	M	M	L	M		M	L	M	H	H							
Crowley County		M	H	M	L		M	M	M		M	M	M	H	M	L	H	L	L			M		
Custer County	L	L	H	L	L	L	L	M	M	L	M	L	M	L	H	H	H							
Delta County	L	M	H		L	L	H	H		M	L		L		L	H	H		M					
City & County of Denver		M	H		M	L	M	H	H		H	L	H	M	H	L	H		M					
Dolores County	M	L	H	L	L	M	M	M	L	M	M	L	M	L	H	M	H							
Douglas County	L	M	M	M	L	L	M	M	L	M	L	L	M	L	L	H	M		H					
Eagle County	M	L	M		L	M	L	M	L	H	M	M	M	L	M	H	H	M	M	M				
El Paso County	L	L	M	H	L		M	H	M	H	M	L	M	M	L	H	H	M	H	L				
Elbert County		M	M		L		H	H	H		H		H	H	H	H	H							

Jurisdiction	Avalanche	Dam Failure	Drought	Erosion/Deposition	Earthquake	Expansive Soils	Extreme Heat	Flood	Hail	Landslide	Lightning	Subsidence	Thunderstorm	Tornado	Severe Wind	Wildfire	Winter Weather	Public Health	HAZMAT	Terrorism	Volcano	Pest Infestation	Space Weather	Wildlife Collisions
Fremont County		M	M	L	L		M	H	H	L	H	L	H	M	M	H	M							
Garfield County								H		H						H	L	L	H	L				
Gilpin County	L	L	L	M	L	L	L	M	L	L	H	L	H	L	H	H	H							
Grand County	M	L	M		L			M		H	L		L		L	H	H	H	H					M
Gunnison County	L	M	M		L		L	H	L	M	L		M		M	H	H							
Hinsdale County	M	M	H		M		H	H	H	M	H		H	H	H	H	H	M	M	M				
Huerfano County		M	M		M			H	L	M	L	M	L	M	M	H	M	L	H					
Jackson County																								
Jefferson County	L	H	M	M	M	M	L	H	H	M	M	M	M	M	M	H	H							
Kiowa County		L	H	L	L		L	M	M		M	L	M	M	M	L	M	L	M				H	
Kit Carson County		M	H		L		L	M	M	L	M	L	M	H	H	H	H	M						
La Plata County	M		H		L			M	M	M	M		M	M	M	H	H							
Lake County	M	M	M		L		M	M	M	M	M	H	M	L	M	M	H							
Larimer County				M	H	M		H	H	H	H	M	H	H	H	H	H	H	H					
Las Animas County	L	M	H	L	M	L	M	M	H	L	M	L	M	M	M	H	H							
Lincoln County		L	H		M		L	H	M	L	M	L	M	H	H	H	H	M						
Logan County		M	H		L		L	H	M	L	M	L	M	H	H	H	H	M						
Mesa County	M	M	M		M	L	M	H	L	H	M	L		L	M	H	M		M					
Mineral County	H	L	H		M		H	M	M	M	H		M	L	M	H	H							
Moffat County																								
Montezuma County	L	L	H	L	L	L	M	L	L	L	L		H	L	M	H	H							
Montrose County		H	H		M	M		H	H	M	H	M	H		H	H	H	L	H					
Morgan County		H	H		L		L	H	M	L	M	L	M	H	H	H	H	M						
Otero County		M	H	M	L		H	H	H		H	L	H	H	M	M	H	M	M				M	
Ouray County	M	H	M		M		L	H		M	M		M		M	H	M	M	M					
Park County	L	L	H		L		H	M	H	L	H		H	L	H	H	H		H					
Phillips County		M	H		L		L	H	M	L	M	L	M	H	H	H	H	M						

Jurisdiction	Avalanche	Dam Failure	Drought	Erosion/Deposition	Earthquake	Expansive Soils	Extreme Heat	Flood	Hail	Landslide	Lightning	Subsidence	Thunderstorm	Tornado	Severe Wind	Wildfire	Winter Weather	Public Health	HAZMAT	Terrorism	Volcano	Pest Infestation	Space Weather	Wildlife Collisions
Pitkin County	H		M	M				M		H	M		M	M	M	H	M							
Prowers County		H	M	L	L		M	M	H		H	L	H	H	H	H	H	H	M			M		
Pueblo County			M					H	M		H		H	M	M	H	M	H						
Rio Blanco County	M			M		M		H		H		L				H	L							
Rio Grande County	M	L	M		L		H	H	H	M	M		M	M	M	H	H							
Routt County	L	M	M	L	L			H		M	M	L	M		L	H	H		M					
Saguache County	M	L	H		L		M	M	H	L	M		M	M	M	H	M							
San Juan County																								
San Miguel County	M	L	H		L			M	M	M	M		M	M	M	H	H	M	M	L				
Sedgwick County		M	H		L		L	H	M	L	M	L	M	H	H	H	H	M						
Summit County	H	M	M	L	L			H		M	M		M		L	H	H		M					
Teller County		L	H	L	M		H	M	H	M	H	L	H	L	H	H	H		M					
Washington County		M	H		L		L	H	M	L	M	L	M	H	H	H	H	M						
Weld County		H	M	L	L		H	H	H		H	L	H	H	H	H	H	M	M					
Yuma County		M	H		L		L	H	H	L	M	L	H	H	H	H	H	M						
Southern Ute Indian Tribe		M	M		L		L	H	M	L		M	H	H		H	M							
Ute Mountain Ute Tribe		L	H		L		M	H	M	M	M		M	L	M	H	H		H					
City of Aurora		L	M	L	L	L	M	M	H	L	M	L	M	M	M	L	H							
City of Boulder	L	H	H		M	L	L	H	M	L	M	L	L	L	M	H	M	M			L			
City of Colorado Springs		L	M	H	L			H	M	H	M	H	M	H	M	H	H	M	M	M				
City of Manitou Springs	L	L	M	H	L			H	M	H	M	L	M	M	L	H	H							
Thornton/ Federal Heights/ Northglenn		H	H	L	L	L	M	H	H		H	L	H	H	H	L	H							
City of Westminster		L	M		L		M	M	M		L		L	L	L	L	M	M	M					

**3.2 TOP FOUR HAZARD ANALYSIS**

For each of the state’s ‘top four’ hazards, a table was created showing those jurisdictions that rated that hazard as a one of their own local ‘top fours’. Counties not included in this analysis either have expired or no local mitigation plans and includes Jackson, Moffat, Rio Blanco, and San Juan Counties. The following tables show the vulnerability and potential loss estimates for severe winter weather (Table 3-275), wildfire (Table 3-276), flood (Table 3-277), and drought (Table 3-278). Additional hazards that made local jurisdiction’s ‘top four’ list of hazards include avalanche, earthquake, expansive soils, extreme heat, pest infestation, hail, landslide, subsidence, thunderstorm, tornado, severe wind, human health (pandemic), dam failure, and hazardous materials release. These tables include the applicable structure and critical facility information, vulnerability and loss estimates, and any additional development notes.

**TABLE 3-275 JURISDICTIONS WITH SEVERE WINTER WEATHER RANKED AS A ‘TOP FOUR HAZARD’**

Jurisdiction	# of Structures in Hazard Area	# Critical Facilities in Hazard Area	Loss Estimate	Local Development Concerns*
<b>Alamosa County</b>		18		
<b>Archuleta County</b>	18,356	63		
<b>City of Aurora</b>	96,098	313	\$759,803	
<b>Boulder County</b>	60,000 (50% of 120,137 properties likely severely damaged)	1,405		As building and population trends continue to increase, more persons will be exposed to the winter storm hazard, therefore increasing pressure on local government snow removal and emergency services.
<b>City and County of Broomfield</b>	23,564 (total housing units)	20		
<b>Chaffee County</b>	9,943	107 (all critical facilities)	\$224,666	
<b>Cheyenne County</b>	1,922	47		
<b>Clear Creek County</b>	5,244	9	\$815,800	Clear Creek County is a historic mining district that has only seen modest land development since. There is extensive large-lot development however in the eastern-most areas of the county adjoining Jefferson County. Most all of the commercial development is located within the towns and

Jurisdiction	# of Structures in Hazard Area	# Critical Facilities in Hazard Area	Loss Estimate	Local Development Concerns*
				cities along I-70 bordering Clear Creek.
<b>City of Colorado Springs</b>	All structures			Continuing development pressures along the Front Range will likely increase the overall vulnerability. New development should be able to withstand significant snow loads.
<b>Conejos County</b>	5,653	37		
<b>Costilla County</b>	2,613 (total homes in County)	36 (all critical facilities)		
<b>Crowley County</b>	2,143	117		
<b>Custer County</b>	4,486	61	\$285,000	
<b>Delta County</b>	15,125	92		Unincorporated areas do not have building codes.
<b>City and County of Denver</b>	211,619	2,618		Stricter codes for snow loads.
<b>Dolores County</b>	1,747	69	\$53,685	
<b>Eagle County</b>	24,222			
<b>El Paso County (Unincorporated)</b>	234,843	1,044	\$11,715,435,338	
<b>Elbert County</b>	9,816	66		
<b>Gilpin County</b>	3,843	47	\$775,000	
<b>Grand County</b>		170		Population growth in the County and growth in visitors will increase problems with road, business, and school closures and increase the need for snow removal and emergency services related to severe winter weather events.
<b>Gunnison County</b>	15,455	127	\$19,225	
<b>Hinsdale County</b>		34		
<b>Jefferson County</b>	205,858	1,499	\$12,299,742	
<b>Kiowa County</b>	1,474	42		
<b>Kit Carson County</b>	6,113	186		
<b>La Plata County</b>	25,860 (only housing units)	99 (total critical facilities)		New structures built in La Plata County should be able to withstand significant snow load snow loads when constructed to current

Jurisdiction	# of Structures in Hazard Area	# Critical Facilities in Hazard Area	Loss Estimate	Local Development Concerns*
				building codes. There have been several local amendments to the international codes, including a formula to establish the roof snow load based on the elevation of a building site. Development in more remote areas of the county may be more susceptible to access issues for emergency services and road crews.
Lake County	8,937 (total structures)	57 (total critical facilities)	\$14,437	
Larimer County	159,154 (total structures)	937 (total critical structures)		
Las Animas County	14,232	338	\$27,500	
Lincoln County	3,815	146		
Logan County	11,912	73		
City of Manitou Springs				
Mesa County		378 (total critical structures)		
Mineral County	1,575	3		
Montezuma County	38,904	124	\$1,053	
Montrose County (Unincorporated)		13		
Otero County	12,103	344		
Park County	334,741		\$234,708,300	
Phillips County	3,996	30		
Pitkin County	10,913	99		
Prowers County	7,933	287		
Rio Grande County	9,482	45		
San Miguel County	7,263	9		
Summit County	14,467	123		
Teller County	14,819	112	\$516,795,334	
Thornton/Federal Heights/Northglenn	64,000 (housing units)	395 (parcels containing critical facilities)		

Jurisdiction	# of Structures in Hazard Area	# Critical Facilities in Hazard Area	Loss Estimate	Local Development Concerns*
<b>Ute Mountain Ute</b>				
<b>Washington County</b>	4,539	39		
<b>Weld County</b>	121,749	1,284		
<b>City of Westminster</b>		36		
<b>Yuma County</b>	7,511	159		

\*Whenever possible, local information about development trends and pressures has been collected from Local HMPs and included in this table.

TABLE 3-276 JURISDICTIONS WITH WILDFIRE RANKED AS A 'TOP FOUR HAZARD'

Jurisdiction	# of Structures in Hazard Area	# Critical Facilities in Hazard Area	Loss Estimate	Local Development Concerns*
<b>Alamosa County</b>		18		
<b>Arapahoe County</b>		136		Updating new building codes.
<b>Archuleta County</b>	6,387	45	\$2,233,393,273	
<b>City of Boulder</b>	3,907	4	\$1,530,604,000	
<b>Chaffee County</b>	6,579	57	\$1,944,720,000	
<b>Cheyenne County</b>		36		
<b>Clear Creek County</b>	2,059	101	\$395,000,000	Clear Creek County is a historic mining district that has only seen modest land development. There is extensive large-lot development however in the eastern-most areas of the county adjoining Jefferson County. Most all of the commercial development is located within the towns and cities along I-70 bordering Clear Creek.
<b>City of Colorado Springs</b>	28,351 (parcels)			Building standards can offer only limited protection from fire damage. Increasing population growth and development increases vulnerability to fires, specifically along the foothills.
<b>University of Colorado Boulder</b>				
<b>Conejos County</b>	5,653	37		
<b>Costilla County</b>	723	33		Comprehensive plan

Jurisdiction	# of Structures in Hazard Area	# Critical Facilities in Hazard Area	Loss Estimate	Local Development Concerns*
				discourages development in fire prone areas, wetlands, areas subject to erosion and other geologic hazards and in floodplains.
<b>Custer County</b>	4,179	53	\$1,591,430,000	
<b>Delta County</b>	2,792	64	\$424,003,316	Growth continues, there are community wildfire protection plans, but no mitigation review requirements for development.
<b>Dolores County</b>	1,104	36	\$703,609,000	
<b>Douglas County</b>	21,134	528	\$15,600,000,000	
<b>Eagle County</b>	15,367		\$17,690,470,000	
<b>El Paso County (Unincorporated)</b>	131,708	725	\$63,735,721,000	
<b>Elbert County</b>	900 (just in 2 high risk areas)	66		
<b>Fremont County</b>	15,288	221	\$5,744,537,170	
<b>Gilpin County</b>	3,326	40	\$1,602,888,000	
<b>Grand County</b>	23,279	123	\$7,689,125,055	
<b>Gunnison County</b>	6,678	10	\$3,168,259,529	
<b>Hinsdale County</b>		25		
<b>Huerfano County</b>	6,772	268	\$601,229,414	
<b>Jefferson County</b>	27,574	345	\$14,569,972,026	
<b>Kit Carson County</b>		155	\$5,600,000	
<b>La Plata County</b>	20,457		\$3,201,830,000	As the county and municipalities consider future changes to their comprehensive plans and development wildfire mitigation measures may be included regulations, important additions may include wildfire mitigation measures to support defensible spaces; Firewise construction, maintenance, and landscaping techniques; as well as access, driveway, and roadway standards.
<b>Lake County</b>	4,796	30	\$1,155	
<b>Larimer County</b>	159,154	25		

Jurisdiction	# of Structures in Hazard Area	# Critical Facilities in Hazard Area	Loss Estimate	Local Development Concerns*
Las Animas County	4,870	264	\$1,560,025,000	
Lincoln County		111		
Logan County		216		
City of Manitou Springs	1,359		\$264,075,512	
Mesa County				
Mineral County	0.4% land in hazard zone			
Montezuma County	5,426	124	\$2,220,531,000	
Montrose County (Unincorporated)			\$2,342,787,330	
Morgan County		211		
Ouray County	2,617	35	\$930,044,845	187 new properties developed in WUI between 2008 and 2013; greatest growth in Log Hill Village/Fairway Pines and North Log Hill Mesa.
Park County		137	\$1,124,755,018	
Phillips County		35		
Pitkin County	10,913		\$14,585,000,000	
Pueblo County	11,338			
Rio Blanco County				
Rio Grande County				
Saguache County				
San Miguel County	6,891	15		
Sedgwick County		63		
Southern Ute Indian Tribe	1,969		\$341,580,671	
Summit County	19,662	36	\$10,642,912,909	
Teller County	14,809	101	\$2,582,852,293	
Ute Mountain Ute Tribe	471	1	\$46,414,000	
Washington County		81		
Weld County	2,323	5	\$472,916,287	
Yuma County		100		

\*Whenever possible, local information about development trends and pressures has been collected from Local HMPs and included in this table.

TABLE 3-277 JURISDICTIONS WITH FLOOD RANKED AS A 'TOP FOUR HAZARD'

Jurisdiction	# of Structures in Hazard Area	# Critical Facilities in Hazard Area	Loss Estimate	Local Development Concerns*
<b>Adams County</b>	4,461	6	\$315,824,000	High probability of increased development in floodplain.
<b>Alamosa County</b>	1,259	4	\$57,441,000	New development controlled through development regulations.
<b>Arapahoe County</b>	294	66	\$41,000,000	
<b>Archuleta County</b>	326	2	\$13,404,490	
<b>City of Aurora</b>	7,392	0	\$10,512,223,000	Wise land decisions as future growth impacts flood hazard areas. Participates in NFIP and adopted flood damage prevention codes.
<b>Baca County</b>		0	\$2,367,000	
<b>Bent County</b>		130	\$5,503,000	
<b>Boulder County</b>	3,040	51	\$1,555,460,000	
<b>City of Boulder</b>	2,021	41	\$489,967,000	Development that occurs is typically re-development of a previously developed area. The 2006 redevelopment of the Crossroads Mall into the 29th Street shopping district is an example. This development considers flood hazard risk from Boulder Creek and includes a Home Depot elevated to provide protection from the 100-year flood.
<b>City and County of Broomfield</b>	59	0		
<b>Chaffee County</b>	532	13	\$400,246,000	
<b>Cheyenne County</b>		10	\$6,151,000	

Jurisdiction	# of Structures in Hazard Area	# Critical Facilities in Hazard Area	Loss Estimate	Local Development Concerns*
Clear Creek County	143	9	\$14,369,000	
City of Colorado Springs	6,107	8	\$937,952,000	No new structures to be built in floodway.
University of Colorado		40	\$87,370,100	
Conejos County		0	\$4,440,000	
Costilla County		13	\$120,835,308	Comprehensive plan discourages development in wetlands, areas subject to erosion, and other geologic hazards and in floodplains.
Crowley County			\$15,848,000	
Custer County	79	3	\$22,588,324	
Delta County	124	23	\$21,468	Need to undertake floodplain studies on 10 streams. Need to strengthen floodplain ordinances.
City and County of Denver	1,468	134	\$79,404,645	Floodplain ordinance with consequences.
Dolores County	39	3	\$4,825,000	
Douglas County	452	101	\$18,680,574	Zoning regulations prohibit various types of development within the floodplain.
Eagle County	886			
El Paso County	5,556	114	\$1,692,013,000	Part of NFIP - prepared for moderate growth.
Elbert County	545	0	\$23,690,000	
Fremont County	1,258	37	\$157,985,000	
Gilpin County	55	8	\$18,636,000	
Grand County	199	2	\$16,812,176	
Gunnison County	591	3	\$48,460,652	
Hinsdale County		28	\$2,000,000	
Huerfano County	372	89	\$20,405,619	
Jefferson County	4,843	224	\$705,804,417	
Kiowa County			\$2,365,000	

Jurisdiction	# of Structures in Hazard Area	# Critical Facilities in Hazard Area	Loss Estimate	Local Development Concerns*
Kit Carson County		0	\$3,060,000	
La Plata County	23180	5	\$88,050,000	La Plata County, and its incorporated cities and towns, have floodplain policies regulating development in flood prone areas. Some flood protection measures are provided in the City and Town Ordinances and La Plata County Flood Hazard Regulations for areas within the 100-year Floodplains, regulating development in flood prone areas.
Lake County	752	0	\$1,687,000	
Larimer County	126,553	38	\$145,111,080	
Las Animas County	271	5	\$36,916,000	
Lincoln County		43	\$8,920,000	
Logan County		8	\$52,966,000	
City of Manitou Springs	480	10	\$192,051,000	
Mineral County			\$6,050,000	
Montezuma County	3366	28	\$62,266,000	
Montrose County			\$3,580,460	
Morgan County		10	\$97,477,000	
Otero County			\$40,756,000	
Ouray County	78	2	\$7,180,748	
Park County	5611	38	\$26,876,000	
Phillips County		13	\$27,783,000	
Pitkin County			\$71,590,000	
Prowers County		50	\$112,838,000	
Pueblo County	1,298		\$1,205,174,000	
Rio Grande County	797	2	\$47,419,000	

Jurisdiction	# of Structures in Hazard Area	# Critical Facilities in Hazard Area	Loss Estimate	Local Development Concerns*
Saguache County	335	1	\$12,494,000	
San Miguel County	2098	9		
Sedgwick County		5	\$5,079,000	
Southern Ute Indian Tribe	138	99	\$12,994,040	
Summit County	499	1	\$172,477,598	
Teller County	182	25	\$3,973,500	
Thornton/Federal Heights/Northglenn	1682	67	\$9,200,000	
Ute Mountain Ute Tribe	71		\$176,000	
Washington County		1	\$6,798,000	
Weld County	2,096	55	\$54,067,400	
City of Westminster		0		Participates in NFIP.
Yuma County		10	\$29,543,000	

\*Whenever possible, local information about development trends and pressures has been collected from Local HMPs and included in this table.

TABLE 3-278 JURISDICTIONS WITH DROUGHT RANKED AS A 'TOP FOUR HAZARD'

Jurisdiction	# of Structures in Hazard Area	# of Critical Facilities in Hazard Area	Loss Estimate	Local Development Concerns*
Adams County	0	0		
Alamosa County	0	0		
Arapahoe County	0	0		
Archuleta County	0	0		
Baca County	0	0	\$2,290,000	
Bent County	0	0	\$340,000	
Boulder County	0	0		Future growth in the unincorporated areas will mean more wells and more demands on groundwater resources.

Jurisdiction	# of Structures in Hazard Area	# of Critical Facilities in Hazard Area	Loss Estimate	Local Development Concerns*
City of Boulder	0	0		
Chaffee County	0	0		
Cheyenne County	0	0	\$3,200,000	
City & County of Denver	0	0		Water resource planning and sustainability goals.
City of Aurora	0	0		
City of Westminster	0	0		
Clear Creek County	0	0		Clear Creek County is a historic mining district that has only seen modest land development since that period. There is extensive large-lot development however in the eastern-most areas of the county adjoining Jefferson County. Most all of the commercial development is located within the towns and cities along Interstate 70 bordering Clear Creek.
Conejos County	0	0		
Costilla County	0	0		
Crowley County	0	0	\$47,00	
Custer County	0	0		
Delta County	0	0	\$23,274,106	
Dolores County	0	0	\$221,928	
Douglas County	0	0		Water supply concerns.
Gunnison County				
Huerfano County	0	0	\$1,748,800	
Kiowa County	0	0	\$1,470,000	
Kit Carson County	0	0	\$5,600,000	
Las Animas County	0	0		
Lincoln County			\$1,200,000	
Logan County			\$1,600,000	
Mineral County	0	0		
Montezuma County	0	0		
Morgan County			\$1,500,000	
Otero County	0	0	\$227,000	
Park County	0	0		
Phillips County	0	0	\$1,700,000	

Jurisdiction	# of Structures in Hazard Area	# of Critical Facilities in Hazard Area	Loss Estimate	Local Development Concerns*
<b>Prowers County</b>	0	0	\$1,262,000	
<b>Saguache County</b>	0	0		
<b>San Miguel County</b>	0	0		
<b>Sedgwick County</b>			\$711,00	
<b>Teller County</b>	0	0		
<b>Thornton/Federal Heights/Northglenn</b>	0	0		
<b>Washington County</b>	0	0	\$2,200,00	
<b>Yuma County</b>	0	0	\$2,000,000	

\*Whenever possible, local information about development trends and pressures has been collected from Local HMPs and included in this table.

#### 4. VULNERABILITY AND LOSS ESTIMATION METHODOLOGY

Table 3-279 below summarizes the methodologies used in the 2013 Colorado SHMP to analyze vulnerability and estimate losses associated with each identified hazard, and the updated methodologies used as part of the 2018 Plan update.

TABLE 3-279 VULNERABILITY AND LOSS ESTIMATION METHODOLOGY SUMMARY

Hazard	2013	2018
<b>Natural Hazards</b>		
<i>Atmospheric</i>		
<b>Dense Fog</b>	Hazard not profiled in 2013 Plan.	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• New assessment using National Oceanic and Atmospheric Administration's (NOAA) National Center for Environmental Information (NCEI) data for past events by county.</li> <li>• Crashes due to fog CDOT data for historic events.</li> </ul> <p><i>Future Conditions</i></p> <ul style="list-style-type: none"> <li>• Analysis using CO State Demography Office (DOLA) population projections and NCEI data.</li> <li>• Climate change narrative using best available data to Colorado.</li> </ul> <p><i>Loss Estimations:</i></p> <ul style="list-style-type: none"> <li>• New assessment of injuries and fatalities based on NCEI data.</li> <li>• Damages from NCEI.</li> </ul>

Hazard	2013	2018
<p><b>Drought</b></p>	<p><i>Vulnerability Analysis:</i> Integrate summary results of vulnerability analysis from the 2013 Colorado Drought Mitigation and Response Plan</p> <p><i>Loss Estimation:</i> Narrative</p>	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• Update to the methodology utilized in the 2013 SHMP</li> <li>• Integrated summary results of vulnerability analysis update from the 2018 Colorado Drought Mitigation and Response Plan.</li> <li>• Review and analysis of local hazard mitigation plans (Local HMPs).</li> <li>• State asset narrative</li> </ul> <p><i>Future Conditions</i></p> <ul style="list-style-type: none"> <li>• Integrated summary results of vulnerability analysis update from the 2018 Colorado Drought Mitigation and Response Plan.</li> <li>• Climate change narrative using best available data to Colorado.</li> </ul> <p><i>Loss Estimations:</i></p> <ul style="list-style-type: none"> <li>• Incorporate updated loss estimates from 2018 Drought Mitigation and Response Plan update (when available).</li> <li>• USDA crop losses by county.</li> <li>• Losses by jurisdiction from Local HMPs.</li> </ul>
<p><b>Extreme Heat</b></p>	<p><i>Vulnerability Analysis:</i> Assessment of historical extreme heat events based on data supplied by the National Weather Service and the USDA NRCS. Review and analysis of local hazard mitigation plan mitigation strategies and hazard profiles.</p> <p><i>Loss Estimation:</i> Narrative.</p>	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• Update to the assessment of historical extreme heat events based on data supplied by NOAA, USDA NRCS, and PRISM Climate Group.</li> <li>• Review and analysis of mitigation strategies and hazard profiles.</li> <li>• State asset narrative</li> </ul> <p><i>Future Conditions</i></p> <ul style="list-style-type: none"> <li>• Analysis using DOLA population projections and NCEI data.</li> <li>• Climate change narrative using best available data to Colorado.</li> <li>• State asset exposure analysis.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• Update to narrative.</li> <li>• Office of Risk Management (ORM) state asset losses.</li> <li>• Losses by jurisdiction from Local HMPs.</li> </ul>

Hazard	2013	2018
<b>Flood</b>	<p><i>Vulnerability Analysis:</i> Integrate summary results of vulnerability analysis from the 2013 Colorado Flood Hazard Mitigation Plan</p> <p><i>Loss Estimation:</i> Narrative</p>	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• Update to the methodology utilized in the 2013 SHMP</li> <li>• Conducting Standard Hazus analysis for each county.</li> <li>• Review and analysis of local HMP mitigation strategies and hazard profiles.</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Future exposure analysis using DOLA population projections, Hazus analysis, and NOAA</li> <li>• Climate change narrative.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• Update to existing methodology in the 2013 SHMP using updated Hazus estimations.</li> <li>• Review and analysis of local HMP mitigation strategies and hazard profiles.</li> <li>• FEMA flood insurance data.</li> <li>• State asset analysis using ORM data and Hazus analysis.</li> <li>• Losses by jurisdiction from Local HMPs.</li> </ul>
<b>Hail</b>	<p><i>Vulnerability Analysis:</i> Assessment of historical hail events based on data supplied by the Storm Prediction Center. Analysis of those areas vulnerable to hail to quantify relative vulnerability rankings between the state's counties. Review and analysis of local hazard mitigation plan mitigation strategies and hazard profiles. Assessment of future population growth trends and hazard exposure projections.</p> <p><i>Loss Estimation:</i> Analysis of counts and associated replacement costs of state assets, including critical facilities, that are exposed to hail vulnerability as defined by the Storm Prediction Center. Colorado State insured physical assets provided by the Office of Risk Management.</p>	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• Update to the assessment of historical hail events based on best available data supplied by NOAA.</li> <li>• Review and analysis of local HMP mitigation strategies and hazard profiles.</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Assessment of future population trends and hazard exposure using DOLA population projections and NOAA data.</li> <li>• Climate change narrative.</li> <li>• State asset exposure analysis.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• Using NOAA damage data, quantified losses across counties.</li> <li>• RMIIA data to quantify insurance losses.</li> <li>• ORM state asset losses.</li> <li>• Losses by jurisdiction from Local HMPs.</li> </ul>

Hazard	2013	2018
<b>Severe Wind</b>	<p><i>Vulnerability Analysis:</i> Assessment of historical severe wind events based on data supplied by the Storm Prediction Center. Analysis of those areas vulnerable to severe wind to quantify relative vulnerability rankings between the state's counties. Review and analysis of local hazard mitigation plan mitigation strategies and hazard profiles.</p> <p>Assessment of future population growth and hazard exposure projections.</p> <p><i>Loss Estimation:</i> Analysis of counts and associated replacement costs of state assets, including critical facilities, that are exposed to severe wind vulnerability as defined by the Storm Prediction Center. Colorado State insured physical assets provided by the Office of Risk Management.</p>	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• Update to the assessment of historical severe wind events based on best available data supplied by NOAA's Storm Prediction Center.</li> <li>• Review and analysis of local HMP mitigation strategies and hazard profiles.</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Assessment of future population trends and hazard exposure using DOLA population projections and NOAA data.</li> <li>• Climate change narrative.</li> <li>• State asset exposure analysis.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• Analysis using deaths, injuries, and damages using NOAA data by county.</li> <li>• ORM state asset losses.</li> <li>• Losses by jurisdiction from Local HMPs.</li> </ul>
<b>Thunderstorms and Lightning</b>	<p><i>Vulnerability Analysis:</i> Assessment of historical lightning events based on data supplied by the Storm Prediction Center. Review and analysis of local hazard mitigation plan mitigation strategies and hazard profiles. Assessment of future population growth trends and hazard exposure projections.</p> <p><i>Loss Estimation:</i> Narrative.</p>	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• New assessment of historical events based on data provided by NOAA's NCEI by county.</li> <li>• Review and analysis of local HMP mitigation strategies and hazard profiles.</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Assessment of future population trends and hazard exposure using DOLA population projections and NOAA data.</li> <li>• Climate change narrative.</li> <li>• State asset exposure analysis.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• New assessment of damages, deaths, and injuries by county using NOAA data.</li> <li>• ORM state asset losses.</li> <li>• Losses by jurisdiction from Local HMPs.</li> </ul>

Hazard	2013	2018
<p><b>Tornado</b></p>	<p><i>Vulnerability Analysis:</i> Assessment of historical tornado events based on data supplied by the Storm Prediction Center. Analysis of those areas vulnerable to tornadoes to quantify relative vulnerability rankings between the state's counties. Review and analysis of local hazard mitigation plan mitigation strategies and hazard profiles. Assessment of future population growth trends and hazard exposure projections. Analysis of social vulnerability present in high hazard areas.</p> <p><i>Loss Estimation:</i> Analysis of counts and associated replacement costs of state assets, including critical facilities, that are exposed to tornado vulnerability as defined by the Storm Prediction Center. Colorado State insured physical assets provided by the Office of Risk Management.</p>	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• Update to the assessment of historical tornado events based on best available data supplied by NOAA.</li> <li>• Review and analysis of local HMP mitigation strategies and hazard profiles.</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Assessment of future population trends and hazard exposure using DOLA population projections and NOAA data.</li> <li>• Climate change narrative.</li> <li>• State asset exposure analysis.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• Analysis of deaths, injuries, and damages by county using NOAA data.</li> <li>• ORM state asset losses.</li> <li>• Losses by jurisdiction from Local HMPs.</li> </ul>

Hazard	2013	2018
<p><b>Wildfire</b></p>	<p><i>Vulnerability Analysis:</i>  Assessment of historical wildfire events based on data supplied by the Colorado State Forest Service. Analysis of those areas vulnerable to wildfire to quantify relative vulnerability rankings between the state’s counties. Wildland Urban Interface (WUI)-specific analysis to quantify relative vulnerability rankings between the state’s counties. Review and analysis of local hazard mitigation plan mitigation strategies and hazard profiles. Assessment of future population growth trends and hazard exposure projections. Analysis of social vulnerability present in collective high hazard areas.</p> <p><i>Loss Estimation:</i> Analysis of counts and associated replacement costs of state assets, including critical facilities, that are exposed to wildfire vulnerability as defined by the Colorado State Forest Service. Colorado State insured physical assets provided by the Office of Risk Management.</p>	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• Update to the assessment of historical wildfire events based on best available data supplied by the Colorado State Forest Service (CSFS) and NOAA.</li> <li>• WUI-specific analysis to quantify relative vulnerability rankings between the state’s counties.</li> <li>• Review and analysis of local HMP mitigation strategies and hazard profiles.</li> <li>• State asset analysis using ORM data and CSFS wildfire threat data.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Assessment of future population trends and hazard exposure using DOLA population projections and wildfire risk data.</li> <li>• Climate change narrative.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• Analysis of deaths, injuries, and damages by county using NOAA and CSFS data.</li> <li>• Losses by jurisdiction from Local HMPs.</li> <li>• State asset loss estimations based on ORM data and CSFS wildfire threat data.</li> </ul>

Hazard	2013	2018
<p><b>Severe Winter Weather</b></p>	<p><i>Vulnerability Analysis:</i> Assessment of historical winter storm events based on data supplied by SHELDUS. Review and analysis of local hazard mitigation plan mitigation strategies and hazard profiles. Assessment of future population growth trends and hazard exposure projections.</p> <p><i>Loss Estimation:</i> Narrative.</p>	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• Update to the assessment of historical winter storm events based on best available data supplied by NOAA and USDA.</li> <li>• New assessment of historical blizzard, ice storm, freezing rain, and extreme cold events based on data provided by NOAA.</li> <li>• Review and analysis of local HMP mitigation strategies and hazard profiles.</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Assessment of future population trends and hazard exposure using DOLA population projections and NOAA data.</li> <li>• Climate change narrative.</li> <li>• State asset exposure analysis.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• Analysis of deaths, injuries, and damages by county using NOAA data.</li> <li>• ORM state asset losses.</li> <li>• Losses by jurisdiction from Local HMPs.</li> </ul>
<p><b>Geologic Hazards</b></p>		

Hazard	2013	2018
<p><b>Subsidence and Abandoned Mine Lands</b></p>	<p>Hazard not profiled in 2013 Plan</p>	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• New assessment of historical events based on data provided by the Colorado Division of Reclamation Mining and Safety and Colorado Geological Survey (CGS)/United States Forest Service (USFS) abandoned mine data.</li> <li>• Review and analysis of local HMP mitigation strategies and hazard profiles.</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Future development narrative.</li> <li>• Climate change narrative.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• ORM state asset losses.</li> <li>• Losses by jurisdiction from Local HMPs.</li> <li>• Loss narrative.</li> </ul>

Hazard	2013	2018
<p><b>Avalanche</b></p>	<p><i>Vulnerability Analysis:</i> Assessment of historical avalanche events based on data supplied by the Colorado Geological Survey. Analysis of those areas vulnerable to avalanches to quantify relative vulnerability rankings between the state's counties. Review and analysis of local hazard mitigation plan mitigation strategies and hazard profiles.</p> <p><i>Loss Estimation:</i> Analysis of counts and associated replacement costs of state assets, including critical facilities, that are exposed to avalanche vulnerability as defined by the Colorado Geological Survey. Colorado State insured physical assets provided by the Office of Risk Management.</p>	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• Update to the assessment of historical avalanche events based on best available data supplied by the CGS, NOAA, and the Colorado Avalanche Center.</li> <li>• Review and analysis of local HMP mitigation strategies and hazard profiles.</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Assessment of future population trends and hazard exposure using DOLA population projections and NOAA and CAIC data.</li> <li>• Climate change narrative</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• Deaths and injuries data from NOAA and CAIC.</li> <li>• Structure loss narrative.</li> <li>• ORM state asset losses.</li> <li>• Losses by jurisdiction from Local HMPs.</li> </ul>

Hazard	2013	2018
<p><b>Earthquake</b></p>	<p><i>Vulnerability Analysis and Loss Estimation:</i> Hazus analysis utilizing a number of model runs per county including: annualized events, known faults, and worst-case scenarios. Hazus utilized 2010 Census data, updated Highway Safety Improvement Plan (HSIP) inventory data, and Colorado Geological Survey soil and landslide inputs. Review and analysis of local hazard mitigation plan mitigation strategies and hazard profiles.</p> <p>Assessment of future population growth trends and hazard exposure projections. Analysis of social vulnerability present in high hazard areas.</p>	<p><i>Vulnerability Analysis</i></p> <ul style="list-style-type: none"> <li>• Historic events using CGS data.</li> <li>• Update to the Hazus analysis utilizing a number of model runs per county including: annualized events, known faults, and worst-case scenarios. Hazus utilized 2010 Census data, updated HSIP inventory data, and Colorado Geological Survey soil and landslide inputs.</li> <li>• Review and analysis of local HMP mitigation strategies and hazard profiles.</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Analysis using Hazus annual loss output and DOLA population projections.</li> </ul> <p><i>Loss Estimates:</i></p> <ul style="list-style-type: none"> <li>• Update to Hazus analysis.</li> <li>• Incorporation of the results from FEMA's 2017 Estimated Annualized Earthquake Losses (EAL) analysis.</li> <li>• ORM state asset loss analysis based on building construction type.</li> </ul>

Hazard	2013	2018
<p><b>Erosion and Deposition</b></p>	<p><i>Vulnerability Analysis:</i> Review and analysis of local hazard mitigation plan mitigation strategies and hazard profiles.</p> <p><i>Loss Estimation:</i> Narrative.</p>	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• Historic events provided by CGS.</li> <li>• Review and analysis of local HMP mitigation strategies and hazard profiles.</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Assessment of future population trends and hazard exposure using DOLA population projections and local HMP data.</li> <li>• Climate change narrative.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• Loss narrative.</li> <li>• Losses from Local HMPs.</li> <li>• State asset narrative.</li> </ul>
<p><b>Expansive Soils and Heaving Bedrock</b></p>	<p><i>Vulnerability Analysis:</i> Analysis of those areas vulnerable to expansive soils to quantify relative vulnerability rankings between the state's counties. Review and analysis of local hazard mitigation plan mitigation strategies and hazard profiles. Assessment of future population growth trends and hazard exposure projections.</p> <p><i>Loss Estimation:</i> Analysis of counts and associated replacement costs of state assets, including critical facilities, that are exposed to expansive soils vulnerability as defined by the Colorado Geological Survey. Colorado State insured physical assets provided by the Office of Risk Management.</p>	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• Historic events provided by CGS.</li> <li>• Review and analysis of local HMP mitigation strategies and hazard profiles.</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Assessment of future population trends and hazard exposure using DOLA population projections and local HMP data.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• Loss narrative.</li> <li>• Losses from Local HMPs.</li> <li>• State asset loss analysis using ORM and CGS data.</li> </ul>

Hazard	2013	2018
<p><b>Landslide/Mud/Debris Flows/Rock Fall/Rockslide</b></p>	<p><i>Vulnerability Analysis:</i> Assessment of historical landslide events based on data supplied by the Colorado Geological Survey. Separate analysis of those areas vulnerable to landslides, mud/debris flow, and rockfall to quantify relative vulnerability rankings between the state's counties. Review and analysis of local hazard mitigation plan mitigation strategies and hazard profiles. Analysis of social vulnerability present in high hazard areas for landslides, mud/debris flow, and rockfall.</p> <p><i>Loss Estimation:</i> Separate analysis of counts and associated replacement costs of state assets, including critical facilities that are exposed to landslides, mud/debris flow, and rockfall vulnerability as defined by the Colorado Geological Survey. Colorado State insured physical assets provided by the Office of Risk Management.</p>	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• Update to the assessment of historical landslide events based on best available data supplied by the CGS and CDOT.</li> <li>• Review and analysis of local HMP mitigation strategies and hazard profiles</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Assessment of future population trends and hazard exposure using DOLA population projections and local HMP data.</li> <li>• Climate change narrative.</li> </ul> <p><i>Loss Estimates:</i></p> <ul style="list-style-type: none"> <li>• Deaths, injuries, loss data provided by CDOT, CGS, and NOAA.</li> <li>• Losses from Local HMPs.</li> <li>• State asset loss analysis with data provided CGS, CDOT, and ORM.</li> </ul>
<p><b>Radon/Carbon Monoxide/Methane/Other Seeps</b></p>	<p>Hazard not profiled in 2013 Plan.</p>	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• New assessment of historical events based on data provided by the CGS.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Future development narrative.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• New narrative or methodology utilizing best available data provided by CGS.</li> <li>• State asset loss narrative.</li> </ul>
<p><b>Biological Hazards</b></p>		

Hazard	2013	2018
<b>Animal Disease Outbreak</b>	Hazard not profiled in 2013 Plan.	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• New assessment utilizing best available data from the Colorado Department of Agriculture (CDA) and CDPHE.</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Future development narrative.</li> <li>• Climate change narrative.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• New narrative or methodology utilizing best available data provided by CDA.</li> <li>• State asset loss narrative.</li> </ul>
<b>Pandemic/ Epidemiology (Epidemic/ Pandemic)</b>	Hazard not profiled in 2013 Plan.	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• New assessment utilizing best available data from the CDPHE and population data from the U.S. Census Bureau.</li> <li>• Local HMP analysis and narrative.</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Future development narrative and population projections provided by DOLA.</li> <li>• Climate change narrative.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• New narrative or methodology utilizing best available data from CDPHE.</li> <li>• Loss estimations from Local HMPs.</li> </ul>
<b>Other Hazards</b>		

Hazard	2013	2018
<b>Wildlife Vehicle Collisions</b>	Hazard not profiled in 2013 Plan.	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• New assessment utilizing best available data from Colorado Parks and Wildlife (CPW) and CDOT.</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Assessment of future population trends and hazard exposure using DOLA population projections and CDOT data.</li> <li>• Climate change narrative.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• Deaths, injuries, and damages by county provided by CDOT.</li> <li>• State asset loss narrative.</li> </ul>
<b>Pest Infestation</b>	<p><i>Vulnerability Analysis:</i> Narrative.</p> <p><i>Loss Estimation:</i> Narrative.</p>	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• Historic events provided by USDA, CSFS, and CDA.</li> <li>• Local HMP analysis and narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Future development narrative.</li> <li>• Climate change narrative.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• Update to loss narrative.</li> <li>• State asset loss narrative.</li> </ul>
<b>Technological Hazards</b>		
<b>Critical Infrastructure Disruption/ Failure</b>	Hazard not profiled in 2013 Plan.	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• New assessment utilizing best available historic data from the state and the Colorado Energy Assurance Emergency Plan 2016.</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Future development narrative.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• New narrative discussion based on analysis of available data.</li> <li>• State asset loss narrative.</li> </ul>

Hazard	2013	2018
<p><b>Dam/Levee Failure</b></p>	<p>Hazard not profiled in 2013 Plan.</p>	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• New assessment utilizing best available data from the Division of Homeland Security &amp; Emergency Management (DHSEM) and Colorado Division of Water Resources (DWR), State Engineer’s Office.</li> <li>• Local HMP analysis and narrative.</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Assessment of future population trends and hazard exposure using DOLA population projections and DWR data.</li> <li>• Climate change narrative.</li> <li>• State asset exposure analysis.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• Loss estimation narrative.</li> <li>• Local HMP loss estimations.</li> <li>• State asset losses using ORM and DWR data.</li> </ul>
<p><b>Hazardous Materials Release</b></p>	<p>Hazard not profiled in 2013 Plan.</p>	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• New assessment of historic events utilizing best available data for transportation and fixed facilities from the Colorado Emergency Planning Commission (CEPC), Colorado Oil and Gas Commission (COGCC), and CDPHE.</li> <li>• Local HMP analysis and narrative.</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Future development narrative.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• Injuries, deaths, and damages by county using USDOT data.</li> <li>• Local HMP loss estimations.</li> </ul>

Hazard	2013	2018
<b>Mine Accident</b>	Hazard not profiled in 2013 Plan.	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• New assessment utilizing best available historic data from the Colorado Division of Reclamation Mining and Safety.</li> <li>• Local HMP analysis and narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Future development narrative.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• Injuries, deaths, and damages by jurisdiction using best available data.</li> </ul>
<b>Power Failure</b>	Hazard not profiled in 2013 Plan.	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• New assessment utilizing best available historic data from the state and the Colorado Energy Assurance Emergency Plan 2016.</li> <li>• Local HMP narrative.</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Future development narrative.</li> <li>• Climate change narrative.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• New narrative discussion based on analysis of available data.</li> </ul>
<b>Radiological Release</b>	Hazard not profiled in 2013 Plan.	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• New assessment utilizing best available data from DHSEM and USDOT by county.</li> <li>• Local HMP narrative.</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Future development narrative.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• New assessment utilizing best available data from DHSEM.</li> <li>• State asset loss narrative.</li> </ul>
<b>Human-Caused Hazards (Terrorism to include the following)</b>		

Hazard	2013	2018
<b>Chemical, Biological, Radiological, and Nuclear Attacks</b>	Hazard not profiled in 2013 Plan.	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• New assessment utilizing best available data from DHSEM.</li> <li>• Local HMP analysis and narrative.</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Future development narrative.</li> <li>• Climate change narrative.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• New assessment utilizing best available data from DHSEM.</li> <li>• Scenario example analyses.</li> <li>• State asset loss narrative.</li> <li>• Local HMP loss narrative.</li> </ul>
<b>Cyber Attack</b>	Hazard not profiled in 2013 Plan.	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• New assessment utilizing best available historic data from DHSEM and CDOT.</li> <li>• Local HMP narrative.</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Future development narrative.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• New assessment utilizing best available data from DHSEM.</li> <li>• Local HMP loss narrative.</li> <li>• State asset loss narrative.</li> </ul>
<b>Explosive Attack</b>	Hazard not profiled in 2013 Plan.	<p><i>Vulnerability Analysis:</i></p> <ul style="list-style-type: none"> <li>• New assessment utilizing best available historic data from DHSEM.</li> <li>• Local HMP narrative.</li> <li>• State asset narrative.</li> </ul> <p><i>Future Conditions:</i></p> <ul style="list-style-type: none"> <li>• Future development narrative.</li> </ul> <p><i>Loss Estimation:</i></p> <ul style="list-style-type: none"> <li>• New assessment utilizing best available data from DHSEM.</li> <li>• Local HMP loss narrative.</li> <li>• State asset loss narrative.</li> </ul>

## 5. RESOURCES

- The Coloradoan. December 16, 2015. Colorado ski industry generates nearly \$5B to economy. <https://www.coloradoan.com/story/sports/outdoors/2015/12/16/colorado-ski-industry-economy/77421260/>. Accessed February 2018.

## SECTION 4. CAPABILITIES

# SECTION 4. CAPABILITIES

## CONTENTS

Section 4. Capabilities.....	4-2
Introduction.....	4-3
State Capabilities.....	4-3
1. Mitigation Responsibilities .....	4-3
2. State Mitigation Policies, Regulations, Practices, and Programs.....	4-15
3. Development in Hazard Prone Areas .....	4-50
4. State Mitigation Funding Capabilities.....	4-53
5. Obstacles and Challenges.....	4-70
Local Capabilities.....	4-73
1. Local Capability Overview.....	4-73
2. Evaluation of Local Capabilities.....	4-90

## LIST OF TABLES

Table 4-1 Colorado State Government Mitigation Responsibilities .....	4-4
Table 4-2 State Government Capability Summary .....	4-16
Table 4-3 Colorado State Government Capability Matrix .....	4-18
Table 4-4 State Funded Mitigation Programs Summary by Agency .....	4-53
Table 4-5 Federal, State, Local, and Non-Profit Mitigation Funding Sources in Colorado.....	4-63
Table 4-6 Local Capabilities Categories Evaluated.....	4-74
Table 4-7 Planning & Regulatory Capabilities Sub-categories.....	4-74
Table 4-8 Administrative & Technical Capabilities Sub-categories .....	4-75
Table 4-9 Financial Capabilities Sub-categories .....	4-76
Table 4-10 Education & Outreach Capabilities Sub-categories .....	4-76
Table 4-11 Local Capabilities .....	4-77

# INTRODUCTION

The assessment of mitigation capabilities is the next step after assessing hazard risk. The combination of these two elements provides the foundation for developing a comprehensive action strategy to mitigate risks in Colorado. An understanding of state government and local authorities and capabilities is necessary in order to develop a comprehensive and feasible mitigation strategy.

Hazard mitigation is implemented through a portfolio of capabilities. These capabilities include regulations, codes, plans, public education efforts, preparedness initiatives, and structural approaches. The Capabilities Assessment represents the SHMT's best effort to identify state and local agencies, policies, regulations, plans, personnel, and programs that play a significant role in protecting life, property, and infrastructure. Information in this section as it pertains to Colorado state government was reviewed and updated as necessary as part of the 2018 Plan update process.

## STATE CAPABILITIES

State departments are responsible, within their statutory authorities, to perform direct activities and/or provide assistance and support to local jurisdictions in identifying risks to hazards. This assistance includes developing and running programs to provide technical assistance and funding to develop and implement mitigation actions to reduce those identified risks.

This section provides a discussion of Colorado state government's financial, legal, and programmatic ability to carry out mitigation actions in the pre-and post-disaster setting to achieve its mitigation goals and objectives. The mitigation capabilities are addressed by evaluating how a program, policy, regulation, or practice contributes to the statewide mitigation program, but also address areas in which the state needs to strengthen its capabilities by providing applicable limitations. Additionally, the discussion of state capabilities is extended to provide an overview of how they address development in hazard-prone areas and to highlight general changes in capabilities since approval of the previous plan.

Additional discussion on state government capabilities includes what funding mechanisms are in place to improve or sustain capabilities and implement the mitigation strategy. This discussion includes the assessment of funding capabilities for hazard mitigation projects to include their limitations and where additional funding is necessary.

### 1. MITIGATION RESPONSIBILITIES

Thirty-five agencies and organizations are identified as having mitigation responsibilities within the statewide mitigation program. The state agencies are represented by eight state departments (denoted by a gray background in Table 4-1). Table 4-1 comprises the Colorado State Government Mitigation Responsibilities and provides a list of agencies and organizations

that have mitigation activities, and provides a general description of what those responsibilities entail.

In evaluating agencies with mitigation responsibilities, it was determined that not all agencies have identified capabilities or funding opportunities that benefit the statewide mitigation program. One future task of the DHSEM Mitigation Team and the SHMT is to refine what constitutes a mitigation responsibility and identify gaps in related capabilities, by department and to the appropriate division or office.

**TABLE 4-1 COLORADO STATE GOVERNMENT MITIGATION RESPONSIBILITIES**

<b>Department/ Agency</b>	<b>Mitigation Responsibilities</b>
<b>Department of Agriculture (CDA)</b>	<ul style="list-style-type: none"> <li>• Strengthens agriculture’s future, provides consumer protection, promotes environmental quality, protects plant and animal health, and ensures equity and integrity in business and government.</li> <li>• Protects agricultural producers through appropriate activities for disease control in plants and livestock and helps to maintain business continuity for Ag producers to mitigate further losses.</li> <li>• During natural disasters affecting Ag, CDA is the state supporting agency for Ag issues and serves as the ESF #11 Emergency Response Coordinator for Agriculture.</li> <li>• Participates as a member of State Hazard Mitigation Team (SHMT).</li> </ul>

Department/ Agency	Mitigation Responsibilities
<p><b>CDA</b></p> <p><b>Animal Health Division</b></p>	<ul style="list-style-type: none"> <li>• Maintains responsibility for animal health and disease control activities in Colorado - commonly known as the State Veterinarian Office.</li> <li>• Works cooperatively with livestock industry, veterinary medical organizations, and other state and federal agencies to protect health, welfare, and marketability of Colorado livestock through livestock import rules / compliance.</li> <li>• Serves as the lead agency when there is a significant livestock disease outbreak – serves to lead the response to control, mitigate, and eliminate the disease.</li> <li>• At the time of a zoonotic disease event (affecting both animal and public health), it is a co-lead agency with the Colorado Department of Public Health &amp; Environment (CDPHE) for disease control and mitigation of the event.</li> <li>• At the time of mass mortality event of livestock, CDA has an MOU with CDPHE whereby CDA is the lead agency for carcass disposal of those livestock mortalities.</li> <li>• Issues quarantines for livestock premises to restrict the movement of livestock and livestock products (on the farm) in order to control disease and protect and mitigate further losses to livestock producers and owners.</li> <li>• Determines necessary biosecurity and testing required before the release of quarantines to mitigate further losses and impact on Colorado livestock and farmers/ranchers.</li> <li>• Develops and builds emergency disease response plans, policies, and protocols to mitigate the impact of a significant livestock disease outbreak.</li> <li>• Works with the different livestock sectors in Colorado such as the beef, dairy, swine, small ruminants, alternative livestock, and poultry industries to develop plans for continuity of business operations by the use of “Secure Food Supply” plans so that emergency disease response activities do not cripple their farming / ranching operations. These plans are called Secure Milk Supply, Secure Egg Supply, Secure Beef Supply, and Secure Pork Supply.</li> <li>• Building relationships with local ranchers, veterinarians, emergency managers, Extension Agents, state EM field staff, and federal Ag related agency representatives for better communication and information sharing in response to Ag issues to mitigate the losses that can occur in natural disaster or disease disaster.</li> <li>• Participates as a member of State Hazard Mitigation Team (SHMT).</li> </ul>

Department/ Agency	Mitigation Responsibilities
<b>CDA</b>  <b>Conservation Services Division</b>	<ul style="list-style-type: none"> <li>• Provides technical and financial support, leadership and statewide coordination, and regulatory oversight to public/private landowners and agricultural businesses statewide on an array of natural resource management challenges.</li> <li>• The Colorado State Conservation Board is comprised of Conservation District representatives from Colorado's 10 watersheds and provides guidance to the Department of Agriculture for: dispersing state grant funds and direct assistance to the 76 Conservation Districts; developing training tools for long and short term planning, budgeting, and laws pertaining to local governance; performing as a board of appeals for landowners appealing Conservation District activities; and facilitating local conservation programs that improve soil health, water quality, water conservation, wildlife habitat, forest health, plant communities, and energy conservation.</li> <li>• Coordinates the efforts of local, state, and federal noxious weed managers; provides funding for local entities to carry out on-the-ground weed management projects; conducts education and outreach activities and supports similar local activities; and maintains close contact with neighboring states and counties to prevent the interstate spread of noxious weeds.</li> <li>• Imports, rears, establishes, and colonizes new beneficial organisms for control of specific plant and insect pests. Successful biological pest control reduces production costs, decreases amounts of chemicals entering the environment, and establishes colonies of beneficial insects offering a natural permanent pest control solution.</li> <li>• Participates as a member of State Hazard Mitigation Team (SHMT).</li> </ul>
<b>Department of Higher Education (DHE)</b>	<ul style="list-style-type: none"> <li>• Coordinates policy and state resources for 28 public institutions and several hundred proprietary schools and oversees two key loan programs; seeks to ensure that higher education is accessible and affordable to all Coloradoans.</li> <li>• Brings cultural and artistic education opportunities to citizens.</li> </ul>
<b>History Colorado (HC) Office of Archaeology &amp; Historic Preservation (OAHP)</b>	<ul style="list-style-type: none"> <li>• Helps individuals, communities, and organizations identify, protect, and preserve state cultural resources and foster appreciation of and respect for Colorado's cultural heritage.</li> <li>• State Historic Preservation Officer (SHPO) is responsible for administering program as defined in the National Historic Preservation Act of 1966, and administers state historic preservation laws and regulations.</li> <li>• Participates as a member of State Hazard Mitigation Team (SHMT).</li> </ul>
<b>Department of Human Services (DHS)</b>	<ul style="list-style-type: none"> <li>• Oversees state's 64 county departments of social/human services, public mental health system, services for people with developmental disabilities, juvenile corrections system, and all state and veterans' nursing homes.</li> </ul>
<b>Department of Local Affairs (DOLA)</b>	<ul style="list-style-type: none"> <li>• Provides a range of services to communities and local governments to build capacity and resilience, including specialized training, technical and financial assistance, and data and information.</li> <li>• Provides for establishment of Disaster Assistance Centers (DACs) and long-term recovery efforts.</li> <li>• Participates as a member of State Hazard Mitigation Team (SHMT).</li> </ul>

Department/ Agency	Mitigation Responsibilities
<p><b>DOLA</b></p> <p><b>Division of Housing (DOH)</b></p>	<ul style="list-style-type: none"> <li>• Provides federal and state funds to finance construction of new housing, rehabilitation of existing housing, and down payment and rental assistance.</li> <li>• Inspects hotels, motels, and multifamily homes built in the 17 counties without building departments.</li> <li>• Works with American Red Cross (ARC), FEMA, DHSEM, local OEMs, local housing authorities, rehabilitation agencies, and local county building departments to provide assistance and funds to families whose homes have been destroyed or in need of major repair following a disaster.</li> <li>• Provides various levels of damage assessment for homes and buildings affected by disaster; assists local officials in determining feasibility of repairs.</li> <li>• Participates in establishing community Disaster Assistance Centers (DACs), assists in locating suitable housing for victims, rehabilitation, repair, and replacement of single family, owner-occupied properties, temporary rental assistance for displaced families, and temporary rental expenses for renters.</li> <li>• Participates as a member of State Hazard Mitigation Team (SHMT).</li> </ul>
<p><b>DOLA</b></p> <p><b>Division of Local Government (DLG)</b></p>	<ul style="list-style-type: none"> <li>• Delivers technical, financial, and information services to local governments.</li> <li>• Manages grant and loan programs within DOLA designed to address planning, public facility, and service needs; provides technical assistance to municipalities, counties, and special districts on budgeting, financial management, special district elections, drinking water and wastewater systems, and other matters.</li> <li>• Provides population and socio-economic data analyses and forecasts to local governments and general public. (State Demography Office)</li> <li>• Provides training and resources on integrating hazards and mitigation into community land use planning, including the <i>Planning for Hazards: Land Use Solutions for Colorado</i> guide and website (<a href="http://www.planningforhazards.com">www.planningforhazards.com</a>). Offers webinars and collaborative workshops with DHSEM and other partners.</li> <li>• Funds county and municipal Comprehensive Plans and requires the plan to address hazards and mitigation.</li> <li>• With local governments and partner agencies, sets up Disaster Assistance Centers (DACs).</li> <li>• Provides long-term recovery planning and disaster assistance to local governments and communities through grant funding and technical assistance, including funding mitigation projects for local governments.</li> <li>• Participates as a member of State Hazard Mitigation Team (SHMT).</li> </ul>
<p><b>DOLA</b></p> <p><b>DLG</b></p> <p><b>Colorado Resiliency Office (CRO) (formerly CRRO)</b></p>	<ul style="list-style-type: none"> <li>• Created as the Colorado Resiliency &amp; Recovery Office (CRRO) following the 2013 floods as an independent agency reporting to the Governor's Office.</li> <li>• Supports and helps empower Colorado communities in building stronger, safer, and more resilient in the face of natural disasters and other major challenges.</li> <li>• Hosted inaugural Colorado Resiliency Summit on June 4, 2014.</li> <li>• Colorado Resiliency Working Group (CRWG) created to steer interagency development of a resiliency framework.</li> <li>• Colorado Resiliency Framework (CRF) released May 28, 2015.</li> <li>• Maintains <a href="http://www.coresiliency.com">www.coresiliency.com</a> website of resources for individuals and local governments.</li> <li>• Transferred to DOLA-DLG on May 24, 2018 as a result of HB 18-1394 and renamed the Colorado Resiliency Office (CRO).</li> <li>• Colorado Resiliency Institutionalization Project (CORIP) launched in 2018 to explore ways to more formally build resiliency into state operations and investments.</li> </ul>

Department/ Agency	Mitigation Responsibilities
<b>Department of Natural Resources (DNR)</b>	<ul style="list-style-type: none"> <li>• Mandated to conserve, protect, promote development, and regulate use and enjoyment of state natural resources related to water, minerals, mineral fuels, soil conservation, reclamation of mined land, management of state lands, wildlife, parks, outdoor recreation, geological features, and mine safety.</li> <li>• Participates as a member of State Hazard Mitigation Team (SHMT).</li> </ul>
<b>Colorado Avalanche Information Center (CAIC)</b>	<ul style="list-style-type: none"> <li>• Protects people and property by reducing or eliminating short- and long-term risks from avalanches.</li> <li>• Provides forecasting, online tools, and maps to avoid or reduce vulnerability and losses to avalanche hazards.</li> <li>• Increases public safety through extensive educational programs and educational aids readily available to the public.</li> <li>• Referral agency for addressing avalanche hazards with various land use planning.</li> <li>• Participates as a member of State Hazard Mitigation Team (SHMT).</li> </ul>
<b>Division of Parks &amp; Wildlife (DPW)</b>	<ul style="list-style-type: none"> <li>• Perpetuates wildlife resources; provides quality state parks system and sustainable outdoor recreation opportunities to educate and inspire active stewards of Colorado's natural resources; administers state trail program; registers boats, snowmobiles, off-highway vehicles, and river outfitters.</li> <li>• Issues hunting and fishing licenses, enforces regulations; conducts research to improve wildlife management activities, protects high priority wildlife habitat through acquisitions and partnerships; provides technical assistance to private and other public landowners concerning wildlife and habitat management; develops programs to understand, protect, and recover threatened and endangered species.</li> </ul>
<b>Department of Natural Resources (DNR)</b>  <b>Colorado Water Conservation Board (CWCB)</b>	<ul style="list-style-type: none"> <li>• Promotes conservation of waters of the State of Colorado to secure greatest utilization of such waters and utmost prevention of floods.</li> <li>• Directed in Section 37-60-106(1) C.R.S. (1990) to prevent flood damages, review and approve floodplain designations prior to adoption by local government entities, and provide local jurisdictions with technical assistance and floodplain information.</li> <li>• Provides assistance to entities in meeting requirements of the National Flood Insurance Program (NFIP); funds mapping efforts.</li> <li>• Chairs multi-agency Flood Task Force; monitors state for possible flood conditions; Co-Chairs the Water Availability Task Force (WATF) and coordinates the Drought Task Force when activated.</li> <li>• Participates in multi-agency Flood Technical Assistance Partnership (TAP).</li> <li>• Leads maintenance of Colorado Flood Hazard Mitigation Plan; administers Community Assistance Program (CAP).</li> <li>• Promotes efficient water usage, provides public information, technical, and financial assistance for water conservation planning; promotes drought planning, encourages and assists communities to prepare and implement drought mitigation plans through technical and financial assistance; monitors drought impacts, and informs public, media, and state officials.</li> <li>• Leads development and maintenance of Colorado Drought Mitigation and Response Plan.</li> <li>• Leads the Colorado Emergency Watershed Protection (EWP) to incorporate recovery measures into watersheds impacted by the 2013 floods.</li> <li>• Participates as a member of State Hazard Mitigation Team (SHMT).</li> </ul>

Department/ Agency	Mitigation Responsibilities
<p><b>DNR</b></p> <p><b>Division of Water Resources (DWR)</b></p> <p><b>(Office of the State Engineer)</b></p> <p><b>Dam Safety Program</b></p>	<ul style="list-style-type: none"> <li>• Administers water rights, issues water well permits, represents Colorado in interstate water compact proceedings, monitors streamflow and water use, approves construction and repair of dams, performs dam safety inspections, issues licenses for well drillers and assures safe and proper construction of water wells, and maintains numerous databases of Colorado water information.</li> <li>• Administers Dam Safety Program; determines safe storage level of reservoir dams by conducting regular safety inspections of jurisdictional dams by dam safety engineers.</li> <li>• Reviews and approves plans and specifications for construction and repair of jurisdictional dams; conducts construction inspections by dam safety engineers.</li> <li>• Prioritizes jurisdictional dams; maintains data information system to meet public information needs; provides training and professional development of personnel; participates in development of national policies on dam safety.</li> <li>• Maintains repository for Emergency Action Plans (EAPs) and dam failure inundation maps for High and Significant Hazard dams.</li> <li>• Regionally located dam safety engineers coordinate capabilities with local and state emergency managers and floodplain managers for preparedness and mitigation activities and emergency response to dam safety incidents.</li> <li>• Maintains publicly available data and database of dam information including hazard classification and latest condition assessment on the “Colorado Information Marketplace” website.</li> <li>• Maintains full voting membership in the Association of State Dam Safety Officials (ASDSO).</li> <li>• Participates as a member of State Hazard Mitigation Team (SHMT).</li> </ul>
<p><b>Office of Risk Management (ORM)</b></p>	<ul style="list-style-type: none"> <li>• Provides insurance coverage for state buildings, contents, boilers, machinery, aircraft, and employee fidelity; insures state for liability claims and workers’ compensation; works directly with state departments to provide training, technical, and insurance consulting services; supervises liability claim handling, related litigation, and issues certificates of insurance.</li> </ul>

Department/ Agency	Mitigation Responsibilities
<b>Department of Public Health &amp; Environment (CDPHE)</b>	<ul style="list-style-type: none"> <li>• Protects and preserves the public health and environment of people of Colorado through health programs, environmental programs, and administration.</li> <li>• Maintains role in mitigating hazards related to potential medical surges, water quality problems, stormwater permitting, air pollution monitoring, hazardous materials issues, or monitoring of critical infrastructure such as wastewater treatment plants and drinking water systems.</li> <li>• Provides detection and investigation for disease control and environmental epidemiology.</li> <li>• Lead state agency responsible for coordinating public health and medical response activities and supporting mass fatality response for all-hazard emergency or disaster events.</li> <li>• Develops and coordinates health emergency response plans; assesses natural and human-caused disasters and enhances public health response to those events; integrates public health and medical systems with other local and state partners; trains public health, medical, and emergency response partners on latest and improved protocols related to health, medical, and mortuary response; distributes health information and implements systems for effective, redundant communication among stakeholders involved in public health detection and response; assesses Colorado's ability to respond to medical care of victims during an emergency; identifies best practices for mass casualty response.</li> <li>• Provides disaster related services for emergency services personnel, disaster survivors, schools, businesses, and industry; provides pre-incident training and consulting to local departments of public health, post-disaster intervention services, and support to local communities throughout recovery.</li> <li>• Participates as a member of State Hazard Mitigation Team (SHMT).</li> </ul>
<b>Department of Public Safety (CDPS)</b>	<ul style="list-style-type: none"> <li>• Includes the Colorado Bureau of Investigation (CBI), Colorado State Patrol (CSP), Colorado Division of Criminal Justice (DCJ), Division of Fire Prevention &amp; Control (DFPC), Division of Homeland Security &amp; Emergency Management (DHSEM), and the Colorado School Safety Resource Center.</li> <li>• Provides emergency response as the Designated Emergency Response Authority (DERA) to HazMat incidents occurring within a highway right-of-way; provides assistance to other DERAs responsible for HazMat incidents elsewhere in the state, based on mutual aid agreements; responds to incidents to mitigate, reduce, and/or prevent potential negative effects on public health and environment.</li> <li>• Performs responsibility of "Incident Command" at highway related incidents; enforces state hazardous materials laws, rules, and regulations of transportation by highway; enforces routing, permitting, and safe transportation of hazardous materials; performs spot driver and vehicle inspections to determine compliance with standards.</li> <li>• Participates as a member of State Hazard Mitigation Team (SHMT).</li> </ul>
<b>CDPS</b>  <b>Division of Fire Prevention &amp; Control (DFPC)</b>	<ul style="list-style-type: none"> <li>• Trains and certifies firefighters, conducts fire safety inspections of public schools, hospitals, and nursing homes; coordinates wildfire response; provides firefighting resources when wildfires occur; completes wildland fire management billing and National Fire Incident Reporting System (NFIRS).</li> <li>• Provides fire prevention and code enforcement, wildfire preparedness, response, suppression, coordination and management, training and certification, public information and education, and technical assistance to local governments.</li> <li>• Provides for life safety, occupant protection, and training and exercises.</li> </ul>

Department/ Agency	Mitigation Responsibilities
<p><b>CDPS</b></p> <p><b>Division of Homeland Security &amp; Emergency Management (DHSEM)</b></p> <p><b>Chief of Staff's Office</b></p>	<ul style="list-style-type: none"> <li>• Responsible for general administrative management of the Division. This includes reviewing, updating, and developing policies and procedures, leading strategic initiatives, projects, staff development, and engagement in the Division's strategic planning.</li> <li>• Responsible for internal and external communications and stakeholder outreach and education.</li> <li>• The Strategic Communications and Outreach Section is responsible for communications with external stakeholders, media, and public. Supports the Division's four websites (DHSEM, MARS, CO-BEOC, CO Emergency) and multiple social media channels and digital platforms.</li> <li>• Responsible for support of the Homeland Security &amp; All Hazards Advisory Committee (HSAC).</li> </ul>
<p><b>CDPS</b></p> <p><b>DHSEM</b></p> <p><b>Office of Emergency Management (OEM)</b></p>	<ul style="list-style-type: none"> <li>• Provides comprehensive state emergency management program supporting local government and state agencies; addresses all phases of emergency management supporting all-hazards and disaster emergencies.</li> <li>• Integrates emergency management efforts across all levels of government, including state, local, tribal, and federal.</li> <li>• Provides planning and training services to local governments including financial and technical assistance, training and exercise support, mitigation, domestic preparedness, and disaster recovery; sponsors workshops for local elected officials and staff.</li> <li>• Leads maintenance of Colorado State Hazard Mitigation Plan (SHMP).</li> <li>• Manages FEMA mitigation grant programs, local hazard mitigation plan (HMP) activities, and mitigation public awareness and education projects; utilizes federal funds to promote local and state mitigation projects.</li> <li>• Coordinates state response and recovery program in support of local governments; maintains State Emergency Operations Center (SEOC) where emergency support function (ESF) representatives from other departments/agencies and federal agencies coordinate response to disaster emergencies.</li> <li>• Facilitates state-level training; works with local agencies and regions to ensure coordination in planning and implementation of local and regional exercises.</li> <li>• Leads the State Hazard Mitigation Team (SHMT).</li> </ul>
<p><b>CDPS</b></p> <p><b>DHSEM</b></p> <p><b>Office of Grants Management (OGM)</b></p>	<ul style="list-style-type: none"> <li>• Promotes and provides assistance for projects and programs to build, sustain, and deliver the capabilities necessary to prevent, protect against, mitigate, respond to, and recover from all hazards events.</li> <li>• Subrecipient Monitoring (SRM) Section conducts risk assessments of all subrecipients receiving a grant from DHSEM; conducts on-site monitoring, and provides subrecipients with technical assistance and grants management best practices.</li> <li>• The Grant Reporting &amp; Management Section oversees the grant management system (EMGrantsPro), a platform that delivers a seamless grant management solution for the entire grant lifecycle from application to closeout.</li> <li>• The Preparedness Grants &amp; Contract Section provides management and technical assistance for state and federal grants focused on pre-disaster preparedness.</li> <li>• The Recovery Grants Section provides management and technical assistance for state and federal grants focused on disaster recovery, including Public Assistance (PA) grants and Community Development Block Grant-Disaster Recovery (CDBG-DR).</li> <li>• Participates as a member of State Hazard Mitigation Team (SHMT).</li> </ul>

Department/ Agency	Mitigation Responsibilities
<p><b>CDPS</b></p> <p><b>DHSEM</b></p> <p><b>Office of Security and Prevention</b></p> <p><b>Colorado Information Analysis Center (CIAC)</b></p>	<ul style="list-style-type: none"> <li>• Serves as the focal point within the state for receiving, analyzing, and sharing threat-related information among private sector, local, tribal, and federal partners.</li> <li>• The All-Hazards Threat Analysis Unit receives, reviews, analyzes, and disseminates threat and hazard related information / intelligence. Shares criminal acts that may be related to terrorism threats that may directly affect Colorado.</li> <li>• The Watch Center produces consolidated situational awareness information and intelligence during any major incidents.</li> <li>• The Terrorism Liaison Officer (TLO) is an identified person responsible for reporting and disseminating suspicious activity and other criminal intelligence information to their local agency and the CIAC.</li> <li>• CIAC creates connections between federal, state, tribal, and local agencies and private sector partners promoting a strategic initiative for information sharing.</li> <li>• Participates as a member of State Hazard Mitigation Team (SHMT).</li> </ul>
<p><b>Department of Transportation (CDOT)</b></p>	<ul style="list-style-type: none"> <li>• Maintains responsibility for 9,144 mile highway system, including 3,429 bridges, handling over 28 billion vehicle travel miles (40 percent of all travel).</li> <li>• Utilizes variable message signs and highway radio advisories to warn of dangerous road and weather conditions including blizzards, rockfall potential, and road closures; uses road closure devices including road-closed signs, gates, and flashing lights to warn of closed roads due to adverse conditions.</li> <li>• Provides Avalanche Management Program and staff training in awareness, survival, and rescue techniques; provides forecasting to monitor snow conditions, issue hazard assessments, recommend road closures, and suggest avalanche control operations; performs active avalanche control operations using helicopters, avalaunchers, artillery, and snowshoe routes.</li> <li>• Designs bridges, culverts, and highways based on 100-year, 50-year, and 25-year flood design standards; performs benefit/cost analysis and 100-year flood consequence analysis; signs off on all projects and reviews existing work by other agencies (Hydraulic Unit); performs additional work necessary to design structures in floodplain.</li> <li>• Reviews, updates, and prioritizes action strategies for statewide list of CDOT scour critical bridges and bridges with unknown foundation based on risk level; performs site inspections, utilizing current USACE and FEMA reports, hydrologic, and hydraulic analyses; performs new hydrologic and hydraulic analyses where necessary, and creates action plans to reduce risks to bridges from scour.</li> <li>• Has expanded the authority and capabilities of its internal Office of Emergency Management to better manage incidents and emergencies across the state. This includes an increased focus on increasing resiliency and mitigating against hazards.</li> <li>• Resilience Program created in wake of 2013 flooding to build mitigation into rebuilding of damaged infrastructure, and analyze risks and resilience opportunities along the I-70 corridor.</li> <li>• Participates as a member of State Hazard Mitigation Team (SHMT).</li> </ul>

Department/ Agency	Mitigation Responsibilities
<b>CDOT</b>  <b>Geotechnical Program</b>	<ul style="list-style-type: none"> <li>• Administers Rockfall Program providing internal mitigation design and review for projects funded by rockfall mitigation budget; performs site inspections during project construction; provides personnel designated as first responders during rockfall related emergencies; installs control devices on rock walls for prevention; posts falling rock signs on highways.</li> <li>• Evaluates and prioritizes mitigation locations by utilizing Colorado Rockfall Hazard Rating System (CRHRS) and Colorado Rockfall Simulation Program; combines geologic and climate information with traffic and slope data to rank rockfall hazards according to severity of risk.</li> <li>• Participates as a member of State Hazard Mitigation Team (SHMT).</li> </ul>
<b>Other Resources/Capabilities</b>	
<b>Colorado Climate Center (CCC)</b>	<ul style="list-style-type: none"> <li>• Provides information and expertise on Colorado's climate through Climate Monitoring (data acquisition, analysis, and archiving), Climate Research, and Climate Services.</li> <li>• Responds to climate related questions and problems affecting the state.</li> <li>• Trains volunteers in collection of rain and hail data for improved radar estimates and detection; provides training and education opportunities to students and community members for improved local awareness of severe weather and other natural hazards, making Colorado more hazard resistant.</li> <li>• Participates as a member of both the Water Availability Task Force and Flood Task Force.</li> <li>• Participates as a member of State Hazard Mitigation Team (SHMT).</li> </ul>
<b>Colorado Geological Survey (CGS)</b>	<ul style="list-style-type: none"> <li>• Builds economies and sustainable communities free from geologic hazards for people to live, work, and play through good science, collaboration, and sound management of mineral, energy, and water resources.</li> <li>• Protects people and property by reducing or eliminating short- and long-term risks from geologic hazards and lack of safe, adequate water.</li> <li>• Reviews geological-suitability of schools and subdivision sites for local governments; provides statewide research on a variety of geologic hazards; assists state agencies with geological issues including rockfall areas, road alignments, and construction planning and support.</li> <li>• Provides geologic hazard, water quality data, groundwater-supply maps, online tools, and on the ground assistance to avoid or reduce vulnerability and losses to geologic hazards and lack of safe water.</li> <li>• Increases awareness and understanding of geologic issues in Colorado through educational programs.</li> <li>• Provides studies, maps, and statistical data from Mineral Resources &amp; Mapping Program to responsibly explore and develop critical mineral and energy resources.</li> <li>• Lead agency for maintaining Colorado Landslide Hazard Mitigation Plan, studies landslide areas throughout the state, and conducts debris flow studies; maintains Earthquake Reference Collection.</li> <li>• Referral agency for addressing geologic hazards with various land use planning.</li> <li>• Participates as a member of State Hazard Mitigation Team (SHMT).</li> </ul>

Department/ Agency	Mitigation Responsibilities
<b>Colorado State Forest Service (CSFS)</b>	<ul style="list-style-type: none"> <li>• Provides technical assistance in forest stewardship and wildfire mitigation planning and implementation to landowners, communities, local, state, and federal partners; increases awareness of fire’s role in ecosystem health and resilience; informs decision-makers of wildfire threat and risk; administers and implements science-based best management practices to reduce the negative impacts from wildfires to forested landscapes and watersheds (C.R.S § 23-31-201, 23-31-313).</li> <li>• Coordinates cooperatively with local, private, state, federal, and tribal partners.</li> <li>• Continues strategic effort of wildfire mitigation including hazard identification &amp; risk assessment, applied research and technology transfer, public awareness, training and education, incentives and resources, and leadership and coordination.</li> <li>• Administers NFPA Firewise USA™ program.</li> <li>• Maintains Colorado Wildfire Risk Assessment Portal (CO-WRAP).</li> <li>• Administers state and federal grant funds for wildfire risk reduction and forest resiliency projects.</li> <li>• Assists jurisdictions with identifying wildfire hazard areas and provides recommendations to reduce hazards.</li> <li>• Fulfills the role of the Division of Forestry within the Department of Natural Resources including mitigating hazards and restoring critical watersheds on state lands (C.R.S. § 24-33-201).</li> <li>• Establishes guidelines and criteria for Community Wildfire Protection Plans (CWPPs). Provides technical assistance during CWPP process and is one of three plan approvers.</li> <li>• Referral agency for addressing wildfire hazards with various land use planning.</li> <li>• Participates as a member of State Hazard Mitigation Team (SHMT).</li> </ul>
<b>Governor’s Office</b>	<ul style="list-style-type: none"> <li>• Possesses inherent responsibility, constitutional, and statutory authority to commit state and local resources (personnel, equipment, and finances) for purpose of “meeting the dangers to the state and its people presented by disasters.” [“Colorado Disaster Emergency Act of 1992” (Part 21 of Article 32, Title 24, Colorado Revised Statute, 1988 as amended)]</li> <li>• Makes state disaster declarations, at recommendation of Office of Emergency Management (OEM), and requests to president for a major disaster declaration.</li> <li>• Governor’s Disaster Emergency Council serves as an advisory council to the governor and OEM Director on matters pertaining to declarations of state disaster emergencies, and response and recovery activities of state government.</li> <li>• Works with state agencies including DHSEM/OEM to promote hazard awareness weeks.</li> <li>• Sponsors various conferences on hazard issues.</li> </ul>
<b>Governor’s Office of Information Technology (OIT)</b>	<ul style="list-style-type: none"> <li>• Provides centralized information technology management, purchasing, spending, and planning.</li> <li>• Maximizes efficiency of service delivery and operates as a seamless enterprise to deliver consistent, cost-effective, reliable, accessible, and secure services to satisfy needs of the citizens of Colorado, its business communities, and public sector agencies.</li> </ul>
<b>Colorado Energy Office (CEO) - Public Utilities Commission (PUC)</b>	<ul style="list-style-type: none"> <li>• Advances energy efficiency and renewable, clean energy resources.</li> <li>• Building an intrastate framework for handling energy emergencies such as cyber-attacks, major system outages, and threats to critical energy infrastructure statewide.</li> </ul>

Department/ Agency	Mitigation Responsibilities
<b>Natural Hazards Research &amp; Applications Information Center (NHRAIC)</b>	<ul style="list-style-type: none"> <li>• Advances and communicates knowledge on hazard mitigation, disaster preparedness, response, and recovery.</li> <li>• Serves as a national clearinghouse for research addressing economic loss, human suffering, and social disruption caused by natural disasters.</li> <li>• Maintains a library and annotated database to respond to requests for information.</li> <li>• Publishes monographs, working papers, and bibliographies related to natural hazards and mitigation programs; hosts symposia and workshops on natural hazards, and publishes a regular email listserv bimonthly newsletter.</li> </ul>
<b>Colorado Watershed Coalitions and Groups</b>	<ul style="list-style-type: none"> <li>• Brings together local, state, and federal agencies, along with nonprofit organizations and private land-owners to work to restore healthy and resilient streams and watersheds.</li> <li>• Implements projects to increase resilience of watersheds to multiple natural hazards.</li> </ul>

## 2. STATE MITIGATION POLICIES, REGULATIONS, PRACTICES, AND PROGRAMS

The Colorado State Government Capability Matrix (Table 4-3) identifies state regulations and authorities providing information on the legal foundation for the state government’s role in hazard mitigation and critically analyzes specific programs within agencies to assess their effectiveness in facilitating risk reduction. Most of the programs identified relate to natural hazards, but may also cover programs that overlap in reducing risks from all-hazards, including human-caused and technological. Table 4-3 also includes a designation of the program’s applicability to pre- and/or post-disaster mitigation.

Information in Table 4-3 was reviewed by the SHMT. Agencies were requested to review, revise, and update capabilities from the previous plan and provide a discussion on accomplishments as well as limitations. In addition, newly identified capabilities and significant changes to capabilities were requested to be added into the Capability Matrix along with whether the capability supported pre- or post-disaster mitigation.

Table 4-2 provides a summary of the state’s capabilities related to policies, regulations, practices, and programs, as well as their pre- and post-disaster application. Of the 100 total state capabilities identified, those related to programs and regulations are the most numerous with 47 and 40 total, respectively. There were 11 practices, one policy, and one law identified that contribute to mitigation. The high number of programs indicates the commitment of Colorado state government to statewide mitigation of natural, technological, and human-caused hazards.

The Colorado State Forest Service (CSFS) is currently aligned with 20 of the 100 state capabilities, representing 20 percent of the state’s total. These CSFS capabilities are strongly aligned with the continuing high risk of wildfire identified by the SHMT and local jurisdictions. The

Colorado Water Conservation Board (CWCB) is aligned with nine capabilities, four programmatic and five regulatory. The CWCB capabilities, coupled with the three capabilities supported by the Division of Water Resources (DWR), align well with the identification of flood and drought as high hazards in Colorado as well as in local jurisdictions.

**TABLE 4-2 STATE GOVERNMENT CAPABILITY SUMMARY**

Lead Agency	Policy	Practice	Program	Regulation	Law	Total	Pre-Disaster	Post-Disaster
Colorado Avalanche Information Center (CAIC)			1			1	1	1
Colorado Avalanche Information Center (CAIC) / Department of Transportation (CDOT) Avalanche Control			1			1	1	1
Colorado Climate Center (CCC)			2			2	2	
Colorado Department of Agriculture (CDA) Animal Health Division				5		5	5	5
Colorado Department of Agriculture (CDA) Conservation Services Division			2			2	2	1
Colorado Department of Public Safety (CDPS)				1		1	1	1
Colorado Department of Revenue (CDR)				1		1	1	
Colorado Geological Survey (CGS)			3	3		6	6	2
Colorado State Forest Service (CSFS)		4	10	6		20	20	4
Colorado State House				1		1	1	
Colorado Water Conservation Board (CWCB)			4	5		9	9	2
County Governments				5		5	5	
County Planning Commissions				2		2	2	
Department of Higher Education			7			7	7	1
Department of Natural Resources (DNR)			1	1		2	2	
Department of Transportation (CDOT) Geotechnical Program			1			1	1	1
DHSEM Chief of Staff Office			1			1	1	
DHSEM / OEM Community Preparedness			1			1	1	
DHSEM / OEM Field Services			1			1	1	
DHSEM / OEM Mitigation		3	4			7	5	2
Division of Fire Prevention & Control (DFPC)			2	4		6	6	0
Division of Local Government (DLG)		1	4			5	5	3
Division of Water Resources (DWR)				2		2	2	
Division of Water Resources (DWR) Dam Safety			1			1	1	
DOLA		1				1	1	
Governor's Office					1	1	1	
Governor's Office / DHSEM / OEM Strategic Communications		1				1	1	

<b>Lead Agency</b>	<b>Policy</b>	<b>Practice</b>	<b>Program</b>	<b>Regulation</b>	<b>Law</b>	<b>Total</b>	<b>Pre-Disaster</b>	<b>Post-Disaster</b>
<b>Local Governments</b>				1		1	1	
<b>State Government</b>				3		3	3	1
<b>Urban Drainage &amp; Flood Control District (UDFCD)</b>	1					1	1	
<b>Multi-agency</b>		1				1	1	
<b>Non-profit</b>			1			1	1	1
<b>Total Capabilities</b>	<b>1</b>	<b>11</b>	<b>47</b>	<b>40</b>	<b>1</b>	<b>100</b>	<b>98</b>	<b>26</b>

TABLE 4-3 COLORADO STATE GOVERNMENT CAPABILITY MATRIX

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
<b>Colorado Resiliency Framework</b>	DOLA	Division of Local Government (DLG) / CRO	Program, Policy	<ul style="list-style-type: none"> <li>Coordinates efforts to help communities recover from disasters and build resiliency throughout the state.</li> <li>Established formal Colorado Resiliency Working Group as ongoing coordination and steering committee for state's resiliency efforts.</li> <li>Incorporates mitigation into post-disaster recovery.</li> </ul>	Dependent on grant funding.	X	X
<b>CoAgMet (Colorado Agricultural Meteorological Network)</b>	CCC	Colorado Climate Center (CCC)	Program	<ul style="list-style-type: none"> <li>Automated weather stations mainly used for agricultural monitoring.</li> <li>Hourly datasets for temperature, relative humidity, wind speed/direction, solar radiation, soil temperature, precipitation, soil moisture (most CoAgMET stations now update every five minutes).</li> <li>Monitoring evapotranspiration for drought monitoring.</li> <li>Potential data source during severe weather.</li> </ul>	Precipitation is seasonal (tipping bucket gage not good for snow). Not all sites have soil moisture; hourly, not real-time data.	X	
<b>Colorado Community Collaborative Rain, Hail, &amp; Snow Network (CoCoRaHS)</b>	CCC	Colorado Climate Center (CCC)	Program	<ul style="list-style-type: none"> <li>High spatial coverage of precipitation reports.</li> <li>One of the most comprehensive datasets for hail measurements and characterization in the country.</li> <li>Educational outreach opportunities for reaching citizens.</li> </ul>	Inconsistency in reporting; not all stations report all the time.	X	
<b>Protection of Livestock from All Hazards Emergencies CRS § 35-50-101-114</b>	CDA	Animal Health Division	Regulation: Animal Health & Disease Control	<ul style="list-style-type: none"> <li>Oversees livestock movement into the state to prevent disease in Colorado.</li> <li>Control disease, mitigate losses, and recovery from disaster or disease.</li> <li>Proper carcass disposal to prevent disease and protect public and environment.</li> </ul>	Limited by compliance of livestock owners with import and testing rules. Limited by level of biosecurity or disease prevention practices on livestock operations.	X	X

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
					Limited by disease transmission (vectors) and susceptibility of animals.		
<b>State Emergency Preparedness &amp; Response Plans CRS § 35-50-105</b>	CDA	Animal Health Division	Regulation: Establishment of emergency preparedness plans	<ul style="list-style-type: none"> <li>• Protect livestock health and ranchers/farmers agricultural operations.</li> <li>• Plan, prepare, train, and exercise CDA staff, emergency response partners, and livestock producers.</li> </ul>	Limited by small number of staff to prepare for Ag emergencies. Limited by time spent in other livestock disease control efforts. Limited by lack of understanding of the importance of Ag by most citizens.	X	X
<b>USAHerds Animal Health Emergency Reporting Diagnostic System CRS § 35-57.9-101-104</b>	CDA	Animal Health Division	Regulation: Colorado Livestock Information Security Act	<ul style="list-style-type: none"> <li>• Database has livestock premises, movement, and animal ID data.</li> <li>• Capable of mapping locations and movements of livestock to mitigate losses of disasters and disease.</li> </ul> <p>Mapping of livestock premises aids in protecting animal and public health during wildfires, flooding, blizzards.</p>	Limited by data that is entered into the system through electronic documents that are migrated into system and through CDA data entry staff. Limited by availability to server and application – remote areas may not have internet capabilities. Limited by staff availability during emergencies.	X	X

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
<b>Secure Food Supply Plans CRS § 35-50-105</b>	CDA	Animal Health Division	Regulation to protect livestock in disease or other livestock emergencies	<ul style="list-style-type: none"> <li>• Use of movement controls, permitting, biosecurity, and surveillance to keep livestock and products moving in the face of disease outbreak.</li> <li>• Working with livestock industry to develop best COOP plans.</li> </ul>	<p>Limited by livestock industry willingness to cooperate and collaborate in planning.</p> <p>Limited by lack of current livestock industry's contingency plans and resources for response.</p> <p>Limited staff time at CDA to devote to the process of interaction with industry.</p>	X	X
<b>AgAlert System CRS § 35-50-108</b>	CDA	Animal Health Division	Regulation: Mandatory reporting & Quarantine to prevent spread of disease	<ul style="list-style-type: none"> <li>• Use of the DHS FEMA IPAWS system for alert notification of Ag emergencies when livestock are in danger of disaster or disease.</li> <li>• Capability to reach more people to restrict movement of livestock.</li> </ul>	<p>Limited by livestock owners and transporters to receive alerts via Wireless Emergency Alerts (WEA).</p> <p>Limited by compliance of livestock owners to call the CDA for special permits to move livestock and livestock products.</p>	X	X
<b>Colorado Weed Management Grant Program</b>	CDA	Conservation Services Division	Program	<ul style="list-style-type: none"> <li>• Organized private interests, conservation districts, and municipalities are eligible to apply for assistance from the Colorado Noxious Weed Management Fund to enhance weed management efforts within the State of Colorado. Additionally, the Noxious Weed Program continues to administer federal noxious weed management</li> </ul>		X	X

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
				funds from the U.S. Forest Service's State and Private Forestry program.			
<b>Request-A-Bug Program</b>	CDA	Conservation Services Division	Program	<ul style="list-style-type: none"> <li>Biological pest control agents are seasonally available to help suppress weed and insect pests in Colorado. They can be requested by private landowners in the state or other governmental agencies concerned with controlling the spread of exotic invaders. Approximately 30 weed predators are being cultured, released, and established on weed infestations throughout the state. In addition to the biological weed control programs, this section conducts control programs for the alfalfa weevil and Oriental fruit moth, with a total of twelve beneficial species.</li> </ul>		X	
<b>Rockfall Mitigation Program</b>	CDOT	Department of Transportation (DOT) Geotechnical Program	Program	<ul style="list-style-type: none"> <li>Provides internal mitigation design and review for projects funded by rockfall mitigation budget; performs site inspections during project construction; provides personnel designated as first responders during rockfall related emergencies; installs control devices on rock walls for prevention; posts falling rock signs on highways.</li> <li>Evaluates and prioritizes mitigation locations; combines geologic and climate information with traffic and slope data to rank rockfall hazards according to severity of risk.</li> <li>Program evaluates post-event safety conditions and appropriate mitigation.</li> </ul>		X	X
<b>Colorado Wildfire Preparedness Plan and Fund SB 06-96, CRS §24-30-310 (2)(3)</b>	CDPS	Division of Fire Prevention & Control (DFPC)	Regulation	<ul style="list-style-type: none"> <li>Amended to read Wildfire Emergency Response Fund creation, Wildfire Preparedness Fund creation.</li> <li>Requires the Director of the Division of Fire Prevention and Control to develop an annual Wildfire Preparedness Plan, in collaboration with a representative of the County Sheriffs of Colorado, a representative of the Colorado State Fire Chiefs'</li> </ul>		x	

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
				Association, the Director of the Office of Emergency Management, and the Adjutant General. <ul style="list-style-type: none"> <li>DFPC may use the moneys in the Wildfire Preparedness Fund to implement the Wildfire Preparedness Plan.</li> </ul>			
<b>State Public Safety Entity Reorganization HB 12-1283</b>	CDPS	Colorado Department of Public Safety (CDPS)	Regulation	<ul style="list-style-type: none"> <li>Consolidates homeland security functions into the Colorado Department of Public Safety (CDPS).</li> <li>Transfers wildfire command and control responsibilities from Colorado State Forest Service (CSFS) to CDPS/DFPC.</li> <li>Places Office of Emergency Management (OEM) under CDPS and creates Division of Homeland Security &amp; Emergency Management (DHSEM).</li> <li>Defines OEM role.</li> <li>Purpose is efficiencies in pre- and post-disaster related operations and communications.</li> </ul>		X	X
<b>ReadyColorado</b>	CDPS	DHSEM / OEM Community Preparedness	Program	<ul style="list-style-type: none"> <li>Serves as the primary prevention-based resource managed by DHSEM.</li> <li>Provides information on what to do before, during, after significant hazard events.</li> <li>Describes risk communication such as NWS watch and warning definitions.</li> </ul>		X	
<b>Emergency Management Accreditation Program (EMAP)</b>	CDPS	DHSEM Chief of Staff Office	Program	<ul style="list-style-type: none"> <li>Establishes a baseline capability for Colorado's emergency management and homeland security programs. Benchmarks for risk assessment and mitigation are included as a primary component of this program.</li> <li>Requires HIRA and consequence analysis.</li> </ul>	This program assesses a baseline of capability. This program is not intended to drive or encourage mitigation activities.	X	
<b>Emergency Management Performance Grants (EMPG)</b>	CDPS	DHSEM / OEM Field Services	Program	<ul style="list-style-type: none"> <li>Administration of FEMA EMPG Program.</li> <li>Provides funding to states and local governments to enhance and sustain all-hazards emergency management programs.</li> </ul>	Not all participating jurisdictions have enough matching funds to optimize the program; underfunded on a federal level.	X	

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
<b>Local Hazard Mitigation Plans (HMPs)</b>	CDPS	DHSEM / OEM Mitigation	Practice	<ul style="list-style-type: none"> <li>Local hazard mitigation plans are a critical input in developing the statewide mitigation strategy. These plans are reviewed and incorporated into the state plan, directing a portion of the statewide mitigation strategy and prioritization of local assistance.</li> </ul>	Implementation of the plans has been limited in many jurisdictions due to funding and staffing limitations, other priorities, et cetera.	X	
<b>Mitigation Trainings and Workshops</b>	CDPS	DHSEM / OEM Mitigation	Practice	<ul style="list-style-type: none"> <li>Educates mitigation partners on how to develop local hazard mitigation plans.</li> <li>Provides a common base of information to mitigation partners and builds state and local capability.</li> </ul>	Logistics and delivery state-wide can be prohibitive; not all part-time EMs are available to attend.	X	
<b>State Hazard Mitigation Team (SHMT)</b>	CDPS	DHSEM / OEM Mitigation	Practice	<ul style="list-style-type: none"> <li>Comprised of SMEs representing Technical Assistance Partnerships (TAPs) and state agencies, state agency partners, associated FEMA and CRO sectors, and the greater statewide mitigation community.</li> </ul>		X	

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
<b>Flood Mitigation Assistance (FMA)</b>	CDPS	DHSEM / OEM Mitigation	Program	<ul style="list-style-type: none"> <li>• Administration of FEMA FMA Grant Program.</li> <li>• The FMA Program offers grants for developing a local flood hazard mitigation plan and for completing flood mitigation projects to reduce flood risk in communities.</li> <li>• Prioritizes mitigation funding on insured properties with post-event repetitive losses.</li> </ul>	<p>Prioritized funding is for NFIP insured and repetitive loss properties, of which Colorado has less of than many other states, but still has high need for flood protection infrastructure projects. In the 2011 Hazard Mitigation Assistance Guidance, the requirement for flood insurance was reduced to having at least one affected property required for project application.</p>		X
<b>Hazard Mitigation Grant Program (HMGP)</b>	CDPS	DHSEM / OEM Mitigation	Program	<ul style="list-style-type: none"> <li>• Administration of FEMA HMGP, which provides post-disaster mitigation funding in the event of a Presidential Disaster Declaration.</li> </ul>	<p>Up until 2013, the low occurrence of Presidential disasters in Colorado resulted in a limited number of HMGP projects and many local governments were not familiar with the program. Complexities in benefit cost analysis and application can be a significant hurdle to overcome. In 2014 additional</p>		X

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
					DHSEM staff were hired and consultants procured to provide surge capacity assistance to overcome these limitations.		
<b>State &amp; Local Hazard Mitigation Planning Program</b>	CDPS	DHSEM / OEM Mitigation	Program	<ul style="list-style-type: none"> <li>DHSEM / OEM Mitigation Team has two dedicated positions to provide technical assistance in the development of the SHMP as well as local hazard mitigation plans (HMPs). These positions facilitate and/or attend planning process meetings such as kick-off and mitigation strategy development, and also support public meetings and presentations to state agencies and local elected or appointed officials throughout the plan's approval process, implementation &amp; maintenance, and five-year eligibility cycle.</li> </ul>		X	
<b>Pre-Disaster Mitigation Program (PDM)</b>	CDPS	DHSEM / OEM Mitigation	Program	<ul style="list-style-type: none"> <li>Administration of FEMA PDM Grant Program.</li> <li>Provides funding on a competitive basis for hazard mitigation plans (HMPs) and projects including studies, construction, wildfire mitigation, and property acquisition.</li> </ul>	The program generally facilitates loss reduction, but it can also hinder programmatic progress because of an irregular availability of funds.	X	
<b>Training Directors of Fire Protection Districts in Wildland Urban Interface (WUI)</b> SB 08-039	CDPS	Division of Fire Prevention & Control (DFPC)	Program	<ul style="list-style-type: none"> <li>Directs DFPC to develop a pilot education program for Board members of Fire Protection Districts in the wildland-urban interface.</li> </ul>		X	

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
<b>County Open Burning Slash Permit Program</b> <b>SB 11-110</b>	CDPS	Division of Fire Prevention & Control (DFPC)	Regulation	<ul style="list-style-type: none"> <li>Requires counties with 44% forest cover to maintain open burning permit system for unincorporated areas.</li> <li>Exempts prescribed burns following federal and state guidelines, and preserves existing rights of agricultural producers to conduct burning on their property.</li> </ul>		X	
<b>Fire Suppression Program Rules</b> <b>CRS § 24-33.5-1205(1)(a)</b>	CDPS	Division of Fire Prevention & Control (DFPC)	Regulation	<ul style="list-style-type: none"> <li>Creation of Fire Suppression Program.</li> <li>Establishes minimum standards of performance to ensure fire suppression systems are installed with nationally recognized standards.</li> </ul>		X	
<b>Prescribed Burn Program</b> <b>SB 13-083</b>	CDPS	Division of Fire Prevention & Control (DFPC)	Program	<ul style="list-style-type: none"> <li>Requires DFPC to implement a prescribed burning program.</li> <li>Bill reassigns to Director of DFPC certain permitting and planning activities related to prescribed fire, previously the responsibility of the State Forester.</li> </ul>		X	
<b>Prescribed Fire Certification Standard</b> <b>SB 10-102</b>	CDPS	Division of Fire Prevention & Control (DFPC)	Regulation	<ul style="list-style-type: none"> <li>Requires DFPC to establish standards for training and for certification of prescribed fire users.</li> </ul>		X	
<b>Wildfire Mitigation Measures Tax Subtraction</b> <b>HB 13-1012</b> <b>CRS § 39-22-104</b>	CDR	Colorado Department of Revenue (CDR)	Regulation	<ul style="list-style-type: none"> <li>Allows landowners completing wildfire reduction measures on lands in the WUI to deduct a maximum of \$2,500 from federal taxable income; deduction is available until 2024.</li> </ul>	The cost of performing fuels mitigation in WUI areas is high due to difficulty of treatments and lack of vibrant forest products market. Taxpayer must own the property; property must be	X	

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
					located in the WUI; total amount of the subtraction cannot exceed 50% of the landowner's out of pocket expense or \$2500, whichever is less; available through 2024.		
<b>CGS Land Use Review Program Subdivision Law</b> <b>1972 SB 35-3, CRS § 30-28-101, et seq.</b>	CGS	Colorado Geological Survey (CGS)	Program	<ul style="list-style-type: none"> <li>• Several state statutes and/or state agency regulations specify requirements for the submission of geologic suitability reports in conjunction with land-use applications.</li> <li>• Review geologic reports for new developments in unincorporated areas of the state with lot sizes less than 35 acres. Reports must include information on soils suitability and geologic conditions.</li> <li>• Provide a report to counties stating whether geologic hazards present on a site have been properly identified and if the proposed plan of mitigation is adequate.</li> <li>• Consult with counties and private geologists to produce geologic hazard maps that should be regarded as a starting point for any site-specific geologic-suitability investigation. A particular county's HB 1041 maps should be available for inspection at the county planning department, as well as at the CGS.</li> <li>• Charges CGS with evaluating geologic factors that would have significant impact on the proposed use of the land for subdivision purposes by reviewing preliminary plat applications.</li> <li>• Requires subdividers to submit reports concerning geologic characteristics, potential radiation hazards, soil suitability, storm drainage plans, on-lot sewage disposal, and any soil or</li> </ul>	<p>Land use review is not required in incorporated areas or in divisions of land where lots are greater than 35 acres.</p> <p>Geologic hazard mapping is only available for limited areas.</p> <p>Enforcement - not all counties follow the statute.</p>	x	

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
				<p>topographic conditions that present hazards or require special precautions.</p> <ul style="list-style-type: none"> <li>• Directs county planning agencies to refer a copy of the preliminary plan submittal to the CGS for review .</li> </ul>			
<b>STATEMAP and Geologic Hazards Mapping Program</b>	CGS	Colorado Geological Survey (CGS)	Program	<p>Competitive, matching-funds grant program between state geological surveys and the United States mapping program.</p> <ul style="list-style-type: none"> <li>• Develops geologic map information for incorporation into decision-making on a wide variety of local and countywide issues.</li> <li>• Focuses maps on high-growth areas throughout Colorado.</li> <li>• Informs Colorado Geologic Mapping Advisory Committee stakeholder group that prioritizes the areas for mapping.</li> </ul>	Continuation of program is dependent on awards from competitive federal grant program and matching funds from the state.	X	
<b>Building Codes – Zoning – Planning</b> <b>1984 HB 1045, CRS § 22-32-124 (1)</b>	CGS	Colorado Geological Survey (CGS)	Regulation	<ul style="list-style-type: none"> <li>• Requires that, prior to the acquisition of land for school building sites or construction of any buildings thereon, the Board of Education must consult with the Colorado Geological Survey regarding potentially swelling soils, mine subsidence, and other geologic hazards and determine the geologic suitability of the site for its proposed use.</li> </ul>	There is no enforcement provision in statute and some school districts do not comply with the law .	X	
<b>Colorado Geological Survey</b> <b>1969 HB 1282, CRS § 34-1-101 and 103</b>	CGS	Colorado Geological Survey (CGS)	Regulation	<ul style="list-style-type: none"> <li>• Establishes CGS to collect, analyze, and disseminate geologic information and provide technical assistance to local governments.</li> <li>• Authorizes CGS to determine areas of natural geologic hazards that could affect the safety of or economic loss to the citizens of Colorado.</li> <li>• Directs CGS to assist, consult with, and advise existing state and local government agencies on geologic problems; for instance, after significant rain event causes instability due to soil saturation, or after a hazard event to determine additional instability and risk.</li> </ul>	CGS was transferred to the Colorado School of Mines. The statutory mission of CGS remains the same; however, funding and staff were reduced. This impacts the ability of CGS to help local governments identify	X	X

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
					and plan for natural hazards.		
<b>Soils and Hazard Analyses of Residential Construction Act</b>  <b>1984 SB 13, CRS § 6-6.5-101</b>	CGS	Colorado Geological Survey (CGS)	Regulation	<ul style="list-style-type: none"> <li>Requires all residential developers to analyze and disclose any potentially hazardous conditions to prospective home buyers.</li> </ul>	Geologic hazard mapping is only available for limited areas.	X	
<b>National Earthquake Hazards Reduction Program (NEHRP)</b>	CGS	Colorado Geological Survey (CGS)	Program	<ul style="list-style-type: none"> <li>Administration of FEMA NEHRP State Earthquake Program.</li> <li>Supports enhanced earthquake risk assessments in local hazard mitigation plans (HMPs).</li> <li>Provides funding for earthquake modeling and loss estimation.</li> <li>Provides funding for partnership building, planning, and training activities.</li> <li>Provides funding for prevention materials and activities.</li> <li>Provides support for limited post-event inspection and reporting.</li> </ul>	This is a non-construction project grant. Mitigation activities such as structural retrofit are not allowed under program guidance.	X	X
<b>Creating a Permanent Interim Committee of the General Assembly on Wildfire Matters</b>	Colorado State House	Colorado State House	Regulation	<ul style="list-style-type: none"> <li>Creates permanent Interim Committee (Wildfire Matters Review Committee) to review and propose legislation related to wildfire prevention and mitigation in the state.</li> <li>Committee will meet at least once during the interim, and consult with experts, including CDPS and CSFS.</li> </ul>		X	

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
SB 13-082							
<b>NFPA's Firewise Communities/ USA™ Program</b>	CSFS	Colorado State Forest Service (CSFS)	Program	<ul style="list-style-type: none"> <li>• Supports communities working toward national Firewise Community (FWC) USA™ designation.</li> <li>• Supports communities renewing their Firewise USA™ designation each year.</li> <li>• Maintains database of communities participating in the program; 169 Firewise USA™ communities currently exist in Colorado.</li> <li>• Results in fuels reduction implementation reducing risk to lives, property, communities, and other values at risk.</li> </ul>	<p>There are five requirements communities must meet to complete and receive the Firewise USA™ designation:</p> <ol style="list-style-type: none"> <li>1) complete a community wildfire risk assessment,</li> <li>2) complete an action plan,</li> <li>3) spend minimum of \$22.14/dwelling unit on Firewise™ wildfire risk reduction activities,</li> <li>4) create a Firewise™ board/committee, and</li> <li>5) hold an annual education event or activity and complete application for designation.</li> </ol>	X	
<b>Forestry Collaboratives and Partnerships</b>	CSFS	Colorado State Forest Service (CSFS)	Practice	<ul style="list-style-type: none"> <li>• Provides leadership to collaboratives and partnerships promoting consistent forest stewardship, watershed management, and fuels mitigation information messaging.</li> <li>• Examples include: Rocky Mountain Coordinating</li> </ul>	Capacity to engage with the number of groups throughout Colorado.	X	X

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
				Group Information and Education Committee, South Platte Urban Waters Partnership, Coalition for the Upper South Platte (CUSP) Partnership, Rio Grande Watershed Emergency Action Coordination Team (RWEACT), Front Range Roundtable, Denver Water Forest to Faucets, Watershed Wildfire Protection Group, Front Range Fuels Treatment Partnership, and Colorado Bark Beetle Cooperative.			
<b>Interagency Coordination</b>	CSFS	Colorado State Forest Service (CSFS)	Practice	<ul style="list-style-type: none"> <li>• Planning and implementation with local, state, and federal partners on forest health, fuels reduction, post-fire rehabilitation, and Good Neighbor Authority projects.</li> <li>• Allocation of federal and state funds.</li> <li>• Delivering coordinated interagency messages to homeowners, landowners, and land management agencies.</li> </ul>	Efficiencies in prioritizing mitigation projects across boundaries; leveraging of federal funds.	X	
<b>Outreach and Educational Campaigns</b>	CSFS	Colorado State Forest Service (CSFS)	Practice	<ul style="list-style-type: none"> <li>• State and Federal Funds.</li> <li>• State support of HB 1199.</li> <li>• Encourage development of professional outreach and information campaigns to targeted audiences within the state.</li> <li>• Informed decision-making at the individual landowner and local level can result in actions towards hazard mitigation in wildland areas.</li> </ul>		X	
<b>State Leadership in Wildfire Mitigation and Forest Health</b>	CSFS	Colorado State Forest Service (CSFS)	Practice	<ul style="list-style-type: none"> <li>• Allocation of federal and state funds.</li> <li>• Delivery of coordinated interagency messages to homeowners, landowners, and land management agencies.</li> <li>• Potential awareness leads to informed decision making and action to mitigate wildfire threats.</li> </ul>		X	
<b>Colorado Wildfire Risk Assessment Portal (CO-WRAP)</b>	CSFS	Colorado State Forest Service (CSFS)	Program	<ul style="list-style-type: none"> <li>• Web mapping tool providing access to statewide wildfire risk assessment information.</li> <li>• Provides a consistent, comparable set of scientific results to be used as a foundation for wildfire mitigation and prevention planning in Colorado.</li> </ul>	Funding for enhancements to system as data layers are updated.	X	X

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
				<ul style="list-style-type: none"> <li>• Creates public awareness about wildfire risk and informs decision-making at local and state levels.</li> <li>• Provides state and local planners with information to support mitigation and prevention efforts.</li> <li>• Identifies areas that may require additional planning related to wildfire mitigation projects.</li> <li>• Assists in the development of Community Wildfire Protection Plans (CWPPs).</li> </ul>			
<p><b>Colorado Healthy Forest and Vibrant Communities Act of 2009</b></p> <p><b>HB 09-1199</b> <b>CRS § 23-31-313</b> <b>HB 16-1255</b> <b>SB 17-050</b> <b>SB 17-259</b></p>	CSFS	Colorado State Forest Service (CSFS)	Regulation	<ul style="list-style-type: none"> <li>• Improved technical capacity for CSFS to implement forest management/fuel reduction projects; reduces wildfire risk to life, property, and watersheds; assists communities and others with CWPP development; offers spatially based wildfire risk analysis through enhancements to CO-WRAP; expands outreach/education activities related to wildfire risk reduction and healthy, resilient forests.</li> <li>• Supports utilization and marketing of wood products by providing loans to businesses.</li> <li>• Outlines CSFS responsibilities with Community Wildfire Protection Plans and community wildfire risk mitigation.</li> <li>• Leverages other funding sources through the use of state funds.</li> <li>• Annual transfer of ~\$1 million to the Healthy Forests &amp; Vibrant Communities Fund through 2023.</li> </ul>	Availability of severance tax funding to fund program is not reliable; demand for CSFS services under this program currently exceeds available resources.	X	X
<p><b>Fire Adapted Communities (FAC)</b></p>	CSFS	Colorado State Forest Service (CSFS)	Program	<ul style="list-style-type: none"> <li>• Works closely with homeowners and communities to provide guidance on reducing fuels and increasing community safety.</li> <li>• FAC is an umbrella concept that includes all programs and activities to reduce wildfire risk.</li> <li>• Maintains consistent wildfire messaging from national to local partners.</li> <li>• Includes Colorado's Are You Firewise? Program</li> </ul>	Consistent understanding and messaging amongst partners.	X	

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
<b>Forest Restoration and Wildfire Risk Mitigation Grant</b>  <b>SB 17-050</b> <b>SB 17-259</b> <b>CRS § 23-31-313</b>	CSFS	Colorado State Forest Service (CSFS)	Regulation	<ul style="list-style-type: none"> <li>• Consolidation of two grant programs, Colorado Forest Restoration Grant and DNR Wildfire Risk Reduction Grant, into one program administered by the CSFS.</li> <li>• Assists with funding community-level actions across the state that are implemented to protect populations and property in the wildland-urban interface and to promote forest health and the utilization of woody material. Includes funding for capacity building.</li> <li>• Pre/post treatment monitoring of select projects to determine treatment effectiveness and gather information to assist with adaptive management.</li> <li>• Annual transfers of ~\$1 million from operational account of Severance Tax Trust Fund to the Forest Restoration and Wildfire Mitigation Grant Program Fund.</li> </ul>	Continuing availability of severance tax funding to fully fund program; demand for CSFS services under this program currently exceed available resources.	X	
<b>Forestry Programs for Homeowners and Landowners</b>  <b>CRS § 23-31-202</b> <b>CRS § 23-31-201</b>	CSFS	Colorado State Forest Service (CSFS)	Program	<ul style="list-style-type: none"> <li>• CSFS foresters provide forestry-related technical assistance to homeowners and landowners to help them manage property and meet overall stewardship/management objectives, which includes wildfire risk reduction activities.</li> <li>• Home assessments offer landowners recommendations on how to reduce wildfire risk and manage for healthy forests, depending on landowner objectives.</li> <li>• A vibrant forest products industry will help offset some costs of fuels management implementation projects in the wildland-urban interface (WUI).</li> </ul>	<p>The Colorado wildland-urban interface (WUI) is predicted to grow exponentially, and more resources are needed to reduce risk and protect critical infrastructure.</p> <p>Costs to implement fuels reduction projects are prohibitive to some landowners.</p> <p>Lack of public acceptance of forest management practices can</p>	X	

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
					prohibit landowners from taking necessary actions to reduce wildfire risk.		
<b>Mitigating the Effects of the Pine Beetle Infestation</b>  <b>HB 08-1318</b> <b>CRS § 23-31-303</b>	CSFS	Colorado State Forest Service (CSFS)	Program	<ul style="list-style-type: none"> <li>Established a beetle mitigation fund allowing the public to make voluntary donations used to treat beetle-infested state-owned lands.</li> </ul>		X	
<b>Renewable Energy Forest Biomass Incentives</b>  <b>SB 13-273</b>	CSFS	Colorado State Forest Service (CSFS)	Program	<ul style="list-style-type: none"> <li>Provides variety of incentives for use of forest biomass within "red zones."</li> <li>Defines red zone as a wildland-urban interface (WUI) area of high wildfire risk in Colorado, identified by the CSFS updated red zone map.</li> <li>Directs CSFS to collaborate with federal agencies to facilitate use of forest biomass as feedstock for timber mills, and authorizes CSFS to assist communities in high risk areas with Community Wildfire Protection Plans (CWPPs).</li> </ul>	High percentage of lands under federal ownership makes it difficult to implement landscape-scale forest management projects. Appropriate management of available lands at landscape level would provide a continuing source of forest products sustaining a wide array of market opportunities.	X	
<b>State Fire Assistance (SFA) WUI Grants</b>	CSFS	Colorado State Forest Service (CSFS)	Program	<ul style="list-style-type: none"> <li>Competitive program makes federal funds available to homeowner &amp; property owner associations, subdivisions, fire departments, counties, and other groups to implement projects that mitigate wildfire hazards in the wildland-urban interface (WUI).</li> <li>Funds hazardous fuels reduction, fire information</li> </ul>	Requires a minimum one-to-one match from recipients. Additional recipient match may make the proposal more competitive.	X	

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
				and education, and community and homeowner action. Projects affiliated with approved Community Wildfire Protection Plans (CWPPs), demonstrating interagency collaboration, incorporating a landscape scale approach, and a documented maintenance schedule are more competitive.	Limited funding is available; demand for funds far exceeds availability.		
<b>Community Assistance Funds Adjacent to National Forest Lands (CAFA) Grants – Stevens Hazardous Fuels Grant</b>	CSFS	Colorado State Forest Service (CSFS)	Program	<ul style="list-style-type: none"> <li>Competitive program makes federal funds available to communities to treat adjacent non-federal lands to protect communities when hazard reduction activities are planned on NFS lands.</li> <li>Funds hazardous fuels reduction. Projects affiliated with approved Community Wildfire Protection Plans (CWPPs), demonstrating interagency collaboration, and incorporating a landscape scale approach are more competitive.</li> </ul>	Limited funding is available; demand for funds far exceeds availability.	X	
<b>Wildfire Mitigation Education and Outreach</b>  <a href="http://www.csfs.colostate.edu">www.csfs.colostate.edu</a>	CSFS	Colorado State Forest Service (CSFS)	Program	<ul style="list-style-type: none"> <li>CSFS foresters provide educational workshops, events, and programs to youth and adult audiences and are catered to meet the specific needs and interests of the audience.</li> </ul>	Colorado's WUI is not fully developed, so demand for wildfire mitigation education will continue to increase.	X	
<b>Wildfire and Watershed Assessments (WWAs)</b>	CSFS	Colorado State Forest Service (CSFS)	Program	<ul style="list-style-type: none"> <li>Uses template for assessing individual 6th-level watersheds, developed by Front Range Watershed Wildfire Protection Working Group, 15 initial (i.e., Phase 1) WWAs have been completed. Eleven of the 15 WWAs have entered Phase 2 level with stakeholder involvement process and specific "zones of concern" identified on the ground.</li> <li>Four primary components integral in evaluating zones of concern are: wildfire hazard, flooding or debris flow risk, soil erodibility, and water uses ranking.</li> <li>Individual WWAs have been completed identifying critical zones of concern within</li> </ul>	Assessments are still being completed, and much of the state is in need of detailed assessments to determine risk of wildfires to important watersheds.	X	X

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
				watersheds. Zones of concern identify areas in need of forest management and fuels mitigation. • Provides post-wildfire assessments to minimize impact to critical watersheds.			
<b>Community Wildfire Protection Planning</b>  <b>SB 09-001</b> <b>CRS § 23-31-312</b> <b>CRS § 30-15-401.7</b>	CSFS	Colorado State Forest Service (CSFS)	Regulation	<ul style="list-style-type: none"> <li>• Requires the CSFS to establish guidelines and criteria for counties to consider in preparing Community Wildfire Protection Plans (CWPPs) to address wildfires in fire hazard areas within the unincorporated portion of a county.</li> <li>• Supports development, revision, and implementation of Community Wildfire Protection Plans (CWPPs) by providing technical assistance ultimately resulting in implementation.</li> <li>• Provide technical assistance to communities, local government, and land managers regarding wildfire hazard areas.</li> <li>• Provide educational materials and information to communities developing CWPPs.</li> <li>• Maintains database of completed CWPPs in Colorado on CSFS website (currently 225 CWPPs exist in Colorado; 47 are county-level plans).</li> </ul>	CWPPs must meet the minimum standards required by the CSFS. Level of specificity may be a factor in completing implementation. County-wide plans often aren't specific enough to provide necessary guidance for community project implementation.	X	
<b>Forest Improvement Districts</b>  <b>HB 07-1168</b>	CSFS	Colorado State Forest Service (CSFS)	Regulation	<ul style="list-style-type: none"> <li>• Authorizes a municipality or county to propose to its voters the formation of a Forest Improvement District through which the municipality or county could tax itself to raise money for priority forest improvement projects.</li> </ul>		X	
<b>Inter-governmental Cooperation to address Wildfire Mitigation</b>  <b>HB 09-1162</b>	CSFS	Colorado State Forest Service (CSFS)	Regulation	<ul style="list-style-type: none"> <li>• Requires local governments that own any land area for any reason other than utility purposes that is located entirely or partially outside its own territorial boundaries and inside the boundaries of a county that contains at least 50% forest land or land that constitutes a wildland area, to enter into an IGA with the county or CSFS for the purpose of mitigating forest land.</li> </ul>	Limited funding to implement fuels mitigation projects at the county level.	X	

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
				<ul style="list-style-type: none"> <li>• Purpose of agreement is to mitigate forest land/wildland fires that affect contiguous land areas of the local government and county.</li> </ul>			
<b>Watershed Bonding for Forest Health</b>  <b>SB 08-221</b> <b>CRS § 37-95-112.5</b>	CSFS	Colorado State Forest Service (CSFS)	Regulation	<ul style="list-style-type: none"> <li>• Allows Colorado Water Resources &amp; Power Development Authority (CWRPDA) to issue up to \$50 million in bonds; proceeds can be used to help CSFS, in partnership with another governmental agency, identify and complete watershed protection and forest health projects.</li> <li>• With proper authority and agreement, bonds can be issued for forest health and watershed protection projects.</li> </ul>		X	X
<b>Center for Colorado Policy Studies: Program on Growth Issues</b>	DHE	Department of Higher Education	Program	<ul style="list-style-type: none"> <li>• Located at UC-Colorado Springs; applies the latest research in land use and environmental economics, along with public finance and basic economic theory, to growth issues facing Colorado.</li> </ul>		X	
<b>Center for the American West</b>	DHE	Department of Higher Education	Program	<ul style="list-style-type: none"> <li>• Located at UC-Boulder, a creative and innovative organization identifying and addressing multiculturalism, community building, fire policy, and land, water, and energy use.</li> <li>• Operates on premise that exploration of minds of residents of the American West is an important inquiry into the workings of cultures and ecosystems.</li> <li>• Helps citizens of the West become agents of sustainability; illuminates challenges and opportunities facing Colorado's complicated geographic and cultural area.</li> </ul>		X	

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
<b>Colorado Climate Center (CCC)</b>	DHE	Department of Higher Education	Program	<ul style="list-style-type: none"> <li>• Part of the Department of Atmospheric Science at Colorado State University (CSU), Fort Collins.</li> <li>• Assists the State of Colorado in monitoring climate; involves complex interactions between the atmosphere, the oceans, continental glaciers, and the land, as well as vegetative processes.</li> <li>• CCC studies should contribute to a reduction in the state's vulnerability to climate variability and change.</li> </ul>		X	
<b>Education Studies and Programs</b>	DHE	Department of Higher Education	Program	<ul style="list-style-type: none"> <li>• University activities around the state support and facilitate education opportunities and studies. These programs are very successful in promoting and forwarding mitigation activities.</li> </ul>		X	
<b>Natural Hazards Research &amp; Applications Information Center (NHRAIC) (aka "Natural Hazards Center")</b>	DHE	Department of Higher Education	Program	<ul style="list-style-type: none"> <li>• Located at the University of Colorado Boulder (CU Boulder); serves as a national and international clearinghouse of knowledge concerning social science and policy aspects of disasters.</li> <li>• Collects and shares research and experience related to preparedness for, response to, recovery from, and mitigation of disasters, emphasizing link between hazard mitigation and sustainability to both producers and users of research and knowledge on extreme events.</li> <li>• Strengthens communication among researchers, individuals, organizations, and agencies concerned with reducing damages caused by disasters.</li> <li>• Promotes all-hazards approach for addressing environmental extremes and is a leading proponent of cooperative partnerships among varying disciplines.</li> </ul>		X	X

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
<b>Western Forest Fire Research Center (WESTFIRE)</b>	DHE	Department of Higher Education	Program	<ul style="list-style-type: none"> <li>• Interdisciplinary research facility based at Colorado State University (CSU) Fort Collins, College of Natural Resources associated with the Forest, Rangeland, and Watershed Stewardship programs.</li> </ul>		X	
<b>Colorado Center for Community Development (CCCD)</b>	DHE	Department of Higher Education	Program	<ul style="list-style-type: none"> <li>• Located at the University of Colorado Denver (CU Denver), community development focused center which provides students opportunities to support community development and design, preservation, and other projects in communities.</li> <li>• Partners with DOLA (University TA program) to provide conceptual design and related work for communities; can provide assistance, using students, pre- and post-disaster. DOLA funds projects matched by the communities.</li> </ul>		X	X
<b>Colorado Avalanche Information Center (CAIC)</b>	DNR	Colorado Avalanche Information Center (CAIC)	Program	<ul style="list-style-type: none"> <li>• Issues backcountry avalanche forecasts.</li> <li>• Issues forecasts for State Transportation System.</li> <li>• Provides education tools and avalanche safety classes.</li> <li>• Maintains automated and manual measurement sites in high-elevation areas.</li> <li>• Documents human involvement in avalanches.</li> <li>• Assists in avalanche search and rescue activities.</li> <li>• Assists with determining post-avalanche safety conditions and appropriate mitigation.</li> <li>• Assists in hazard mapping and land-use planning.</li> </ul>	Cash-funded largely from donations, contributions, and Severance Tax fund.	x	x
<b>Avalanche Mitigation Program</b>	DNR	Colorado Avalanche Information Center (CAIC) / Department of	Program	Provides Avalanche Management Program and staff training in awareness, survival, and rescue techniques; provides forecasting to monitor snow conditions, issue hazard assessments, recommend road closures, and suggest avalanche hazard mitigation operations; performs active avalanche hazard mitigation operations using		x	x

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
		Transportation (DOT) Avalanche Control		helicopters, avalaunchers, artillery, fixed installations, and hand-placed explosives.			
<b>Drought Mitigation Planning</b>  <b>CRS § 37-60-126.5</b>	DNR	Colorado Water Conservation Board (CWCB)	Program	<ul style="list-style-type: none"> <li>• Drought mitigation planning programs in relationship to state assistance; scarcity, shortages, supply, demand.</li> <li>• Develops programs and provides technical assistance.</li> <li>• Recommends appropriation and expenditures as necessary (5% share of Operational Severance Tax Trust Fund) for purpose of assisting covered entities and other state and local governments to develop drought mitigation plans.</li> <li>• Guidelines for review and evaluation of drought mitigation plans and prioritization of funds distribution.</li> </ul>		X	
<b>Establishment of Educational Programs Regarding Water Pollution from Storm Run-off</b>  <b>HB 07-1328</b>	DNR	Colorado Water Conservation Board (CWCB)	Program	<ul style="list-style-type: none"> <li>• Legislative declaration.</li> <li>• Stewardship of stormwater run-off damage and hazards.</li> <li>• Educational programs to inform, mitigate, and prevent issues concerning erosion, water conservation, stormwater pollution, and water quality problems.</li> </ul>		X	
<b>Risk Mapping, Assessment, and Planning (RiskMAP)</b>	DNR	Colorado Water Conservation Board (CWCB)	Program	<ul style="list-style-type: none"> <li>• Administers program; funding sources from DHS/FEMA, state, and local funds.</li> <li>• Information regarding Colorado RiskMAP program can be found at: <a href="http://coloradohazardmapping.com/hazardMapping/floodplainMapping/Index">http://coloradohazardmapping.com/hazardMapping/floodplainMapping/Index</a></li> <li>• Projects may be prioritized post-disaster to assist with immediate mapping needs.</li> </ul>		X	X

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
<b>National Flood Insurance Program (NFIP)</b>	DNR	Colorado Water Conservation Board (CWCB)	Program	<ul style="list-style-type: none"> <li>• Provides technical assistance on floodplain issues through FEMA's Community Assistance Program (CAP) administered by CWCB.</li> <li>• Funding provided to state for technical assistance to local governments through DHS/FEMA, with match funds from the state.</li> <li>• Provides funds for mitigation prioritized on repetitive post-event flood losses.</li> </ul>		X	X
<b>Colorado Flood Hazard Evaluation for Land Use Considerations</b>  <b>1977 Executive Order 8491</b>	DNR	Colorado Water Conservation Board (CWCB)	Regulation	<ul style="list-style-type: none"> <li>• Evaluation of flood hazard in locating state buildings, roads, and other facilities, and in approving sewer and water facilities and subdivisions.</li> <li>• Refer to State Flood Hazard Plan and State Drought Hazard Mitigation and Response Plan for additional information.</li> </ul>		X	
<b>Colorado Floodplain Management Authority</b>  <b>1977 SB 126, CRS § 24-65.1-403(1), 1973, as amended</b>	DNR	Colorado Water Conservation Board (CWCB)	Regulation	<ul style="list-style-type: none"> <li>• Authorizes the CWCB to coordinate all activities relating to the designation of floodplains in the state in connection with land use planning.</li> <li>• Floodplain authority; refer to State Flood Mitigation Plan for additional information.</li> </ul>		X	
<b>Colorado Water Conservation Board</b>  <b>1937</b>	DNR	Colorado Water Conservation Board (CWCB)	Regulation	<ul style="list-style-type: none"> <li>• Creation of Colorado Water Conservation Board (CWCB).</li> </ul>		X	

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
<b>Emergency Dam Repair Cash Fund</b>  CRS § 37-60-122.5	DNR	Colorado Water Conservation Board (CWCB)	Regulation	<ul style="list-style-type: none"> <li>Created Emergency Dam Repair Cash Fund.</li> <li>As determined by CWCB, money transferred from CWCB Construction Fund as needed.</li> </ul>		X	
<b>Flood Response Fund</b>  CRS § 37-60-123.2	DNR	Colorado Water Conservation Board (CWCB)	Regulation	<ul style="list-style-type: none"> <li>Created and appropriated funding to the Flood Response Fund, administered by CWCB.</li> </ul>		X	
<b>Wildfire Risk Reduction Grant (WRRG) Program</b>  SB 13-269	DNR	Department of Natural Resources (DNR)	Program	<ul style="list-style-type: none"> <li>Funds focused on reducing hazardous forest fuels in the wildland-urban interface. CSFS collaborates with the DNR and provides technical assistance to grant applicants.</li> <li>Wildfire Risk Reduction Grant Program Advisory Committee consists of eight members appointed by the Executive Director of the DNR to represent various interests involved in, or concerned with, the mitigation of catastrophic wildfires such as federal land management, local government, and the forest products industry.</li> <li>Creates Wildfire Risk Reduction Grant (WRRG) Program, including new cash fund established to provide funding for grants (Wildfire Risk Reduction Fund).</li> <li>Directed the State Treasurer to transfer \$9,800,000 from the General Fund to the Wildfire Risk Reduction Fund on July 1, 2013.</li> </ul>	<p>Additional recipient match may make the proposal more competitive. Limited funding is available; demand for funds far exceeds availability.</p> <p>In 2017, this program was consolidated with the Forest Restoration Grant in SB-70 and is under the responsibility of the CSFS.</p>	X	
<b>Flood Control Planning &amp; Zoning</b>  1966 HB 1007	DNR	Department of Natural Resources (DNR)	Regulation	<ul style="list-style-type: none"> <li>State approval and designation of storm runoff channels and basins.</li> </ul>		X	

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
<b>Colorado NFIP Participation</b>  <b>1977 Executive Order 8504</b>	DNR	Division of Water Resources (DWR)	Regulation	<ul style="list-style-type: none"> <li>Requirements and criteria for state participation in the National Flood Insurance Program (NFIP).</li> </ul>		X	
<b>Rules &amp; Regulations for Dam Safety and Construction, authority granted to State Engineer</b>  <b>1973 CRS § 24-4-103, 2 CCR 402-1, Sections 37-87-102 and 37-87-105 and 37-80-102(11K)</b>	DNR	Division of Water Resources (DWR)	Regulation	<ul style="list-style-type: none"> <li>Requirements for construction or enlargement of dams or reservoirs; alteration, modification or repair; general maintenance; emergency action; safety inspections; owner's responsibilities; restriction of recreational facilities; and Emergency Action Plans (EAPs).</li> <li>All High and Significant Hazard dams must have EAPs.</li> </ul>		X	
<b>National Dam Safety Program State Assistance Grants</b>	DNR	Division of Water Resources (DWR) Dam Safety	Program	<ul style="list-style-type: none"> <li>DHS/FEMA grant assistance to State Dam Safety programs to reduce risks to life and property associated with dams, increase awareness of the benefits and risks related to dams, and advance the state in the practice of dam risk management.</li> </ul>		X	
<b>Land Use Training and Webinars</b>	DOLA	DOLA / Division of Local Government (DLG)	Practice	<ul style="list-style-type: none"> <li><i>Planning for Hazards: Land Use Solutions for Colorado</i> webinars and website.</li> <li><i>Mitigating Hazards through Land Use Solutions</i> workshops with DHSEM and FEMA.</li> </ul>		X	

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
<b>Colorado Demography Office</b>	DOLA	Division of Local Government (DLG)	Program	<ul style="list-style-type: none"> <li>• Provides technical assistance and information on population, housing and households, economy, labor force, census data, profiles, GIS; data can be accessed via internet.</li> <li>• Users include, but are not limited to, local governments including special districts.</li> </ul>		X	
<b>Community Development Block Grant (CDBG)</b>	DOLA	Division of Local Government (DLG)	Program	<ul style="list-style-type: none"> <li>• Coordination and overall administration of federally funded "Small Cities" Community Development Block Grant (CDBG) program.</li> <li>• Funds have been used for pre- and post-disaster mitigation purposes.</li> </ul>		X	X
<b>Energy/Mineral Impact Assistance Fund (EIAF)</b>	DOLA	Division of Local Government (DLG)	Program	<ul style="list-style-type: none"> <li>• Assists communities affected by the growth and decline of energy and mineral industries in the state.</li> <li>• Funded projects include water and sewer improvements, road improvements, construction/improvements to recreation centers, senior centers, and other public facilities, fire protection buildings and equipment, and local government planning.</li> <li>• Funds have been used for pre- and post-disaster mitigation purposes.</li> </ul>		X	X
<b>Office of Smart Growth – Community Development Office</b>  <b>CRS § 24-32-3201, et. seq.</b>	DOLA	Division of Local Government (DLG)	Program	<ul style="list-style-type: none"> <li>• Created within DOLA during 2000 legislative session to assist local governments in addressing unique public impacts of growth.</li> <li>• Provides direct technical and financial assistance to local governments in the areas of land use planning and growth management.</li> </ul>	Still in statute but no longer funded.	X	X

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
<b>State Fire Ban Authority</b> CRS § 24-30-308	Governor's Office	Governor's Office	Law	<ul style="list-style-type: none"> <li>• Authorization by Governor of bans on open burning in designated areas.</li> </ul>		X	
<b>Hazard Awareness Weeks</b>	Governor's Office	Governor's Office DHSEM / OEM Strategic Communications	Practice	<ul style="list-style-type: none"> <li>• Educates public on the dangers of severe weather. Winter weather, severe weather, lightning, wildfire, and general preparedness are the primary topics.</li> <li>• Local governments and the National Weather Service (NWS) provide weather spotter training.</li> <li>• Support materials are provided by all agencies.</li> <li>• Press releases and a Governor's proclamation are issued. ReadyColorado regularly disseminates preparedness information, including promoting Hazard Awareness Weeks and National Preparedness Month.</li> </ul>		X	
<b>Master Plan Wildfire Hazard Area Locations</b> CRS § 30-28-106 CRS § 31-23-206	Local Government	County Planning Commissions	Regulation	<ul style="list-style-type: none"> <li>• CSFS provides assistance to counties in locating wildfire hazards for master plan efforts.</li> </ul>		X	
<b>County Preliminary Plan Referral Reviews</b> CRS § 30-28-136	Local Government	County Planning Commissions	Regulation	<ul style="list-style-type: none"> <li>• For wildfire hazards: Board of County Commissioners (BOCC) distribute copies of prints of the preliminary plan to the CSFS. CSFS provides feedback on wildfire hazards.</li> </ul>		X	

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
<b>County Master Plan</b>  <b>CRS, Title 30, Article 28, Part 1: 30-28-106</b>	Local Government	County Governments – Planning Statutes	Regulation	<ul style="list-style-type: none"> <li>• County Planning: Referral and review requirements.</li> <li>• 30-28-136(1)(i) CGS evaluation of geologic factors.</li> </ul>		X	
<b>County Building Codes Title 30, Article 28, Part 2 30-28-201</b>	Local Government	County Governments	Regulation	<ul style="list-style-type: none"> <li>• Enabling authority for counties to adopt a building code (and if they do, that code must meet or exceed the standards in the 2003 version of the international energy conservation code [20-28-211]).</li> </ul>		X	
<b>County Fire Planning Authority CRS, Title 30, Article 11, Part 1: 30-11-124</b>	Local Government	County Governments	Regulation	<ul style="list-style-type: none"> <li>• County Powers &amp; Functions: fire planning authority.</li> </ul>		X	
<b>Removal of Statutory Limit on the Amount that may be Raised for the Purpose of Fighting Fires</b>  <b>SB 09-105</b>	Local Government	County Governments	Regulation	<ul style="list-style-type: none"> <li>• Removed statutory limit on amount that can be raised in a year by a special property tax levied by a Board of County Commissioners (BOCC) for purpose of fighting specified types of fires in a county.</li> </ul>		X	
<b>Local Government Land Use Control Enabling Act</b>  <b>1974 HB 1034, CRS § 29-20-101, et seq</b>	Local Government	Local Governments	Regulation	<ul style="list-style-type: none"> <li>• Gives broad enabling authority to local governments to plan and regulate the use of land within their jurisdictions, including regulating development and activities in hazardous areas.</li> <li>• Allows counties and municipalities to regulate development and activities in hazardous areas.</li> <li>• General purpose of guiding and accomplishing a coordinated, adjusted, and harmonious development of the municipality and its environs.</li> </ul>		X	X

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
				<ul style="list-style-type: none"> <li>Promote health, safety...and general welfare in the process of development, including among other things...the promotion of safety from fire, and other dangers.</li> </ul>			
<b>Professional Geologist Standard</b>  <b>1973 HB 1574, CRS § 34-1-201, et seq</b>	Local Government	County Governments	Regulation	<ul style="list-style-type: none"> <li>Requires all geologic reports required by law be prepared by a "professional" geologist.</li> </ul>	There is no enforcement provision in statute.	X	
<b>State Planning and Interest (1041 Regulations)</b>  <b>CRS § 24-65.1-201 and 202</b>	State Government	State Government	Regulation	<ul style="list-style-type: none"> <li>Areas of state interest as determined by local governments.</li> <li>Natural hazard areas and mineral resource areas are two of four areas of state interest. Criteria for administration of areas of state interest to minimize hazards (i.e., floodplains, wildfire, and geologic hazard areas).</li> <li>Defines natural hazards as wildfire hazards, flood hazards, and geological hazards. A geological hazard is defined as "...a geologic phenomenon which is so adverse to past, current, or foreseeable construction or land use as to constitute a significant hazard to public health and safety or to property." The term includes, but is not limited to avalanches, landslides, rock falls, mudflows, unstable or potentially unstable slopes, seismic effects, radioactivity, and ground subsidence.</li> <li>Requires that all developments in areas designated by counties as geological hazard areas shall be engineered and administered in a manner that will minimize significant hazards to public health and safety or to property.</li> <li>Instructs local governments to administer such</li> </ul>	Municipalities and counties are not required to adopt 1041 regulations. Geologic hazard mapping is not available in all areas. CGS does not have sufficient funding and staff to provide technical assistance to all municipalities and counties using or considering adoption of 1041 regulations.	X	

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
				<p>areas in a manner that is consistent with model guidelines for land use in each type of natural hazard area.</p> <ul style="list-style-type: none"> <li>• Directs counties to create geologic-hazard maps to establish areas of state interest (natural hazard areas) and to serve as planning tools. Colorado Geological Survey (CGS) provides technical assistance on the identification of geologic hazards, and the review of geologic reports.</li> </ul>			
<p><b>State Planning and Interest</b></p> <p><b>CRS § 24-65.1-203</b></p>	State Government	State Government	Regulation	<ul style="list-style-type: none"> <li>• Functions of state agencies to provide technical assistance to local governments for matters of state interest (i.e., CWCB, State Conservation Board and Districts, CSFS, CGS, Division of Mines, DPW, DNR).</li> </ul>		X	X
<p><b>Amendment to the Colorado Disaster Emergency Act</b></p> <p><b>HB-18-1394</b></p>	State Government	State Government	Regulation	<ul style="list-style-type: none"> <li>• Subject to available grant funding, the bill creates the Colorado Resiliency Office (CRO) in the division of local government within the department of local affairs.</li> <li>• Includes provisions related specifically to recovery, mitigation, and resiliency and to establish the roles and responsibilities of state and local agencies at all stages of emergency management.</li> </ul>	The CRO is currently dependent on grant funding.	X	X
<p><b>Urban Drainage &amp; Flood Control District (UDFCD) 2007 Series, Resolution No. 10 (District Levee Policy)</b></p>	UDFCD	Urban Drainage & Flood Control District (UDFCD)	Policy	<ul style="list-style-type: none"> <li>• Levee policy to discourage local governments within UDFCD authorizing or permitting use of levees in new development of flood hazard areas; ineligible for District maintenance assistance.</li> <li>• UDFCD will consider levees to protect existing development as last resort only, when no other mitigation option is feasible.</li> </ul>		X	

Description	Lead Department / Entity	Lead Agency	Program, Policy, Regulation, or Practice	Capabilities	Limitations	Pre-Disaster	Post-Disaster
<b>Colorado Communities Symposium</b>	Multi-Agency	Governor's Office, CRO, CWCB, DHSEM, DOLA/DLG	Practice	<ul style="list-style-type: none"> <li>• In February 2018, The Colorado Communities Symposium brought together elected officials, community, and business leaders across the state to participate in visioning workshops and educational programs related to climate preparedness and clean energy development in Colorado.</li> <li>• Detailed action items resulted from the symposium and prioritized to be implemented across the state.</li> </ul>		X	
<b>Mountain Studies Institute (MSI)</b>	Non-profit	N/A	Program	<ul style="list-style-type: none"> <li>• The MSI collaborates among researchers, educators and policy makers with an interest in the San Juan Mountains and other mountain systems worldwide can provide increased knowledge and understanding of mountain environments and communities and the issues that affect them.</li> <li>• The MSI has many established programs focusing on issues such as climate, history, land use, water and snow, air quality, and ecosystems in the San Juan mountains in southwest Colorado.</li> <li>• Provides pre and post-fire education and research for communities, as well as post-fire ecosystem monitoring.</li> </ul>		X	X

### 3. DEVELOPMENT IN HAZARD PRONE AREAS

Colorado's natural and cultural amenities continue to make it an attractive place for people to relocate. Between 2010 and 2030, the state's population is estimated to grow by 36 percent. Colorado's increasing population is of particular concern when it comes to addressing the threat of natural hazards and associated vulnerability created when people move to hazard areas.

Continual population growth is typically absorbed through urban infill and densification or new development in previously undisturbed or agricultural lands. In Colorado, these development patterns occur simultaneously, and often result in land use patterns where people want to live close to urban areas yet in a natural or rural environment. One of the preferred places to find this setting is west of the Interstate 25 corridor and within the Front Range foothills. This desire for people to live within Colorado's natural environment is inherent to development occurring in the following three areas:

- Within or adjacent to the wildland-urban interface (WUI)
- Within or near the regulatory floodplain
- On or near geologic hazards

Colorado's foothill and mountain environments are dominated by forests, steep slopes, valleys, canyons, and stream channels located within steep drainages or meandering across valley bottoms. Development within these areas may be at immediate risk to wildfires, flash floods, and landslides, rockfalls, and avalanches.

#### 3.1 WILDLAND-URBAN INTERFACE

Governor John Hickenlooper created the Task Force on Wildfire Insurance and Forest Health through Executive Order B 2013-002. The group was asked to identify and reach agreement on ways to encourage activities, practices, and policies that would reduce the risk of loss in wildland-urban interface (WUI) areas and provide greater customer choice and knowledge of insurance options. On September 30, 2013, the Task Force formally submitted its report and recommendations to the Governor. Task Force Recommendations include:

- Update the Colorado Wildfire Risk Assessment Portal (CO-WRAP) to identify and quantify risk to specific properties in the WUI
- Disclose CO-WRAP scores to stakeholders
- Amend standard real-estate contract form to include disclosure of CO-WRAP score
- Create process for appeals/updates of CO-WRAP scores
- Require Wildfire Mitigation Audits for high risk homes
- Develop and disseminate uniform best management practices (BMPs)
- Implement state-wide model ordinance
- Prohibit inconsistent community building or land use requirements
- Create pilot program for prescribed burns
- Assess a fee on properties in the WUI

- Continue and enhance state grant funding
- Increase awareness of financial assistance and technical support
- Disseminate information about HB 13-1225 (Insurance regulations)

The Colorado State Forest Service (CSFS) is the lead state agency for wildfire mitigation. Recognizing the increasing threat to private property and lives in the WUI related to subdivision and other developments, the CSFS has multiple programs to help reduce the wildfire threat in these areas. Highlighting just a few of these programs, CSFS is proactive in providing technical assistance to counties and communities for Wildfire Protection Planning related to developing Community Wildfire Protection Plans, identifying wildfire risk utilizing CO-WRAP, supporting national Firewise USA™ Community designation, and supporting Fire Adapted Communities (FACs).

### **3.2 FLOODPLAIN**

The CWCB is a Cooperating Technical Partner (CTP) with the Federal Emergency Management Agency (FEMA). The CWCB works with local governments outside of the Denver Metro Area to develop new Flood Insurance Studies (FIS) and Flood Insurance Rate Maps (FIRMs). Within the six county Denver Metro area the Urban Drainage & Flood Control District (UDFCD) is the CTP. FEMA operates the Risk Mapping, Assessment, and Planning Program (RiskMAP), which has been underway since 2010. RiskMAP combines flood hazard mapping, risk assessment tools, and hazard mitigation planning into one seamless program. The budget for RiskMAP is determined on an annual basis. Colorado continues to provide cost-sharing leverage for Digital Flood Insurance Rate Map (DFIRM) and future RiskMAP projects.

Following the September 2013 flood disaster, Colorado has taken steps toward long-term planning and resiliency efforts for flooding. In early 2015, Colorado's Legislature passed a funding bill for the Colorado Hazard Mapping Program (CHAMP), which aims to provide a mitigation and land use framework in areas likely to be affected by future flooding, erosion, and debris flow events. CHAMP is preparing updated hazard information for the streams most affected by the September 2013 flooding. An additional phase of CHAMP is also focusing on counties and communities that are still utilizing paper FEMA floodplain maps. This scope includes digitizing existing FIRM panels in select communities and jurisdictions and wherever topographic data is available, updated flood risk information will be provided as best available information for local communities to utilize. Community leaders can use this updated hazard and newly digitized information to assess risk and identify mitigation opportunities in their community. The updated information is also intended to eventually be used to update FEMA FIRMs. The CWCB is the lead agency coordinating CHAMP.

An additional step the CWCB has taken following the September 2013 floods is identifying risks in Fluvial Hazard Zones (FHZ). Riverine erosion is a significant, but unstudied, flood risk for many Colorado communities. Relying only on Flood Insurance Rate Maps to manage floodplains and to reduce flood risk is insufficient to prevent future damages. Well elevated structures

located above the regulatory surface water elevation and structures located outside of the regulatory floodplain were destroyed by riverine erosion from river banks migrating laterally in September 2013. Despite these very real, extreme hazards, riverine erosion hazard zones are currently not shown on the Flood Insurance Rate Maps. Furthermore, despite NFIP directives that communities should be managing erosion hazard areas, clear guidance from FEMA is not available on how such fluvial risks are to be managed. The State's FHZ mapping efforts will provide technical standards, conduct studies for communities requesting mapping, and provide regulatory guidance.

Updated mapping (RiskMAP and National Flood Hazard Layer) has already been included in Hazus Level II scenarios for 22 counties with the 2018 update of the Colorado Natural Hazard Mitigation Plan (2013). This mapping will continue to be leveraged in local hazard mitigation planning efforts as well when plans are updated.

With enhancements developed by the Colorado Water Conservation Board (CWCB), Colorado continues to require higher regulatory floodplain standards above the minimum NFIP requirements. As of January 2014, the Rules require an additional one foot of elevation above the base flood elevation as the standard in local flood ordinances. This improvement provides additional protection for structures during floods greater than the 1% annual chance flood and is an important and effective flood mitigation strategy across the state for future development. These floodplain standards also include additional protections when locating new critical facilities.

Per Executive Order 8491, the CWCB is also responsible for evaluating flood hazards when locating state buildings, roads, and other facilities, and in approving sewage facilities, water facilities, and subdivisions. In addition, Senate Bill 126 authorizes the CWCB to coordinate all activities relating to the designation of floodplains in the state in connection with land use planning.

### **3.3 GEOLOGIC HAZARDS**

Several state statutes require developers and builders to submit geologic suitability reports in conjunction with subdivision plats (lots sized less than 35 acres) and other types of land-use applications. The Colorado Geological Survey (CGS) leads a land-use review program to evaluate geologic suitability. These reports include information such as the identification of geologic hazards and constraints (potential radiation hazards, soil suitability, storm drainage plans, on-lot sewage disposal, and any soil or topographic conditions) that may require special precautions along with the appropriate mitigation measures. CGS provides recommendations to local governments to consider during land-use decisions.

House Bill 1041, in place for over 40 years, requires that all developments in areas designated by counties as geological hazard areas shall be engineered and administered in a manner that will minimize significant hazards to public health and safety or to property. Another state statute of note requires that, prior to the acquisition of land for school building sites or construction of

any buildings thereon, the Board of Education must consult with the Colorado Geological Survey regarding potentially swelling soils, mine subsidence, and other geologic hazards and determine the geologic suitability of the site for its proposed use.

## 4. STATE MITIGATION FUNDING CAPABILITIES

### 4.1 STATE PROGRAMS

The state has multiple loan and grant programs for which mitigation activities may be eligible. Table 4-4 provides a summary of funding programs provided by each of these agencies. In total, 22 funding programs were identified for this plan update. Many state agencies have grant programs, including but not limited to DOLA, CDPS, CSFS, and DNR. The Colorado Department of Natural Resources, between the Colorado Water Conservation Board (CWCB) and Division of Parks and Wildlife programs (DPW), is responsible for 15, or over two thirds of these funding programs.

TABLE 4-4 STATE FUNDED MITIGATION PROGRAMS SUMMARY BY AGENCY

Department	Funding Program
<b>Natural Resources</b>	<ul style="list-style-type: none"> <li>• Colorado Flood and Drought Response Fund</li> <li>• Colorado Healthy Rivers Fund</li> <li>• Colorado Watershed Restoration Protection</li> <li>• CWCB Construction Fund &amp; Severance Tax Trust Fund</li> <li>• CWCB Drought Mitigation Planning Grant Program</li> <li>• CWCB Water Efficiency Grant Program</li> <li>• CWCB Water Project Loan Program</li> <li>• CWCB Water Supply Reserve Program</li> <li>• Fish and Wildlife Resources Fund</li> <li>• Flood and Drought Response Fund</li> <li>• Non-Point Source Pollution Grants</li> <li>• Severance Tax Multi-Objective Watershed Protection</li> <li>• Watershed Restoration Grants</li> <li>• Wildfire Risk Reduction Grant Program</li> <li>• Agriculture Emergency Drought Response Fund</li> </ul>
<b>Local Affairs</b>	<ul style="list-style-type: none"> <li>• Drinking Water Revolving Fund</li> <li>• Water Pollution Control Revolving Fund</li> <li>• Revolving Loan Fund</li> <li>• Energy/Mineral Impact Assistance Fund (EIAF) Grants</li> </ul>
<b>Colorado State Forest Service</b>	<ul style="list-style-type: none"> <li>• State Fire Assistance WUI Grants</li> <li>• Wildfire Mitigation Financial Incentive for private property owners <ul style="list-style-type: none"> <li>• Tax break for property owners who perform wildfire mitigation</li> </ul> </li> </ul>
<b>Public Safety / DHSEM</b>	<ul style="list-style-type: none"> <li>• State Disaster Emergency Fund</li> </ul>
<b>Colorado Water Resources &amp; Power Development Authority</b>	<ul style="list-style-type: none"> <li>• Water Revenue Bonds Program</li> </ul>

Funding sources traditionally used have been Energy/Mineral Impact Assistance Fund (EIAF) grants, gaming funds, general funds, and severance tax.

In addition, the state administers funds associated with several federal mitigation programs, consisting of FEMA's Hazard Mitigation Assistance (HMA) programs (HMGP, PDM, and FMA), as well as EMPG, NEHRP, and Dam Safety, and USDA programs related to forest health and mitigation. State agencies continually work to identify new strategies for implementing mitigation projects, including new funding sources. The Mitigation Team has also worked closely with the CWCB and DOLA's Division of Local Government to identify potential additional funding when federal grants do not completely meet the needs of a given project or plan budget.

Although state agencies are doing their best to develop capability and processes to maximize the availability and efficient use of mitigation resources in Colorado, demand for mitigation dollars typically exceeds supply. As such, the state Disaster Emergency Fund (DEF) has been used to continue and expand support for statewide mitigation and recovery activities. For Colorado Presidential disasters 4067, 4133, 4134, and 4145, the DEF supported half (12.5%) of the non-federal share on Hazard Mitigation Grant Program (HMGP) projects and Public Assistance 406 projects for state and local entities. The state will consider assisting local governments with increased match in future disasters under circumstances of hardship and demonstrated need.

#### ***4.2 CHANGES IN FUNDING CAPABILITIES SINCE APPROVAL OF THE 2013 COLORADO NATURAL HAZARD MITIGATION PLAN***

Changes in funding capabilities since 2013 should be understood as an outgrowth of events that took place from (2010-2013) which fostered ongoing improvements in funding capability and grants management performance from 2013-2017.

##### **Colorado Division of Homeland Security & Emergency Management**

The movement of COEM to DHSEM since 2012 had (and since 2013 continues to have) no negative impact on the agency's role in the statewide mitigation program. Within DHSEM, the Mitigation Section's capabilities were, however, enhanced by the addition of a State & Local Hazard Mitigation Planning Program Manager in late 2012, another Mitigation Project Specialist in January 2014, and a Mitigation Planning Specialist in December 2016. These positions will continue to ensure mitigation capabilities of DHSEM and the Mitigation Section are maintained through disaster events and subsequent state recovery activities, as well as providing the opportunity for programmatic enhancements. In total, the DHSEM Mitigation Team is comprised of a State Hazard Mitigation Officer (SHMO), Mitigation Plans Unit Supervisor, Mitigation Projects Unit Supervisor, two Mitigation Planning Specialists, and one Mitigation Project Specialist who focuses on HMA funded mitigation projects. To ensure staff sustainability and return on investment, one to two more Mitigation Project Specialists would be beneficial for the DHSEM mitigation program.

Beyond staffing and expertise enhancements, many other changes in funding capabilities have occurred in Colorado pursuant to the enormous impact of the 2013 floods on Colorado's Front Range communities. At the center of such change is the influx (in 12-month lock in amounts) and utilization of FEMA's Hazard Mitigation Grant Program (HMGP) funding in the amount of (Federal Share) \$64,250,197 under DR 4145, and \$3,142,264 under DR 4229. Affected communities have applied for, and implemented a broad variety of projects designed to mitigate the impacts of floods and other hazards. Following is a summary of the type and number of projects implemented for DR 4145 and 4229:

Note: The summary of DR-related expenditures (below) is for HMGP spending only, and is an abbreviated version of the more detailed summary of all mitigation spending (HMGP, PDM, PA/406) located under Section 8 - Hazard Mitigation Assistance Grants Compliance.

#### DR 4145: 77 Projects

- 11 - 5% Initiatives
- 8 - Property Acquisition/Demolition
- 3 - Property Elevation
- 2 - Erosion Control
- 10 - Flood Control
- 17 - Generators
- 13 - Local Hazard Mitigation Plans
- 1 - State Hazard Mitigation Plan
- 10 - Wildfire Mitigation
- 1 - Advance Assistance

#### DR 4229: 10 Projects

- 2 - 5% Initiatives
- 1 - Property Acquisition/Demolition
- 1 - Generator
- 5 - Local Hazard Mitigation Plans

### **Colorado Department of Public Safety**

In 2012, the Colorado General Assembly passed HB12-1283, which transferred the Colorado State Forest Service (CSFS) Fire Division to the Colorado Department of Public Safety (CDPS), effective July 1, 2012. The primary purpose of the transfer was to increase efficiencies in public risk messaging and emergency support functions between the Departments of Local Affairs and Public Safety regarding homeland security and emergency management activities. The transfer also centralized the state's fire response functions into a single, statewide point of contact.

The legislation transferred the state's wildfire preparedness, response, suppression, coordination, and management functions from the Colorado State Forest Service/Colorado

State University to the Colorado Department of Public Safety. In 2012, the following programs, plans, and funding sources were transferred from the CSFS to CDPS:

- Responsibility for state-managed wildland fires and administering of Emergency Fire Fund (EFF)
- Prescribed burn program standards and regulation
- Coordination and administration of Volunteer Fire Assistance (VFA) Grants
- Wildfire Emergency Response Fund
- Wildfire Preparedness Fund
- Federal Excess Personal Property Program and maintenance of wildland fire engine fleet
- Wildfire aviation programs, including Single-Engine Air Tanker (SEAT) program management
- Cooperative wildfire billing
- Support of counties with Annual Operating Plans (AOPs)

### **Colorado State Forest Service**

HB12-1283 reinforced the CSFS status as the lead state agency for forest management and forest stewardship, and allowed the CSFS to strengthen its role in providing outreach and technical assistance in wildland fire ecology, fire prevention outreach, wildland fire mitigation, planning, and assessment of wildfire risk. The following programs and plans related to wildland fire mitigation remain with the CSFS:

- Wildfire Risk Reduction Grant (WRRG) Program
- National Firewise USA™ Community Designation
- Fire Adapted Communities (FAC) Program
  - Including Colorado's Are You Firewise? Program
- Community Wildfire Protection Plan (CWPP) and Technical Assistance Program
- Colorado Wildfire Risk Assessment Portal (CO-WRAP) Risk Mitigation Mapping Program

The CSFS is also an active participant in coordinating with Colorado Citizen and Place-Based Forest Collaboratives. These groups represent grass-roots efforts to collaboratively work on solutions to issues in Colorado's forests.

### **Colorado Geological Survey**

In early 2013, the Colorado Geological Survey (CGS) was transferred by the Governor and legislature from the Colorado Department of Natural Resources to the Colorado School of Mines (CSM). The opportunity presented to CSM and CGS is to leverage common expertise and interests to better serve Colorado. The physical relocation of the CGS from Downtown Denver to the Mines campus in Golden has allowed both organizations to directly collaborate on joint

projects. Through state funding, the agency provides technical assistance to communities for geologic hazard mitigation centered on improving community planning and mapping resources.

### **Colorado Water Conservation Board**

Historically, the Colorado Water Conservation Board (CWCB) has supported programs to fund stream and watershed restoration, many of which have a benefit of flood hazard mitigation. Regarding flood mitigation, the most significant change since 2013 has been the leveraging and implementation of Emergency Watershed Protection (EWP) funding for stream restoration projects along the Front Range in the wake of the 2013 flood disaster. The Colorado EWP Program, 2013 Flood Recovery Phase II, was funded and administered by the USDA Natural Resources Conservation Service (NRCS) and managed by the CWCB on behalf of the state. The Colorado EWP Program provided funding to implement emergency recovery measures to address hazards to life and property in watersheds impaired by the 2013 Colorado flood event. The program provided financial and technical assistance to local project sponsors to reduce erosion and threats from future flooding, protect streambanks, repair conservation practices, remove debris, and more. Sixty-four million dollars in funding was appropriated under EWP Phase II; as of March 2018, 49 of 67 total projects were completed, with the remainder under construction (<https://coloradoewp.com/home>).

In 2014, Colorado Senate Bill 14-179 allocated \$2.53 million to the CWCB for the implementation of the State's first watershed-based disaster recovery pilot program. These flexible funds were granted to local governments, watershed coalitions, non-profit organizations, and individual land and business owners for design and construction of pilot projects that illustrated a proof-of-concept for the watershed-based approach to flood recovery.

The CWCB Water Supply Reserve Fund (WSRF) Grant Program came online in 2016. The WSRF Program provides grants and loans to assist Colorado water users in addressing their critical water supply issues and interests. The funding program evolved from the 2015 State Water Plan, and water supply enhancement projects identified in Basin Implementation Plans may be eligible for the continuous \$10 million (subject to availability) annual appropriation. These water supply enhancement projects could help boost drought resilience.

The CWCB Flood and drought response fund was created in 2012 for flood and drought preparedness, response, and recovery activities. Since its creation in 2012 it has increased from \$300k to \$500k each year based on how much is used the previous year.

### **Colorado Department of Transportation**

The Colorado Department of Transportation (CDOT) allocates internal funding on a regular basis for operational needs related to rockfall and avalanche mitigation.

The state's transportation system has suffered significant damage from floods, fire, rockfall, and other physical events in recent years. The first of these impacts was the physical, social, and economic damage sustained following the September 2013 floods along the Front Range. The second event was the February 2016 Glenwood Canyon rockfall on Interstate 70, resulting in

approximately \$16 million in road-user costs, and additional millions more in economic losses from disruptions to businesses and government operations. (Source: <https://www.codot.gov/about/transportation-commission/documents/2016-archive-of-supporting-documents/september-2016/4-resiliency-committee.pdf>)

Beginning in the fall of 2016, (with funding approved by the Transportation Commission Resiliency Subcommittee in July 2016), CDOT began work on the Interstate 70 Risk and Resiliency Pilot project. This project represents a significant step toward expanding hazard mitigation capability and funding as a key component of the state's efforts to achieve resilient outcomes. The goal of the Pilot is to quantify and improve system resilience in advance of future natural hazard events to better prepare CDOT and reduce future losses. The report was completed in late 2017.

### **Federal Highway Administration (FHWA) Risk and Resilience Funding**

As a result of the impacts to transportation infrastructure from the 2013 flood event, the state secured significant funding for repairs to highway infrastructure which included mitigation inputs into project designs, such as the addition of set-backs in canyons to increase space between roadways and adjacent slopes and canyon walls, in order to reduce the risk of rockfalls and landslides to roadway infrastructure, drivers, and vehicles. This example illustrates the state's effort to expand the use of disaster recovery funding in order to build resiliency into project design by further reducing the exposure of people and public assets beyond standard repair practices.

### **Colorado Department of Local Affairs**

In 2014, the U.S. Department of Housing and Urban Development (HUD) announced it approved Colorado's Community Development Block Grant - Disaster Recovery (CDBG-DR) Action Plan, administered by the Department of Local Affairs (DOLA). The plan outlines how DOLA distributes grant dollars received from HUD for flood recovery programs from the 2013 event. This grant supports recovery efforts in 19 Presidentially declared flood-impacted counties, with a majority of the funds going to counties most affected: Boulder, Larimer, and Weld. Programs focus on housing, public infrastructure, long-term planning and economic development and, as stipulated by the grant, fifty percent of the funds were distributed to low- and moderate-income households (Source: <https://www.colorado.gov/pacific/dola/node/101531/>)

In addition, DOLA recently completed the CDBG-DR Resilience Planning Program with expenditures of over \$12,000,000 in disaster recovery funds through the end of 2017. With the assistance of grantees, 89 projects have been completed across communities, coalitions, and counties impacted by the declared disasters of 2012 and 2013. This funding source is wholly allocated and has completed diverse projects, including the small sample below:

- Municipal Comprehensive Master Plans
  - City of Longmont

- City of Manitou Springs
- Town of Milliken
- Community Planning Resource Documents
  - Planning for Hazards Guide and Implementation
  - Resilient Crossings Handbook
  - Stream Stewardship and Recovery Handbook
- River and Creek Planning and Design
  - Big Thompson River: Canyon and City of Loveland Reaches
  - St. Vrain River: Hall Ranch, Apple Valley
  - Monument Creek Master Plan including U.S. Air Force Academy
- Specialized Planning
  - Hazard Identification & Risk Assessments including the Town of Jamestown and Town of Lyons
  - Wildfire, Hydrology, and Resiliency Master Plans
  - Stormwater Master Plans
- Staff and Community Resiliency Efforts
  - BoCo Strong
  - Larimer Connects
  - Resiliency for All

Other DOLA-based funding initiatives that demonstrate the state's recent and continued improvement and expansion of hazard mitigation, recovery, and resiliency in response to the 2013 flood disaster (DR 4145) include the *Planning for Hazards Implementation Project*, the *Planning for Hazards Guide*, the *Watershed Resilience Pilot Program*, and the Privately-Owned and Non-Profit Ditch Company Grants. Finally, DOLA's Revolving Loan Fund has some flexibility in the terms and conditions of use, and as such, has been identified by the SHMT as a potential resource for mitigation-related initiatives.

### **Colorado Resiliency Office**

The Colorado Resiliency Office (CRO) was formed as the Colorado Resiliency & Recovery Office (CRRO) in response to the massive impact of the 2013 flood event, in order to facilitate deployment of resources to flood-impacted communities. In August of 2017, DOLA announced the transition of the CRRO from the Governor's Office to the CRO in the Division of Local Government (DLG) within the agency; the move was formalized in HB 18-1394, signed into law by the Governor on May 24, 2018. This transition complements disaster recovery work already being carried out in DOLA, and will help to ensure the CRO's ongoing commitment to assist Coloradans in the event of a natural disaster. The organizational shift is also designed to maximize efficient use of existing funding resources which in turn should enhance the ongoing resiliency efforts across the state. The CRO's efficiency efforts focus on centralized reporting, transparency, and building partnerships across public and private organizations.

In 2018, the CRO launched the Colorado Resiliency Institutionalization Project (CORIP) to explore ways to more formally build resiliency into state operations and investments. Based on stakeholder input, CORIP is currently focusing on the following three initiatives:

- Developing a shared approach for guiding internal investments and budgeting using a resilience lens. Project concepts might include, but are not limited to:
  - Conduct a series of focus groups with engaged local partners and key departmental staff to identify best practices and refine resiliency criteria
  - Establish agencies' use of this guidance with an MOU or other agreement
  - Develop a methodology for evaluating the cost/benefit or advantages and disadvantages of state actions with regards to resiliency and equity and test on a sample population or jurisdiction
  - Develop a database tracking ROI on resiliency investments across State government
- Developing a list of laws/regulations that can be adapted to include resiliency requirements or criteria. Project concepts might include, but are not limited to:
  - Develop an implementation plan for revising identified laws and regulations and/or developing and establishing resiliency criteria
  - Include a list of financing mechanisms for resiliency measures that can be used by State departments and/or local communities
- Establishing a behavioral health capacity/workforce resiliency working group. Project concepts might include, but are not limited to:
  - Develop resources for departmental behavioral health staff
  - Plan improvements in the delivery of behavioral health services to State employees
  - Look at DOLA's mental health program for police officers as a model

#### **4.3 FEDERAL MITIGATION FUNDING PROGRAMS**

Federal mitigation programs serve as critical funding sources to reduce the risk of natural hazards to Colorado's people, property, environment, and economy. Colorado and its mitigation partners attempt to maximize the application of federal funding from FEMA, USDA, USA CE, HUD, SBA, and other agencies each year. Mitigation funds from FEMA typically support a number of various projects through DHSEM each year. The state will continue to apply for mitigation grants through the Hazard Mitigation Assistance (HMA) Program, specifically its Flood Mitigation Assistance (FMA) and Pre-Disaster Mitigation (PDM) grants, as availability of funds are announced.

These grants support development of local hazard mitigation plans, as well as construction projects and other eligible FEMA activities. The state leveraged FEMA 406 mitigation with Public Assistance (PA) program funding during DR 4145 which resulted in 674 projects with hazard mitigation components including \$22M in mitigation funding. See Section 8 - Enhanced

Plan for more discussion on how the state will continue to leverage 406 funding for mitigation in recovery.

### **Changes in FEMA Funding Policies since 2013**

It should be noted that the state's success in receiving a significant increase in HMGP funding resulted from its partnership with FEMA and the private sector, its utilization of FEMA's (2013) Advance Assistance Program designed to remove the traditional barriers to states and communities' prioritization, and development of mitigation projects able to meet all of FEMA's criteria for HMGP funding approval. It is important to note that prior to this new program, states and communities had to leverage the expertise and bear the cost of conducting project feasibility and prioritization processes simply in order to arrive at a list of key mitigation projects. As part of this same process, such communities then had to overcome the expertise and resource challenges of developing all the data and analysis required for developing an HMGP project application.

Additionally, as of June 8, 2018 FEMA is making HMPG funds available for states, territories, and federally-recognized tribes that have a Fire Management Assistance Grant (FMAG) declaration between October 1, 2016 and September 30, 2018. Under the HMGP Post Fire program the amount available for eligible applicants with standard state or tribal hazard mitigation plans is \$425,008 per declaration, and for eligible applicants with enhanced state or tribal hazard mitigation plans is \$566,677 per declaration. It is not yet known if this program will be renewed after September 30, 2018. Significant to note is this change in funding policy came about through an initiative proposed by Colorado DHSEM to increase mitigation funding with other types of declarations. Colorado has experienced five wildfires with FMAG declarations during this time period, listed below. Colorado was awarded \$2.1 million for the Post-Fire program on July 23, 2018 and are currently in the process of project development and drafting applications, due February 1, 2019.

- October 4, 2016: Beulah Hill Fire (FM-5155), Pueblo County
- October 17, 2016: Junkins Fire (FM-5157), Custer and Pueblo Counties
- June 28, 2018: Spring Creek Fire (FM-5246), Costilla and Huerfano Counties
- June 30, 2018: Chateau Fire (FM-5247), Teller County
- July 4, 2018: Lake Christine Fire (FM-5249), Eagle County

Beginning in 2013, the State of Colorado utilized the unique benefits of the Advance Assistance Program and provided its communities the ability to "scope" projects, by conducting preliminary engineering, benefit cost analysis, cost estimating, and environmental review of priority projects. Achieving these technical steps is critical to overcoming challenges related to developing project applications, where such challenges may sometimes deter potential HMGP applicants from applying for funding. In summary, the program enabled the State of Colorado to efficiently and successfully develop a broad variety of HMGP project applications and receive funding for

approved projects that have been implemented (or are in process) to mitigate the future physical, economic, and social impacts of hazard events across the state.

In 2015, FEMA initiated policy changes which enabled communities to implement flood control projects beyond traditional limits of HMA programs. FEMA removed “minor” flood control project limitations and newly considered major flood control projects, as well as levee construction/re-construction projects (previously not eligible under HMA), as long as project funding did not involve duplication of federal program funding. With a broader range of mitigation project options now available, the potential to conduct more mitigation activities within Colorado has increased because of this policy change.

### **The US Army Corps of Engineers (USACE) Silver Jackets program**

Education projects, outreach programs, repeater sites, early detection and warning/notification systems, generators for backup power, and chippers for slash and mulch projects are very popular in Colorado. Local communities are constantly seeking sources of funding to maintain programs and install or upgrade systems. Unfortunately, funds for these types of projects are limited and the need strongly outweighs the availability. Even if communities receive startup funds, continuation of programs often create new financial requirements on already very tight budgets with competing demands. Regardless, Colorado communities have made great strides and progress in mitigation, prevention, and preparedness activities and continue to do more each year by taking advantage of limited opportunities. For example, several communities benefited years ago from a grant program through USDA designed to fund repeater sites in remote locations, thereby serving communities with the need but without a means to receive emergency warnings pertinent to their immediate area. DHSEM staff promoted the grant opportunity and worked with communities on grant applications.

### **Bureau of Reclamation**

The Bureau of Reclamation’s WaterSMART program has potential to be leveraged further for both drought mitigation planning and projects. The Drought Act of 1991 empowered the Bureau of Reclamation to provide support to states and local jurisdictions after they had experienced a drought emergency. In 2015, the program was reformulated to a more proactive approach through collaboration with federal and non-federal agencies. The WaterSMART program is an umbrella for the six (6) Bureau of Reclamation water programs. The Drought Response program is one that provides financial assistance to develop or update drought contingency plans and drought resiliency projects.

### **4.4 OTHER PROGRAMS AND SOURCES**

Each year local jurisdictions invest in mitigation activities across the state. These investments may be fully funded and locally directed, or as cash or in-kind matching funds for federal and state mitigation programs. Nonprofit organizations may have various programs or opportunities for public and private sector entities, including private property owners, to receive and apply funding or services to natural hazard mitigation. In addition, other opportunities for mitigation funding exists in the private sector through various foundations.

#### 4.5 SUMMARY OF MITIGATION FUNDING SOURCES

A description of current and potential federal, state, local, and nonprofit mitigation funding programs and opportunities available in Colorado is found in Table 4-5. Although the list of funding sources contains many funding opportunities, the list is not all inclusive.

**TABLE 4-5 FEDERAL, STATE, LOCAL, AND NON-PROFIT MITIGATION FUNDING SOURCES IN COLORADO**

Name	Level	Source Agency	Managing Agency	Purpose of Funding
<b>Agricultural Emergency Drought Response Fund</b>	State	CWCB	CWCB	For emergency drought-related water augmentation purposes to agriculture water users.
<b>AmeriCorps</b>	Federal	Corporation for National & Community Service	Office of Lieutenant Governor	Provides funding for volunteers to serve communities, including disaster prevention. AmeriCorps/Vista has assisted local communities with wildfire mitigation projects.
<b>Clean Water Act Section 319 Grants</b>	Federal	EPA	CDPHE	Provides grants for a wide variety of activities related to non-point source pollution runoff mitigation.
<b>Community Assistance Program (CAP)</b>	Federal	FEMA, NFIP	DNR	Product-oriented financial assistance program directly related to the flood loss reduction objectives of the NFIP.
<b>Community Development Block Grant (CDBG)</b>	Federal	HUD	DOLA	Often following a disaster, the state may receive a CDBG Supplement intended for mitigation projects in the affected areas. Funding also supports public facilities including water and wastewater.
<b>Community Fire Protection Program</b>	Federal	USDA	CSFS	Mitigation delivered via USDA Forest Service and Private Forestry Coop Fire Programs.
<b>Dam Safety Program</b>	Federal	FEMA, State	DNR	Promotes dam safety through Emergency Action Plans (EAPs), risk assessments, and exercises.
<b>Economic Development Administration Grants and Investments</b>	Federal	U.S. DOC, EDA	EDIT	Invests and provides grants for community construction projects, including mitigation activities.

Name	Level	Source Agency	Managing Agency	Purpose of Funding
<b>Emergency Management Performance Grant (EMPG)</b>	Federal	FEMA	DHSEM	The EMPG program provides a yearly allocation of funding to support state and local emergency management programs. In the past, it included providing some funding for local mitigation plans, mitigation-oriented studies, and related activities.
<b>Emergency Watershed Protection (EWP)</b>	Federal	USDA, NRCS	CWCB	Provides funding and technical assistance for emergency measures such as floodplain easements in impaired watersheds.
<b>Environmental Quality Incentives Program</b>	Federal	USDA, NRCS	CDA	Provides funding and technical assistance to farmers and ranchers to promote agricultural production and environmental quality as compatible goals.
<b>Fire Management Assistance Grants (FMAG)</b>	Federal	FEMA	DPFC	Provides fire suppression support to states when loss of life and property are imminent. Wildfire mitigation is also eligible under emergency protection if life is in imminent danger.
<b>Flood Mitigation Assistance (FMA) Program</b>	Federal	FEMA	DHSEM	Repetitive flood loss property reduction. Since many homeowners are not interested in these project opportunities, often the funds go unused.
<b>Forest Land Enhancement Program</b>	Federal	USDA, DNRC	CSFS	Provides educational, technical, and financial assistance to help landowners implement sustainable forestry management objectives
<b>Forest Legacy Program</b>	Federal	USFS	CSFS	Program providing funding to protect private forest lands that are environmentally, economically, and socially critical. This program reduces development in the wildland-urban interface.
<b>Hazard Mitigation Grant Program (HMGP)</b>	Federal	FEMA	DHSEM	Post-disaster multi-hazard mitigation funding.

Name	Level	Source Agency	Managing Agency	Purpose of Funding
<b>Homeland Security Grant Program (HSGP)</b>	Federal	DOJ, DHS	DHSEM	Homeland security activities identified in state and local strategic plans. Funding supports threat and hazard identification and risk identification (THIRA) for natural, technological, and human-caused hazards. Some prevention activities may be considered mitigation.
<b>Housing and Urban Development (HUD) Grants</b>	Federal	HUD	DOLA	Provides a number of grants related to safe housing initiatives.
<b>Individual Assistance (IA)</b>	Federal	FEMA/State	DHSEM	Following a disaster, funds can be used to mitigate hazards when repairing individual and family homes.
<b>In-Lieu Fee Program Mitigation Projects</b>	Federal	USACE	Community Applicants	Restoration, establishment, enhancement, and/or preservation of aquatic resources through funds paid to a governmental or non-profit natural resources management entity to satisfy compensatory mitigation requirements for Department of the Army permits.
<b>RiskMAP Program</b>	Federal	FEMA, NFIP	DNR	Establishes or updates floodplain mapping and multi-hazard risk products.
<b>Mitigation Banks</b>	Federal	USACE	Community Applicants	Mitigation Banks are sites approved by the Corps to sell compensatory mitigation credits for projects resulting in unavoidable impacts to waters of the U.S. When a permit is issued that requires compensatory mitigation, the permit will specify how many credits are required to be purchased at an approved mitigation bank.
<b>National Earthquake Hazards Reduction Program (NEHRP)</b>	Federal	FEMA	CGS	Provides money to support enhanced earthquake risk assessments in local hazard mitigation plans and other earthquake hazard mitigation and preparedness activities.

Name	Level	Source Agency	Managing Agency	Purpose of Funding
<b>National Fire Plan</b>	Federal	USDA, DOI	CSFS	Provides pre-disaster funding for primarily wildland fire mitigation, but also planning for all hazards.
<b>National Wildlife Wetland Refuge System</b>	Federal	USFWS	CPW	Provides funding for the acquisition of lands into the federal wildlife refuge system.
<b>North American Wetland Conservation Fund</b>	Federal	USFWS	CPW	Provides funding for wetland conservation projects.
<b>NRCS Conservation Programs</b>	Federal	USDA, NRCS	Applicant	Provides funding through a number of programs for the conservation of natural resources.
<b>Conservation District Assistance Grants</b>	State	Department of Agriculture	Department of Agriculture	Local conservation programs with state's 76 Conservation Districts that improve soil health, water quality, water conservation, wildlife habitat, forest health, plant communities, energy conservation, and wildfire mitigation.
<b>Partners for Fish and Wildlife</b>	Federal	USFWS	CPW	Provides financial and technical assistance to landowners for wetland restoration projects in "Focus Areas" of the state.
<b>Planning Assistance to States</b>	Federal	USACE	CWCB	Provides assistance to States in planning for the development, utilization, and conservation of water and related land resources.
<b>Pre-Disaster Mitigation (PDM) Program</b>	Federal	FEMA	DHSEM	Grants for specific multi-hazard mitigation projects, including planning.
<b>Public Assistance (PA)</b>	Federal	FEMA/State	DHSEM	Following a disaster, funds can be used to mitigate hazards when repairing damages to a public structure or infrastructure. Wildfire mitigation is also eligible for emergency protective measures for threatened facilities.
<b>Rural Development Grants</b>	Federal	USDA, Rural Development	CDA	Provides grants and loans for infrastructure and public safety development and enhancement in rural areas.
<b>Rural Fire Assistance Grant</b>	Federal	NIFC	Community Applicants	Funds fire mitigation activities in rural communities.

Name	Level	Source Agency	Managing Agency	Purpose of Funding
<b>Small Business Administration (SBA) Pre-Disaster Mitigation Loan Program</b>	Federal	SBA	Applicant coordinated through DHSEM	Provides low-interest loans to small businesses for mitigation projects.
<b>Small Flood Control Projects</b>	Federal	USACE	Local Applicants	Authority of USACE to construct small flood control projects.
<b>Silver Jackets</b>	Federal	USACE	CWCB and Local Applicants	Can provide funding for flood related studies, public awareness, risk analysis, and flood response plans. Construction of small flood control projects.
<b>Urban Drainage &amp; Flood Control District (UDFCD) Capital Improvement Project (CIP) Fund</b>	Local	UDFCD	UDFCD	Provides capital project funding to jurisdictions within the UDFCD boundaries.
<b>Coalition for the Upper South Platte (CUSP)</b>	Nonprofit	CUSP	CUSP	Provides funding for wildfire mitigation, watershed restoration, mine hazard assessments, and other activities.
<b>Colorado Flood and Drought Response Fund</b>	State	DNR	CWCB	The fund can be used for flood and drought preparedness, and for response and recovery activities following flood or drought events and disasters.
<b>Colorado Healthy Rivers Fund</b>	State	DNR	DNR	For projects that promote improvement and/or protection of the condition of the watershed including flood protection and channel stability.
<b>Colorado Water Resources &amp; Power Development Authority Revenue Bonds Program</b>	State	CWRPDA	CWRPDA	Water and wastewater treatment plants, pump stations, dams/reservoirs, water rights, pipelines, hydro-electric projects, wells, meters, reuse, storage tanks, et cetera.

Name	Level	Source Agency	Managing Agency	Purpose of Funding
<b>Colorado Watershed Restoration Protection</b>	State	DNR	DNR	Provides funds for watershed and stream master planning in flood affected watersheds. Master plans should guide communities towards prioritization and implementation of stream rehabilitation and restoration projects that protect life and property from flood hazards.
<b>CWCB Construction Fund &amp; Severance Tax Trust Fund</b>	State	DNR	DNR/CWCB	Provides funding for raw water projects (e.g., dams, pipelines, ditches, wells, new projects or restorations).
<b>CWCB Water Conservation and Drought Mitigation Planning Grant Program</b>	State	DNR	CWCB	Water conservation planning, drought mitigation planning, and project implementation.
<b>CWCB Water Efficiency Grant Program</b>	State	DNR	CWCB	For aid in achieving goals in Water Conservation Plans; to promote the benefits of water resource conservation for education and outreach aimed at demonstrating the benefits of water efficiency.
<b>CWCB Invasive Species Program</b>	State	DNR	CWCB	Reduction of invasive species including tamarisk that contribute to low stream flows in drought.
<b>CWCB Water Project Loan Program</b>	State	DNR	CWCB	Provides funding for raw water projects (e.g., dams, pipelines, ditches, wells, new projects or rehabilitation).
<b>CWCB Water Supply Reserve Fund (WSRF) Grant Program</b>	State	DNR	CWCB	Provides grants and loans to assist Colorado water users in addressing their critical water supply issues and interests.
<b>WaterSMART – Drought Response Program</b>	Federal	Reclamation	Reclamation	Provides for contingency planning, resiliency projects, and emergency response actions.
<b>Drinking Water Revolving Fund</b>	State	DOLA/ CDPHE/ CWRPDA	DOLA/ CDPHE/ CWRPDA	Low-interest loans for drinking water treatment system needs.
<b>Energy/Mineral Impact Assistance Fund (EIAF) Program</b>	State	DNR	DOLA	Public facilities including water and wastewater, fire stations, et cetera.

Name	Level	Source Agency	Managing Agency	Purpose of Funding
<b>Fish and Wildlife Resources Fund</b>	State	DNR	DNR	River restoration feasibility studies and construction projects designed to directly mitigate or significantly improve the environmental impacts of existing water facilities.
<b>Flood and Drought Response Fund</b>	State	DNR	CWCB	Provides for flood and drought preparedness, and response and recovery activities following flood or drought events and disasters.
<b>Non-Point Source Pollution Grants</b>	State	DNR	DNR	Applicants can include governmental and non-governmental organizations.
<b>Severance Tax Multi-Objective Watershed Protection</b>	State	DNR	CWCB	The account exists primarily to provide grants for regional water resource planning studies and associated demonstration projects.
<b>State Disaster Emergency Fund (DEF)</b>	State	Governor's Office	DHSEM	Provides funding for emergency or disaster related activities, to include response, recovery, and mitigation.
<b>State Fire Assistance WUI Grants</b>	State	CSFS	CSFS	Funds available to property and homeowner associations, subdivisions, fire departments, counties, and other groups to implement projects that mitigate wildfire hazards in the wildland-urban interface. Funds hazardous fuels reduction, fire information and education, and community and homeowner action.
<b>Water Pollution Control Revolving Fund</b>	State	DOLA/ CDPHE/ CWRPDA	DOLA/ CDPHE/ CWRPDA	Low-interest loans for public waste water treatment system needs and watershed nonpoint source control projects.
<b>Watershed Restoration Grants</b>	State	DNR	DNR	Watershed/stream restoration and flood mitigation projects. These grants were utilized in response to the 2012 High Park and Waldo Canyon Fires.
<b>Wildfire Mitigation Financial Incentive</b>	State	CSFS	CSFS	Allows landowners who complete wildfire reduction measures on their own lands in the WUI to deduct a maximum of \$2,500 from their federal taxable income.

Name	Level	Source Agency	Managing Agency	Purpose of Funding
<b>Wildfire Risk Reduction Grant (WRRG) Program</b>	State	DNR	DNR	Provides funding to reduce the risk of wildfire in areas where human development and forested lands overlap, areas often called the wildland-urban interface (WUI).

## 5. OBSTACLES AND CHALLENGES

The State of Colorado has made considerable progress in closing gaps and improving overall mitigation capabilities since the creation of the state’s first hazard mitigation plan in 2001. Nevertheless, room for improvement remains. This section discusses some of the challenges facing the state’s hazard mitigation program, what has been done to address those challenges, and what remains to be done.

As previously noted in Section 1, the state developed the *Colorado Enhanced Mitigation Plan: Phase I Road Map* in 2016. The primary purpose of the Road Map was to lay out a path for achieving enhanced plan status, yet many of the gaps and opportunities identified apply to standard plan components as well. Many of these obstacles have been overcome in the two years since the Road Map report was prepared, but other challenges have not yet been addressed and are discussed below. Additional improvements specific to enhanced plan requirements can be found throughout Section 8.

One significant challenge the state has faced since the adoption of the 2013 SHMP was the historic statewide floods of September 2013 and the extended recovery efforts resulting from those floods. The enormity of this event made it difficult to keep up with many of the Plan implementation requirements, such as the Plan Maintenance Activity Timeline spelled out in the 2013 Plan. On the other hand, the response to and recovery from the 2013 floods resulted in some of the best interagency and intergovernmental coordination in Colorado’s history, much of which was focused on mitigating the effects of future disasters. It also resulted in the largest amount of funding the state has ever had for funding hazard mitigation under the HMGP, in addition to millions of dollars made available for mitigation through CDGB-DR, NRCS EWP, and FHWA Risk and Resilience funds. The large influx of funding presented several challenges at the state and local level. Many communities were not experienced with HMGP funding or knowledgeable of the application requirements. To meet this challenge DHSEM supplemented its mitigation program staff and also procured technical consulting assistance that aided over 60 communities with successful grant applications. Additional staffing capabilities, software, and technical consulting assistance was utilized for effective management and implementation of the grant funding.

## 5.1 PROGRESS MADE

The following bullets are obstacles and challenges excerpted from the 2016 Road Map report. Each sub-bullet is followed by a description of how the state addressed these challenges in subsequent years or during the update of the SHMP.

- Planning and updating of the State’s Threat and Hazard Identification and Risk Assessment (THIRA) was not previously well coordinated and integrated with state hazard mitigation planning activities.
  - As discussed in detail in Section 8 (pg. 8-9), the HIRA section of the SHMP was used as a key update in the development of the 2016 THIRA, and information from the THIRA planning scenarios were in turn used in the 2018 SHMP update.
- Strategies for integrating mitigation into post-disaster recovery, including the use of 406 mitigation funds, were not coordinated and integrated with state hazard mitigation planning activities.
  - A detailed strategy for post-disaster mitigation and use of 406 funding was developed as part of this Plan update, and is included in Section 8 (pg. 8-53).
- Coordination between agencies and stakeholders was not always well documented.
  - Documentation of coordination contacts has improved significantly, as discussed throughout Section 8. Several of the Compliance Tools included in Appendix D were developed specifically to aid this documentation.
- The 2013 SHMP did not adequately capture the mitigation activities of other state agencies besides DHSEM.
  - This has been better captured in the current Plan update; see the section above on state capabilities (page 4-3).
- The previous Plan did not adequately address risks to buildings identified as necessary for post-disaster response and recovery operations.
  - This has been better addressed in the 2018 Plan; see the Risk to State Assets section for each hazard addressed in the HIRA (Section 3).
  - A Mitigation Action has been identified in Section 5 to further refine the risk to these facilities (Action 2018.29).
- Hazard-specific plans such as the Flood Hazard Mitigation Plan and the Drought Mitigation and Response Plan were not previously well-integrated with the SHMP planning process.

- The state updated the Flood Hazard Mitigation Plan and the Drought Mitigation and Response Plan concurrently and in coordination with the 2018 SHMP update as described in Section 1. Mitigation actions identified in both plans were incorporated into the SHMP mitigation strategy. (See pgs. 1-9, 5-12.)
- The state did not previously have a strong process or criteria for prioritizing mitigation actions.
  - The state has developed a new process for prioritizing mitigation actions, as described in Section 5 (page 5-9 to 5-12), which utilizes criteria from the Colorado Resiliency Framework.
- The state did not previously have a strong process for measuring the effectiveness of mitigation activities.
  - The state has developed a new process for measuring mitigation effectiveness, as described in Section 5 (page 5-31 to 5-42).
- The state self-identified many areas for improvement in grants management and effective use of funds.
  - Improvements made in these areas are discussed in detail in Section 8 (page 8-33 to 8-44, and 8-52 to 8-53).

## **5.2 REMAINING CHALLENGES**

The following bullets are challenges excerpted from the 2016 Road Map report, with commentary on challenges that remain.

- The SHMT did not meet regularly during the last five years, nor was the Plan reviewed and updated annually as required in the Plan Maintenance Activity Timeline of the 2013 Plan.
  - As noted above, this was largely due to the enormity of the state’s response to and recovery from the 2013 floods. However, the Colorado Resiliency Working Group (CRWG) was formed in June 2014 “to steer the development of a Resiliency Framework and incorporate resiliency strategies and activities into the flood recovery while also establishing a path to integrate resiliency into the fabric of every-day life.” This group has met regularly during the past four years, includes representatives from DHSEM, and has done much to encourage and strengthen mitigation and resiliency throughout the state, meeting many of the intended purposes of the SHMT meetings.
  - Section 7 - Implementation, Maintenance, and Review has been enhanced with a bi-annual meeting schedule. Several of the Compliance Tools included in Appendix D were developed specifically to aid with facilitation of the bi-annual meetings.

- Many of the Lead Agencies identified in the 2013 mitigation strategy did not regularly assess and update mitigation actions as described in the 2013 Plan.
  - Again, this was largely a result of the 2013 floods, and likewise many of the mitigation actions were discussed or reviewed in other contexts post-flood.
  - A process has been identified to aid in this, outlined in Section 7 - Implementation, Maintenance, and Review, and a mitigation actions data base has been created to assist in this process.
- The lack of statewide building codes has been identified as a weakness.
  - While the state cannot require local jurisdictions to adopt building codes, it has looked at ways to encourage and promote local adoption. This is detailed in Appendix C.
- The state has not formally designated an entity responsible for coordinating hazard mitigation, risk reduction, and resiliency across all state agencies.
  - As discussed in Section 8.1.1, the SHMT effectively fills this role. However, its authorities and responsibilities are not spelled out in any formal regulation or order. The CRO also fulfills several of these duties, but its authority is not tied to the SHMP. The SHMT discussed this at length during the planning process, and will further explore solutions in the coming months.

## LOCAL CAPABILITIES

Most local hazard mitigation plans include an assessment of local capabilities, providing insight into how mitigation is and could be implemented at the local level. However, tracking all local mitigation related capabilities can be difficult. In many cases, these capabilities are integrated into every day operations and as such they are not paid special attention in relation to their impact on an overall mitigation program. That being said, numerous communities in Colorado have implemented mitigation practices of some kind. This section is intended to highlight some of those capabilities and successes.

The section includes a general description of local mitigation policies, programs, and personnel, as well as technological and financial tools. This section additionally includes the effectiveness of these local pre- and post-disaster mitigation policies, programs, and tools, such as building codes, zoning, or land use policies.

### 1. LOCAL CAPABILITY OVERVIEW

Local capabilities serve as the cornerstone to successful implementation of mitigation strategies. Within Colorado's 64 counties, two tribes, and 271 incorporated municipal governments, mitigation capabilities vary widely. Variation in capabilities may be the result of many factors,

including where the jurisdiction is located in relation to hazard extent, regional economies impacting local tax base, political support, home rule or statutory authorities, full-time or part-time personnel, regular maintenance of and adherence to community and operational plans, and strength of regulation enforcement.

The State Plan update process is closely integrated with local jurisdiction and tribal planning efforts. Similar to the process used to develop the 2010 State Plan, and the 2013 Plan update, the 2018 Plan update includes an analysis and data roll-up of capability information from 59 local hazard mitigation plans (two multi-county regions, 49 counties, six cities, and two Tribes).

### 1.1 CAPABILITY CATEGORIES

The capability assessment for the 2018 State Plan update included DHSEM’s new Mitigation Capabilities tracker which divides local capabilities into four categories as described by FEMA : *Planning & Regulatory, Administrative & Technical, Financial, and Education & Outreach*. Any and all information related to the capability categories listed in Table 4-6 was collected from each local plan and integrated into the risk assessment of the 2018 State Plan update. This provides a solid baseline to understand what local jurisdictions have in place to implement mitigation. Over time this will allow DHSEM to further track local capability improvements and identify where opportunities may exist to provide further support.

**TABLE 4-6 LOCAL CAPABILITIES CATEGORIES EVALUATED**

Capability Categories	
Planning & Regulatory	Administrative & Technical
Financial	Education & Outreach

### 1.2 PLANNING & REGULATORY CAPABILITIES

The *Planning & Regulatory* category includes plans, codes, ordinances, and planning mechanisms a local jurisdiction may possess that would give support to implementing mitigation action strategies. The types of planning and regulatory capabilities are shown in Table 4-7. Each local jurisdiction is unique and may have additional regulatory or planning capabilities that are not listed in the table below which is why there is also an “other” category.

**TABLE 4-7 PLANNING & REGULATORY CAPABILITIES SUB-CATEGORIES**

Planning & Regulatory Capabilities Sub-categories	
<b>Building Codes</b>	Build Codes Year
Building Code Effectiveness Grading Schedule (BCEGS Rating)	Capital Improvements Program (CIP) or Plan
Community Rating System (CRS)	Community Wildfire Protection Plan (CWPP)

Planning & Regulatory Capabilities Sub-categories	
Comprehensive, Master, or General Plan	Economic Development Plan
Elevation Certificates	Erosion/Sediment Control Program
Floodplain Management Plan or Ordinance	Flood Insurance Study
Growth Management Ordinance	Non-Flood Hazard-Specific Ordinance or Plan (e.g., Steep Slope, Wildfire, Snow Load)
National Flood Insurance Program (NFIP)	Site Plan Review Requirements
Stormwater Program, Plan, or Ordinance	Zoning Ordinance
Other	

### 1.3 ADMINISTRATIVE & TECHNICAL CAPABILITIES

In addition to local planning and regulatory capabilities, having the staff to implement plans, enforce codes, and support programs as well as having the technology to promote these actions was captured in the capability assessment. Table 4-8 lists the types of Administrative & Technical capabilities that were compiled from local plans. As each local jurisdiction is unique and may have additional administrative or technical capabilities that are not listed in the table below there is also an “other” capability to capture the full extent of local jurisdictions’ capabilities in this category.

TABLE 4-8 ADMINISTRATIVE & TECHNICAL CAPABILITIES SUB-CATEGORIES

Administrative & Technical Capabilities Sub-categories	
Emergency Manager	Floodplain Administrator
Community Planning:	Grant Manager, Writer, or Specialist
- Planner/Engineer (Land Development)	Warning Systems/Services:
- Planner/Engineer/Scientist (Natural Hazards)	- General
- Engineer/Professional (Construction)	- Flood
- Resiliency Planner	- Wildfire
- Transportation Planner	- Tornado
Full-Time Building Official	- Geological Hazards
GIS Specialist and Capability	Other

### 1.4 FINANCIAL CAPABILITIES

The ability to fund mitigation actions are important to a local jurisdiction’s capability to mitigate hazards. Table 4-9 below provides a list of financial capabilities that were captured from local jurisdictions. It should be noted the list is not exhaustive, as each local jurisdiction is unique and may have additional financial capabilities available. The “other” capability was added to the table in order to capture the full extent of the capability category.

TABLE 4-9 FINANCIAL CAPABILITIES SUB-CATEGORIES

Financial Capabilities Sub-categories	
<b>Has community used any of the following to fund mitigation activities:</b>	
- Levy for Specific Purposes with Voter Approval	- Stormwater Service Fees
- Utilities Fees	- Capital Improvement Project Funding
- System Development / Impact Development Fee	- Community Development Block Grants
- General Obligation Bonds to Incur Debt	- Withheld Spending in Hazard-Prone Areas
- Special Tax Bonds to Incur Debt	Other

**1.5 EDUCATION & OUTREACH CAPABILITIES**

Having the ability to educate the public on hazards that pose a risk to their community is an important part of enabling individuals to take mitigation actions related to personal property or safety. Table 4-10 lists the types of education and outreach capabilities captured in the capability assessment. Due to the uniqueness of local communities and variety of tools, data collected for this capability was broader compared to other categories making the “other” capability even more important to capture in this category.

TABLE 4-10 EDUCATION & OUTREACH CAPABILITIES SUB-CATEGORIES

Education & Outreach Capabilities Sub-categories	
Local citizen groups that communicate hazard risks	Firewise™
StormReady®	Other

Data on each of the capability categories was gathered from available local hazard mitigation plans and compiled into a master spreadsheet to facilitate detailed review and comparison between jurisdictions. Table 4-11 provides a compilation and overview of the local planning, regulatory, personnel, financial, and outreach capabilities including a description as well as the effectiveness and limitations of each, where applicable.

TABLE 4-11 LOCAL CAPABILITIES

Planning & Regulatory			
Capability	Description	Effectiveness	Limitations
<b>Building Codes</b>	A set of rules and standards established and enforced by local governments for the structural safety of buildings; minimum acceptable level of safety for constructed objects. The main purpose of building codes are to protect public health, safety, and general welfare as they relate to the construction and occupancy of buildings and structures.	<i>56 Jurisdictions yes 16 Jurisdictions no 0 Jurisdictions did not identify capability</i>  An average of 81% of local communities have building codes.	Jurisdictions may adopt codes but poor enforcement can exist; not all jurisdictions enact detailed building codes.
<b>Building Codes Year</b>	The International Code Council (ICC) publishes updated building codes every three years. Adopting and enforcing updated building codes regularly will help to reduce risk and protect communities.		A jurisdiction may not have the capacity to update building codes on a three-year basis; building code inspectors must continually enforce updated codes and communicate the updates to the design community.
<b>Building Code Effectiveness Grading Schedule (BCEGS) Rating</b>	A program through the International Organization for Standardization (ISO) which performs an assessment of local building codes and how a community enforces its buildings. The assessment has an emphasis on natural hazards mitigation. BCEGS program assigns each municipality a BCEGS rating of 1-10, with a rating of 1 <i>being exemplary commitment to building code enforcement</i> . Participation in the BCEGS can help to lower a community's insurances rates.	<i>5 Jurisdictions provided BCEGS ratings 4 Jurisdictions do not participate 59 Jurisdictions did not identify capability</i>	Optional participation in the program.
<b>Capital Improvements Program (CIP)</b>	A short-range plan, usually four to ten years, identifying capital projects and equipment purchases, providing a planning schedule and identifying financing options.	<i>61 Jurisdictions yes 6 Jurisdictions no 2 Jurisdictions did not identify capability</i>  An average of 88% of communities have a Capital Improvements Program.	Variability of funding makes predictability of implementation difficult.

Planning & Regulatory			
Capability	Description	Effectiveness	Limitations
<b>Community Rating System (CRS)</b>	A program developed by FEMA to provide incentives for those communities in the NFIP that have gone beyond the minimum floodplain management requirements to develop extra measures to provide protection from flooding.	<p>20 Jurisdictions yes 38 Jurisdictions no 11 Jurisdictions did not identify yes or no</p> <p>An average of 29% of communities participate in the Community Rating System.</p>	Typically, not tied in to all-hazard mitigation processes as well as it could be.
<b>Community Wildfire Protection Plan (CWPP)</b>	A community based collaborative plan developed by local stakeholders that identifies and prioritizes areas for hazardous fuels reduction treatments to protect communities and infrastructure from wildfire.	<p>50 Jurisdictions yes 18 Jurisdictions no 1 Jurisdiction did not identify capability</p> <p>An average of 72% of communities have a CWPP.</p>	
<b>Comprehensive Plan (Comp Plan), Master Plan, General Plan</b>	Process and Plan used to determine community goals and aspirations in terms of community development; dictates public policy in terms of transportation, utilities, land use, recreation, and housing; typically encompass large geographical areas, broad range of topics, and cover long-term time horizon.	<p>59 Jurisdictions yes 9 Jurisdictions no 1 Jurisdiction did not identify capability</p> <p>An average of 86% of communities have a comprehensive, master, or general plan.</p>	These plans typically do not have a standalone natural hazard element. If natural hazards are addressed, they do not tend to be integrated within the plan. The plans rarely cross-reference a local hazard mitigation plan.
<b>Economic Development Plan</b>	A strategic planning document and process that guides economic growth and development of a community or region. A plan that is rooted in resiliency. An economic development plan can inform hazard mitigation actions by identifying areas of economic growth and development and avoiding areas at risk of hazards.	<p>29 Jurisdictions yes 23 Jurisdictions no 17 Jurisdictions did not identify capability</p> <p>An average of 42% of communities have an economic development plan.</p>	These plans typically do not have a standalone natural hazard element.

Planning & Regulatory			
Capability	Description	Effectiveness	Limitations
<b>Elevation Certificates</b>	Elevation documentation of a building that helps to determine risk-based premium rate for flood insurance policies. An elevation certificate is compared to the building's Base Flood Elevation (BFE) to determine the cost of covering flood risk.	<p><i>21 Jurisdictions yes</i>  <i>24 Jurisdictions no</i>  <i>24 Jurisdictions did not identify capability</i></p> <p>An average of 30% of communities use elevation certificates.</p>	
<b>Erosion and Sediment Control Plan</b>	A plan which provides measures for developers to prevent construction activities on-site from resulting in erosion or the movement of sediment off-site. The plan helps to identify potential problems posed by slope, drainage patterns, and soil types prior to beginning construction.	<p><i>30 Jurisdictions yes</i>  <i>30 Jurisdictions no</i>  <i>9 Jurisdictions did not identify capability</i></p> <p>An average of 43% of communities have an erosion and sediment control plan.</p>	
<b>Floodplain Management Plan or Ordinance</b>	Provides community strategies, projects, and measures with the objective to reduce risk and impacts of future flooding. It may take the form of a plan or ordinance.	<p><i>60 Jurisdictions yes</i>  <i>8 Jurisdictions no</i>  <i>1 Jurisdiction did not identify capability</i></p> <p>An average of 87% of communities have a floodplain management plan or ordinance.</p>	
<b>Flood Insurance Study (FIS)</b>	A study that presents the risk of flooding within a community. A Flood Insurance Study report provides flood profiles that include flood elevation data. A Flood Insurance Study is often completed for the National Flood Insurance Program (NFIP).	<p><i>46 Jurisdictions yes</i>  <i>14 Jurisdictions no</i>  <i>9 Jurisdictions did not identify capability</i></p> <p>An average of 67% of communities have had a flood insurance study conducted.</p>	

Planning & Regulatory			
Capability	Description	Effectiveness	Limitations
<b>Growth Management Plan / Ordinance</b>	Promotes growth in a community and influences where and how growth occurs. Often designates specific areas where growth should occur in a community.	<p><i>16 Jurisdictions yes</i> <i>32 Jurisdictions no</i> <i>21 Jurisdictions did not identify capability</i></p> <p>An average of 23% of communities have a growth management plan.</p>	These plans typically do not have a stand-alone natural hazard element. If natural hazards are addressed, they do not tend to be integrated within the plan. Standalone plan that is only implemented through regulatory tools.
<b>Non-Flood Hazard-Specific Zoning Ordinance (e.g., steep slope, wildfire, snow load)</b>	Written regulations and laws that define hazard-prone areas and prevent or regulate development.	<p><i>52 Jurisdictions yes</i> <i>9 Jurisdictions no</i> <i>8 Jurisdictions did not identify capability</i></p> <p>An average of 75% of communities have non-flood hazard-specific ordinances.</p>	Jurisdictions may adopt but poor enforcement can exist; not all jurisdictions enact detailed hazard-specific zoning ordinances.
<b>National Flood Insurance Program (NFIP)</b>	A program of flood insurance coverage and floodplain management ordinances created by Congress in 1968 through the National Flood Insurance Act of 1968 (P.L. 90-448) aimed to reduce future flood damage and provide protection for property owners; enables property owners in participating communities to purchase government insurance protection against losses from flooding; designed to provide an insurance alternative to disaster assistance to meet the escalating costs of repairing damage to buildings and their contents caused by floods.	<p><i>57 Jurisdictions yes</i> <i>12 Jurisdictions no</i> <i>0 Jurisdictions did not identify capability</i></p> <p>An average of 83% of communities participate in the National Flood Insurance Program.</p>	Local floodplain managers are typically tasked with this responsibility as an additional duty to other roles. Many areas of the state are unmapped or maps need to be updated.

Planning & Regulatory			
Capability	Description	Effectiveness	Limitations
<b>Site Plan Review Requirements</b>	Written requirements and standards that define how a site should be developed in terms of traffic and pedestrian circulation, landscaping, drainage, lighting, and other similar items.	<i>45 Jurisdictions yes 8 Jurisdictions no 16 Jurisdictions did not identify capability</i>  An average of 65% of communities have site plan review requirements for new development.	Jurisdictions may adopt but poor enforcement can exist; not all jurisdictions enact detailed zoning ordinances and/or site plan review requirements.
<b>Stormwater Program, Plan, or Ordinance</b>	A plan to provide recommendations for improvements to flooding, drainage, and stormwater systems.	<i>34 Jurisdictions yes 30 Jurisdictions no 5 Jurisdictions did not identify capability</i>  An average of 49% of communities have a stormwater program, plan, or ordinance in place.	Variability of funding makes predictability of implementation difficult.

Administrative & Technical			
Capability	Description	Effectiveness	Limitations
<b>Emergency Manager (EM)</b>	The managerial function charged with creating a framework within which jurisdictions reduce vulnerability to hazards and cope with disasters; local government personnel that coordinate all phases of disaster emergencies; responsibility is assigned to County BOCC Chair in Colorado, but generally is designated by BOCC to another individual or agency.	<i>64 counties yes</i>  As of July 2018, all counties have an Emergency Manager.	Many counties and jurisdictions do not have a full-time EM; some are part-time, or the responsibility is included with other duties as assigned. Local jurisdictions that do not have an EM rely on their county. Many counties and jurisdictions do not have a designated back-up or deputy EM. The level of capability and depth within a local OEM across the state varies greatly.

Administrative & Technical			
Capability	Description	Effectiveness	Limitations
<b>Floodplain Administrator</b>	The principal community administrator in the daily implementation of flood loss reduction activities including enforcing community flood damage prevention ordinances, updating flood maps, plans, and policies of the community, and any activities related to administration of National Flood Insurance Program (NFIP). The floodplain manager or administrator is responsible for overseeing a community's floodplain management program, and maintains education and experience requirements, certifications, licenses, or registrations.	<p><i>55 Jurisdictions yes 13 Jurisdictions no 1 Jurisdiction did not identify capability</i></p> <p>An average of 80% of communities have a Floodplain Administrator.</p>	This is a combined duty in many jurisdictions; it may also by necessity be contracted to another jurisdiction, authority, or private firm; can be difficult for jurisdiction personnel to maintain minimum education and experience requirements, certifications, licenses, or registrations.
<b>Community Planning: Planning / Engineer with knowledge and experience in land development</b>	Community planners are concerned with dynamics and interrelationships of basic physical, economic, political, and social elements in communities. Through study and analysis, planners project the influence of these elements on a variety of public and private decisions bearing on the future of an urban neighborhood, rural community, Indian reservation, city, or the orderly growth of a broad urban region. Planners work with physical, climatic, economic, social, political, and financial conditions in such communities, the process of change, and policy questions related to guiding that change.	<p><i>58 Jurisdictions yes 6 Jurisdictions no 5 Jurisdictions did not identify capability</i></p> <p>An average of 84% of communities have a Planner or Engineer with knowledge and/or experience in land development processes and practices.</p>	Though most jurisdictions employ Community Planners, there still remains a number that do not, possibly affecting smart growth adaptations and community resiliency.
<b>Community Planning: Planning / Engineer / Scientist with knowledge and experience in natural hazards</b>	Personnel with experience and understanding of the natural hazards that may pose a risk to a community. An understanding of hazard profiles and the potential impacts they may have on the community. Personnel could use this knowledge to inform future development patterns and other community activities.	<p><i>32 Jurisdictions yes 15 Jurisdictions no 22 Jurisdictions did not identify capability</i></p> <p>An average of 46% of communities have personnel with knowledge and experience in natural hazards.</p>	Though most jurisdictions employ Community Planners, there remains a number that do not.

Administrative & Technical			
Capability	Description	Effectiveness	Limitations
<b>Community Planning: Engineer / Professional with knowledge and experience in construction</b>	Personnel with experience and understanding of the construction process.	<p>39 Jurisdictions yes 12 Jurisdictions no 18 Jurisdictions did not identify capability</p> <p>An average of 57% of communities have personnel on staff with knowledge and experience in construction practices.</p>	
<b>Community Planning: Resiliency Planner</b>	Resilience is the ability for a community to prepare for and respond effectively to stress. A Resiliency Planner views the community holistically and considers ways to plan for a sustainable future and anticipate the possible disruption from inevitable natural hazard events.	<p>1 Jurisdiction yes 30 Jurisdictions no 38 Jurisdictions did not identify capability</p> <p>An average of 1% of communities identify as having a Resiliency Planner on staff.</p>	Resilient communities in terms of natural hazard events is still a new concept that some members of a community may be skeptical of embracing.
<b>Community Planning: Transportation Planner</b>	Transportation Planners examine current traffic and population trends in a community and determine the effectiveness of current and future planned roadways.	<p>4 Jurisdictions yes 12 Jurisdictions no 52 Jurisdictions did not identify capability</p> <p>An average of 6% of communities identify as having a Transportation Planner on staff.</p>	
<b>Full-Time Building Official</b>	The community administrator charged with reviewing and enforcing local building codes. The administrator would be responsible for ensuring building codes are updated, and following the ICC three-year code updates.	<p>38 Jurisdictions yes 19 Jurisdictions no 12 Jurisdictions did not identify capability</p> <p>An average of 55% of communities identify having a full-time Building Official on staff.</p>	Not every community has the capacity to have a full-time building official. Many communities outsource building code enforcement.

Administrative & Technical			
Capability	Description	Effectiveness	Limitations
<b>GIS Specialist and/or GIS Capability</b>	<p>Geographic Information Systems (GIS) Specialists work with related software and programs to create and maintain data and/or maps that can be combined with geographically referenced data. This is particularly useful in the assessment to understand risk of hazards to people and property. GIS software has the capacity to relate different types of data such as socioeconomic, demographic, administrative, or political boundaries, land use, land cover, environmental, infrastructure, and transportation networks.</p>	<p><i>60 Jurisdictions yes 8 Jurisdictions no 1 Jurisdictions did not identify capability</i></p> <p>An average of 87% of communities identified having a GIS Specialist on staff or having the capability for GIS.</p>	<p>Not all jurisdictions have trained GIS capabilities or funding to maintain GIS personnel, equipment, and training; some jurisdictions contract GIS services through other jurisdictions or the private sector.</p>
<b>Grant Manager, Writer, or Specialist</b>	<p>The position responsible for writing revenue proposals for projects and submitting timely, accurate reports for all existing grant funded projects; responsible for conducting full range of activities required to research, prepare, submit, and manage grant proposals; works with finance to comply with all grant reporting and maintains current records and grant tracking as necessary.</p>	<p><i>31 Jurisdictions yes 19 Jurisdictions no 19 Jurisdictions did not identify capability</i></p> <p>An average of 45% of communities have a Grant Manager, Writer or Specialist on staff.</p>	<p>Not all jurisdictions have a dedicated grant writer, or funding for such an employee; many assign this duty as needed to various departments, or hire and contract through the private sector.</p>
<b>Warning Systems/ Services: General</b>	<p>Warning systems provide the ability to let people know if a natural hazard event is imminent and communicate time to prepare, shelter in place, or evacuate. Warning systems may include alarms, mass text messages, weather alerts, and other similar uses of technology.</p>	<p><i>60 Jurisdictions yes 2 Jurisdictions no 7 Jurisdictions did not identify capability</i></p> <p>An average of 87% of communities have a general warning system that can be activated in the event of a hazard .</p>	<p>Not every community may have the funding or capacity to employ warning systems or services. A community's perception of risk will have a larger influence on individuals seeking safety than the warning systems.</p>

Administrative & Technical			
Capability	Description	Effectiveness	Limitations
<b>Warning Systems/ Services: Flood</b>	Warning systems specific to flooding detects flood events in advance and warns the community. The advance warning gives community members time to evacuate and move themselves and personal assets to safer locations.	<p><i>9 Jurisdictions yes 6 Jurisdictions no 54 Jurisdictions did not identify capability</i></p> <p>An average of 13% of communities have warning systems or services specific to flood hazards.</p>	Not every community may have the funding or capacity to employ warning systems or services specific to flooding.
<b>Warning Systems/ Services: Wildfire</b>	Warning systems specific to wildfire detect potential wildfire events in advance and warns the community. The advanced warning gives community members time to evacuate and move themselves and personal assets to safer locations. Continuous monitoring of weather and areas prone to fire outbreaks are critical aspects of a wildfire warning systems.	<p><i>1 Jurisdictions yes 8 Jurisdictions no 60 Jurisdiction did not identify capability</i></p> <p>An average of 1% of communities have a warning system or services specific to wildfire.</p>	Not every community may have the funding or capacity to employ warning systems specific to wildfires or the ability to constantly monitor conditions.
<b>Warning Systems/ Services: Tornado</b>	Warning systems specific to tornadoes gives warning to the community before the tornado touches the ground. The advanced warning gives community members time to evacuate and move themselves and personal assets to safer locations. Tornado warning sirens are commonly used to warn community members in advance. NOAA's National Severe Storms Laboratory continuously updates threats of tornadoes, as do most local weather stations where tornadoes are a high risk.	<p><i>13 Jurisdictions yes 7 Jurisdictions no 49 Jurisdictions did not identify capability</i></p> <p>An average of 19% of communities have a warning system or service specific to tornadoes.</p>	Not every community may have the funding or capacity to employ warning systems or services specific to tornadoes.

Administrative & Technical			
Capability	Description	Effectiveness	Limitations
<b>Warning Systems/ Services: Geological Hazards</b>	Warning systems specific to geologic hazards, including earthquakes, landslides, and volcanic eruptions provide warning to communities with enough time to take shelter or move themselves and personal assets to safer locations. Warning systems may include monitoring rainfall in areas at risk of landslides, or shaking waves that may be generated by earthquakes. USGS and NOAA provide support in warnings and alerts related to geologic hazards.	<p><i>2 Jurisdictions yes</i> <i>8 Jurisdictions no</i> <i>59 Jurisdictions did not identify capability</i></p> <p>An average of 3% of communities have a warning system or service specific to geologic hazards.</p>	Not every community may have the funding or capacity to employ warning systems or services specific to geologic hazards.

Financial			
Capability	Description	Effectiveness	Limitations
<b>Levy for Specific Purposes with Voter Approval</b>	A tax approved by voters to generate additional tax revenue for a specific purpose.	<p><i>39 Jurisdictions yes</i> <i>4 Jurisdictions no</i> <i>26 Jurisdictions did not identify capability</i></p> <p>An average of 57% of communities have the capability of using a levy for specific purposes with voter approval.</p>	
<b>Utility Fees</b>	Water or sewer utility fees that members of the community pay to convey utilities such as water, gas, or electricity to their properties and convey sewer away from their properties.	<p><i>18 Jurisdictions yes</i> <i>22 Jurisdictions no</i> <i>29 Jurisdictions did not identify capability</i></p> <p>An average of 26% of communities have the capability to use utility fees as a funding mechanism.</p>	

Financial			
Capability	Description	Effectiveness	Limitations
<b>System Development / Impact Development Fee</b>	System development and impact development fees are one-time fees local governments place on new and proposed development as a way to pay for all or a portion of the costs it will take to bring new public services to the development.	<p>26 Jurisdictions yes 13 Jurisdictions no 30 Jurisdictions did not identify capability</p> <p>An average of 38% of communities have the capability of using system development or impact development fees as a funding mechanism.</p>	Colorado state law denotes that local governments imposing an impact fee must show that the fee is reasonably related to the overall costs of extending the public service.
<b>General Obligation (GO) Bonds to Incur Debt</b>	A municipal bond that is issued by local governments to fund public projects with a pledge to use legally available sources such as tax revenues to repay bond holders. The bonds are backed by the full faith and credit of the municipality. GO bonds typically fund projects that will serve the entire community.	<p>30 Jurisdictions yes 11 Jurisdictions no 28 Jurisdictions did not identify capability</p> <p>An average of 43% of communities have the capability to use general obligation bonds to incur debt as a funding mechanism.</p>	Some local municipalities limit general obligation bonded debt.
<b>Special Tax Bonds to Incur Debt</b>	A municipal bond that is repaid through revenues from a project or asset such as a tax on tobacco, gasoline, hotels, et cetera.	<p>26 Jurisdictions yes 13 Jurisdictions no 30 Jurisdictions did not identify capability</p> <p>An average of 38% of communities have the capability to use special tax bonds to incur debt as a funding mechanism.</p>	Colorado's Taxpayer Bill of Rights (TABOR) places a limit on how much a municipality may raise taxes without voter approval.

Financial			
Capability	Description	Effectiveness	Limitations
<b>Withhold Spending in Hazard-Prone Areas</b>	Some local governments have the ability to determine where government spending may be allocated. The local government may decide to restrict spending in areas determined to be at risk of natural hazards in order to limit development in that area.	<p>11 Jurisdictions yes 26 Jurisdictions no 32 Jurisdictions did not identify capability</p> <p>An average of 16% of communities have the capability to withhold spending in hazard-prone areas.</p>	
<b>Stormwater Service Fees</b>	Similar to a utility fee, a stormwater service fee is a charge for the service provided to convey stormwater off properties and control stormwater runoff through the construction, operation, and maintenance of the stormwater system.	<p>5 Jurisdictions yes 23 Jurisdictions no 41 Jurisdictions did not identify capability</p> <p>An average of 7% of communities have the capability to use stormwater service fees as a funding mechanism.</p>	
<b>Capital Improvement Project (CIP) Funding</b>	Funding specific to capital projects identified in a community's capital improvement plan or program. Capital improvement projects are generally short-term projects.	<p>33 Jurisdictions yes 11 Jurisdictions no 25 Jurisdictions did not identify capability</p> <p>An average of 48% of communities have the capability for using capital improvement project funding as a funding mechanism.</p>	Colorado's TABOR places a limit on how much a municipality may raise taxes without voter approval.

Financial			
Capability	Description	Effectiveness	Limitations
<b>Community Development Block Grants (CDBG)</b>	A grant funded through HUD for community development activities such as construction of public facilities and economic development activities. The Colorado Department of Local Affairs administers the CDBG for municipalities and counties to fund community development activities.	<p><i>31 Jurisdictions yes 8 Jurisdictions no 30 Jurisdictions did not identify capability</i></p> <p>An average of 45% of communities have the capability to use Community Development Block Grants as a funding mechanism.</p>	<p>There is only a limited amount of funding that can be distributed from the CDBG program. The current White House administration has proposed cutting CDBG spending. Proposed projects must be consistent with the broad national priorities for the CDBG program including activities that benefit low- and moderate-income individuals, the prevention or elimination of blight, or community activities that address a threat to health or safety of the community.</p>

Education and Outreach			
Capability	Description	Effectiveness	Limitations
<b>Local Citizen Groups That Communicate Hazard Risks</b>	Local community groups often have a perspective and trust of people in a community that local governments may not. This allows for discussions and activities related to natural hazards to occur with peers in an environment that may be more comfortable for community members.	<p><i>15 Jurisdictions yes 5 Jurisdictions no 49 Jurisdictions did not identify capability</i></p> <p>An average of 22% of communities have local citizen groups that help communicate hazard risks in their community.</p>	

Education and Outreach			
Capability	Description	Effectiveness	Limitations
<b>Firewise™</b>	Communities develop an action plan that guides their residential wildfire risk reduction activities, while engaging and encouraging their neighbors to become active participants in building a safer place in which to reside.	<p>18 Jurisdictions yes 34 Jurisdictions no 17 Jurisdictions did not identify capability</p> <p>An average of 26% of communities participate in the Firewise™ program.</p>	
<b>StormReady®</b>	A nationwide program that helps communities better protect citizens during severe weather; encourages communities to take a proactive approach to improving local hazardous weather operations; provides EMs guidelines on how to improve hazardous weather operations.	<p>19 Jurisdictions yes 37 Jurisdictions no 13 Jurisdictions did not identify capability</p> <p>An average of 28% of communities participate in the StormReady® program.</p>	Focuses solely on communication and safety skills.
<b>Other</b>	Examples of other types of education and outreach include but are not limited to distributing safety and preparedness information, working with school districts on preparedness activities, establishing a Community Emergency Response Team (CERT) in communities, and various citizen academies.	<p>31 Jurisdictions yes 0 Jurisdictions no 38 Jurisdictions did not identify capability</p> <p>An average of 45% of communities have or conduct educational and outreach efforts other than participating in the Firewise™ program or the StormReady® program.</p>	

## 2. EVALUATION OF LOCAL CAPABILITIES

### 2.1 PLANNING & REGULATORY CAPABILITIES

#### Regulations

Local land-use regulations and building codes are sound tools to consider when evaluating local policies related to hazard mitigation. Given Colorado's strong Home rule tradition, land-use regulations and building codes are typically implemented at the local level. Even without a statewide mandate, most counties and many municipalities have enacted regulations and codes. Of jurisdictions responding to DOLA's 2015 Land-Use Survey, 94 percent of municipalities and 93 percent of counties have a local zoning ordinance in effect. Of these, 79 percent of municipalities and 80 percent of counties report having adopted a hazard-specific zoning ordinance.

Codes are one tool that communities use to enhance public safety. In many cases, codes are intended for structural integrity and fire prevention, yet also provide benefits in relation to natural hazard avoidance. See Section 9, Appendix C – Building Codes, for additional information.

### **Plans and Programs**

The 2018 State Plan update process expanded on the number of local planning efforts evaluated as part of the capability assessment in previous plan updates. Capabilities included local hazard mitigation plans (HMPs), Community Wildfire Protection Plans (CWPP), comprehensive plans, and economic development plans. Comprehensive plans appear to be the strongest capability at the local level with 86 percent of counties indicating the capability in their local mitigation plans. DOLA's 2015 Land-Use Survey indicated that 13 counties, or 24 percent of the 54 counties surveyed, reported integrating hazard mitigation elements into their comprehensive plan at some level; this was the first time this question was asked in DOLA's Land-Use Survey. As of May 2018, 61 counties (all but three) and two Tribes have mitigation plans that are either FEMA -approved or Approvable Pending Adoption (APA). There are a number of municipalities with standalone mitigation plans as well. There has been continued success with the CSFS supporting CWPPs since the 2013 Plan update including 50 counties, or 72 percent, indicating they have this capability.

Stormwater master plans, capital improvement plans, and economic development plans all present areas of opportunity for local capability enhancement. Infrastructure improvement plans such as stormwater and capital improvements are commonly found in jurisdictions. Capital improvement plans exist in 88 percent of jurisdictions, while roughly 50 percent of jurisdictions identified a stormwater plan, program, or ordinance. Economic development plans, which guide economic growth and development of a community or region, were accounted for by 42 percent of jurisdictions.

Local jurisdictions in Colorado, especially counties, report high participation in the National Flood Insurance Program (NFIP). For the NFIP, 53 of 64 counties are participating. Of the 11 counties not in the program, nine are not required due to lack of mapping; the other two counties (Grand and Custer) are sanctioned by the NFIP. Regarding CRS, 47 total jurisdictions are in the program including 11 counties and 36 municipalities. The City of Fort Collins has a Class 2 CRS rating, one of the highest in the nation.

## **2.2 ADMINISTRATIVE & TECHNICAL CAPABILITIES**

For the 2018 State Plan update the capabilities related to personnel was expanded to include technical capabilities such as Geographic Information Systems (GIS). One consistent theme related to personnel is limited resources, a trend that has continued since the 2013 Plan update.

### **Administrative**

Of the local jurisdictions whose capabilities were evaluated, 87 percent indicated having an Emergency Manager. Local emergency managers often have workloads that exceed their given resources and staff. They have responsibilities related to preparedness, response, recovery, and mitigation, and, given responsibilities and their limitations, efforts must be prioritized. In some cases, this means that Emergency Managers have not had time to develop a substantial mitigation program or pursue enough training to know where to start. In other cases, economic challenges have forced local governments to reduce staff and resources.

Although over 80 percent of jurisdictions indicated having a planner or engineer with knowledge of land development processes, only 46 percent identified having a planner or engineer with knowledge of natural hazards. Planners often think of their communities holistically taking into consideration the interrelationships between economic, social, and political factors and the effects on their community. Opportunities exist to strengthen a local planner's knowledge and understanding of the relationship between land development and natural hazards.

Additional administrative capabilities were added to the capability assessment for the 2018 Plan update. These capabilities include: Resiliency Planner and Full-time Building Official. Currently, only one jurisdiction has reported having personnel dedicated to resiliency planning. Over time it is expected that the position of Resiliency Planner will become more common in local governments. Building Officials, another addition to the 2018 capability assessment, are vital to a community's ability to implement mitigation strategies. Although 81 percent of local governments reported having building codes, only 55 percent of jurisdictions reported having a full-time Building Official on staff to enforce and update building codes. This discrepancy may be due to the fact that several communities outsource code enforcement and inspection, or may have only a part-time Building Official on staff.

A Grant Manager on staff is a capability that allows communities to keep track of and apply for funding opportunities that will help implement mitigation action items. An average of 45 percent of jurisdictions reported having a designated Grant Manager on staff. It is likely that jurisdictions reporting they do not or did not indicate having this administrative capability may assign this duty to an existing department or hire a contractor to help manage potential and existing grants.

Opportunities abound to make or strengthen connections between emergency managers and their counterparts at public works, planning and building departments, floodplain management, or with other stakeholders who contribute to risk-reduction efforts. Opportunities may come from the development or update of local hazard mitigation plans, and the updating and enforcing of building codes.

## **Technical**

In addition to having dedicated personnel to help in implementing local hazard mitigation plans, technical capabilities such as access to GIS and the deployment of warning systems are also important capabilities for a community. Many jurisdictions, around 87 percent, reported having either a GIS specialist on staff or having the capability to use the analytical software. Similar to the Grant Manager, some jurisdictions may not have a dedicated specialist on staff, and instead the duty may be assigned to an existing department or outsourced to private consultants.

Warning systems alert people when a hazard is imminent and if timely, provides them the chance to react appropriately. Systems may give general warnings or they may be specific to a type of hazard such as a flood or a geologic hazard. The 2018 capabilities assessment evaluated general warning systems as well as flood, wildfire, tornado, and geologic hazard warnings. A majority of communities, 87 percent, indicated they have a general warning system in place. The number of jurisdictions that included a warning system for a specific natural hazard was much less. Only 13 percent noted a warning system for flooding, and 19 percent indicated having systems for warning the public of tornadoes. Roughly two percent of communities indicated having a warning system for wildfire or geologic hazards in place. However, many general warning systems have the ability to provide wildfire related messaging, such as Code RED. There is an opportunity to expand local jurisdiction warning systems and services to be used not only generally but for hazards that pose the greatest risk to a community.

### **2.3 FINANCIAL CAPABILITIES**

An addition to the capabilities assessment for the 2018 State Plan update included local government financial capabilities to fund mitigation. The type of financial capabilities captured included financial tools of which most local governments already have access. Most jurisdictions, 57 percent, can request voter approval for a tax levy to be used for a specific purpose. Other common financial tools indicated by jurisdictions included the use of impact or system development fees (38 percent), general obligation bonds (43 percent), capital improvement funds (48 percent), and Community Development Block Grants (45 percent). One reason for a lack of financial tools indicated by jurisdictions are specific limitations within the State of Colorado, as well as restrictions various jurisdictions have placed on financial mechanisms. Colorado's Taxpayer Bill of Rights (TABOR) limits how much a local government may raise taxes in a given year without voter approval. State law asserts that there must be a rational nexus, or a reasonable relationship between impact development fees imposed on a development and the cost of extending public services. Several financial tools that may be used to subsidize mitigation actions may already be in place in a local jurisdiction. There are opportunities for communities to evaluate existing financial capabilities and how they can be leveraged to support future mitigation activities.

## **2.4 EDUCATION & OUTREACH CAPABILITIES**

The capability to communicate risk of natural hazards to the community was also evaluated. Creating partnerships with local community groups is a capability that could successfully be expanded upon. Only 22 percent of jurisdictions indicated local citizen groups are established in their community to convey hazard risk. Most jurisdictions, 45 percent, report having education and outreach programs other than those captured by the capability assessment. Other outreach programs described by jurisdictions included distributing safety and preparedness information, working with school districts on preparedness activities, establishing a Community Emergency Response Team (CERT), and conducting citizen academies to inform residents of natural hazards, preparedness actions, and evacuation routes. Opportunities to educate and inform local communities on hazard risk and preparedness actions will be a capability that continues to expand over time.

Participation in programs such as StormReady® and Firewise™ also present an opportunity for communities to educate citizens on how to prepare for natural hazards. According to the National Weather Service (NWS), there are 40 StormReady® entities in Colorado, including counties (24), municipalities (14), one university, and one commercial site. Colorado is recognized as the second highest number of Firewise™ communities in the country. Currently, over 150 communities (including Property and Homeowner Associations) and neighborhoods have achieved the Firewise™ designation. The 2013 State Plan included a mitigation activity from the CSFS to continue and strengthen local participation in the Firewise™ program. Since the 2013 Plan there has been nearly a 50 percent increase in the number of Colorado communities participating in the Firewise™.

# SECTION 5. MITIGATION STRATEGY

# SECTION 5. HAZARD MITIGATION STRATEGY

## CONTENTS

Section 5. Hazard Mitigation Strategy.....	5-2
Introduction.....	5-3
Mitigation Goals and Objectives.....	5-3
2013 Mitigation Actions .....	5-6
Progress On Colorado Flood Hazard Mitigation Plan and Colorado Drought Mitigation and Response Plan Actions .....	5-11
2018 Mitigation Actions .....	5-11
1. Flood and Drought Plan Mitigation Action Integration.....	5-14
Assessing Mitigation Effectiveness.....	5-35
1. Assessment Methodologies.....	5-35
2. Integrating Effectiveness Assessments Into the Mitigation Strategy.....	5-42
3. Examples of Assessments Conducted.....	5-43
4. Future Case Studies.....	5-45

## LIST OF TABLES

Table 5-1 State of Colorado 2018 Mitigation Goals.....	5-3
Table 5-2 2013 Mitigation Action Status .....	5-7
Table 5-3 Criteria from Colorado Resiliency Framework .....	5-12
Table 5-4 Colorado Resiliency Framework - FEMA STAPLE/E Comparison.....	5-13
Table 5-5 New and Ongoing Mitigation Actions .....	5-16
Table 5-6 Examples of Key Data Needed to Analyze Project Applications.....	5-36
Table 5-7 Summary of the Regulatory Losses Avoided Analysis .....	5-43

# INTRODUCTION

After evaluating the state’s risk to hazards, the planning process transitioned to identifying potential strategies that reduce or eliminate those risks. The State Hazard Mitigation Team (SHMT) undertook three important tasks after examining the updated risk assessment.

- First, they evaluated the mitigation strategy goals and objectives from the 2013 State Plan for their effectiveness, continued relevance, and to identify any potential gaps.
- Secondly, state agencies that were responsible for actions identified in the 2013 State Plan were asked to review and indicate if the actions were ongoing, completed, deferred, or deleted, as well as provide information related to how they were implemented.
- Finally, members of the SHMT identified new strategies to improve capabilities and mitigate risks identified in the statewide as well as local risk assessments, so that mitigation priorities are based upon loss reduction.

This mitigation strategy was also developed to be compliant with the relevant provisions of the Emergency Management Accreditation Program (EMAP); see Section 8, Page 8-30.

# MITIGATION GOALS AND OBJECTIVES

In general, when a jurisdiction decides that certain risks are unacceptable and certain mitigation actions may be achievable, the development of goals and objectives takes place. Mitigation goals and objectives help to explain what should occur, using increasingly more narrow descriptors.

Initially, broad-based goals are developed, which are long-term general statements. From these goals, objectives are then defined to help guide the resulting mitigation actions that will accomplish the goals.

At the SHMT workshops during the State Plan update, the 2013 goals and objectives were reviewed and refined. Through this process, the SHMT determined that some goals and objectives should remain the same, while others were updated or merged. Additional new goals and objectives were also crafted by the SHMT, to better align with other state planning efforts. As opposed to ranking the goals, as was done in 2013, the SHMT decided there was limited value in doing that for this update.

Table 5-1 below includes the 2018 mitigation goals for the State of Colorado. Corresponding letters beneath each goal relate to mitigation objectives that are applicable to achieving that goal. A list of associated objectives follows. [Roman numerals after each goal are for identification purposes only.]

TABLE 5-1 STATE OF COLORADO 2018 MITIGATION GOALS

State of Colorado Hazard Mitigation Goals & Objectives
<b>Minimize the loss of life and personal injuries from all-hazard events (I)</b>
A, D, F, G, H

<b>State of Colorado Hazard Mitigation Goals &amp; Objectives</b>
<b>Reduce losses and damages to state, tribal, and local governments, as well as special districts and private assets, and support similar local efforts (II)</b>
<b>J, O</b>
<b>Reduce federal, state, tribal, local, and private costs of disaster response and recovery (III)</b>
<b>D, E, J, P, Q</b>
<b>Support mitigation initiatives and policies that promote disaster resiliency, nature-based solutions, cultural resources and historic preservation, and climate adaptation strategies (IV)</b>
<b>A, B, E, M, N</b>
<b>Minimize interruption of essential services and activities (V)</b>
<b>D, E, J, L, P, Q</b>
<b>Incorporate equity considerations into all mitigation strategies (VI)</b>
<b>A, E</b>
<b>Support improved coordination of risk mitigation between and among the public, private, and non-profit sectors (VII)</b>
<b>A, C, D, E, G, I, K, L, M, N, O, R</b>
<b>Create awareness and demand for mitigation as a standard of practice (VIII)</b>
<b>A, B, C, E, G, K, L, M, N, O</b>

**Mitigation Objectives:**

- A. Support and empower local and regional mitigation strategies through statewide guiding principles, programs, and resources
- B. Promote activities that are climate neutral and supportive of appropriate renewable and alternative energy
- C. Strengthen hazard risk communication tools and procedures
- D. Strengthen continuity of operations at the federal, state, regional, tribal, and local levels of government to ensure the delivery of essential services
- E. Strengthen cross-sector connections across the state government
- F. Identify specific areas at risk to natural hazards and zones of vulnerability
- G. Expand public awareness, education, and information programs relating to hazards and mitigation methods and techniques

- H. Develop mitigation projects focused on preventing loss of life, injuries, and negative impacts to natural resources and reliant community sectors from natural, technological, and human-caused hazards
- I. Assist local government officials with construction, non-construction, and regulatory hazard mitigation activities
- J. Protect state critical, essential, and necessary assets located in natural hazard risk areas
- K. Improve state, tribal, and local government mitigation project monitoring and decision-making tools
- L. Strengthen connections between hazard mitigation activities and preparedness, response, and recovery activities
- M. Improve coordination of state government mitigation resources with federal, tribal, and local government and private nonprofit resources
- N. Increase state, tribal, and local government and private nonprofit participation in existing hazard mitigation programs
- O. Partner with local and tribal governments to develop projects, initiatives, and public resources that protect private property from hazards
- P. Reduce services interruptions and revenue losses, resulting from hazard events, to the state
- Q. Reduce downtime and revenue losses, resulting from hazard events, for local and tribal governments and private nonprofit organizations
- R. Through training, grants, and technical assistance, increase local government use of land use strategies that reduce risks to hazards

A review of New and Ongoing Mitigation Actions in Table 5-5 shows that every goal and objective is addressed by at least one action.

Both the Colorado Flood Hazard Mitigation Plan and Colorado Drought Mitigation and Response Plan have goals that are more specific to flood and drought hazards. During the 2018 update of these plans the revised the goals of the SHMP were shared with the Flood TAP and DMRPC for reference during the goals review and update process. Goals from these plans are provided below:

**Flood Mitigation Plan Goals:**

1. Reduce flood impacts to Colorado’s economy, people, state assets, and environment
2. Promote awareness and education of flood hazards and watershed protection
3. Coordinate and provide planning, technical assistance, and financial resources for state, local, and watershed planning efforts

4. Continue to update and develop floodplain maps for risk assessment, planning, and awareness applications
5. Promote and encourage the adoption of model codes and higher standards that emphasize hazard mitigation

**Drought Mitigation and Response Plan Goals:**

1. Improve Water Availability Monitoring and Drought Impact Assessment
2. Increase public awareness and education
3. Work collaboratively with water rights holders to voluntarily augment water supply through mechanisms to transfer to areas of shortage during droughts.
4. Coordinate and provide technical assistance for state, local, and watershed planning efforts
5. Reduce water demand/encourage conservation
6. Reduce drought impacts to Colorado's economy, people, state assets, and environment
7. Continue to develop intergovernmental and interagency stakeholder coordination
8. Evaluate potential impacts from climate change

**2013 MITIGATION ACTIONS**

To evaluate the progress of state-level hazard mitigation efforts over the past five years, the SHMT was asked to report on the status of those mitigation actions identified in the 2013 State Plan. The following Table 5-2 presents this information which is stored, along with all new mitigation actions, in a Mitigation Action Database.

TABLE 5-2 2013 MITIGATION ACTION STATUS

Action ID	Action Title	Hazard	Responsible Lead Agency	Status (May 2018)
HH-1	Implement fuels reduction and forest health projects.	Wildfire	CSFS	This is an ongoing action.
HH-2	Complete hazard maps in areas where geologic mapping is complete.	Geologic Hazards	CGS	This is an ongoing action.
HH-3	Assess risks associated with the Flood/Wildfire nexus and develop mitigating actions and projects.	Flood	CWCB	This is a long-term, ongoing action.
HH-4	Improve statewide drought monitoring system to include additional stations and sensors, remote sensing, rangeland, groundwater, and snowpack sublimation.	Drought	CWCB	This is an ongoing action. See actions under related Goal 1 in the 2018 Colorado Drought Mitigation and Response Plan update.
HH-5	Identify lessons learned and needs from the 2013 September flood.	Flood	CWCB	This is an ongoing action, however the lessons learned and needs for the most part have been identified.
HH-6	Evaluate the threat of avalanches to future projects and developments.	Avalanche	CAIC	This is an ongoing action. Risk assessments are performed when requested.
HH-7	Develop and deliver avalanche safety education materials to middle school students.	Avalanche	CAIC	The program was launched in 2015 to over 9,000 middle schools students. This is an ongoing action.
HH-8	Update the floodplain and stormwater criteria manual.	Flood	CWCB	The manual is currently in the development stage and is ongoing.

Action ID	Action Title	Hazard	Responsible Lead Agency	Status (May 2018)
HH-9	Complete the implementation of statewide floodplain rules and regulations.	Flood	CWCB	This action is 98% complete. Two percent of communities participating in the NFIP are still working on the floodplain rules and regulations. This is an ongoing action.
HH-10	Enhance data and information for analyzing drought vulnerability.	Drought	CWCB	Colorado is the only state in the nation that enhances data and information for the vulnerability analysis of drought. This is an ongoing action. Vulnerability analysis was updated with available data during the 2018 Colorado Drought Mitigation and Response Plan update.
HH-11	Enhance the Colorado Wildfire Risk Assessment Portal (CO-WRAP).	Wildfire	CSFS	This is an ongoing action, with 2018 data enhancements pending.
HH-12	Assist communities in implementing CWPPs.	Wildfire	CSFS	There are currently 225 CWPP's of which 47 are counties. This is an ongoing action.
HH-13	Add earthquake monitoring stations to evaluate seismicity activity.	Earthquake	CGS	The network has been increased by 2 stations since the last status update. This is an ongoing action.
HH-14	Integrate State Drought Plan within other statewide planning efforts.	Drought	CWCB	The Drought Plan has been incorporated through the Water Plan and the Climate Plan, including climate change information. This is an ongoing action.
HH-15	Participate in National Soil Moisture Network.	Drought	CCC	Participation is ongoing in an advisory role. This is an ongoing action.
HH-16	Analyze potential impacts of climate change.	All-Hazard	CWCB	Incorporate climate change into all resiliency efforts. Climate change considerations incorporated into risk assessment during update of 2018 SHMP, Flood, and Drought Plans. This is an ongoing action due to evolving science to ensure best available information is incorporated into future planning efforts.

Action ID	Action Title	Hazard	Responsible Lead Agency	Status (May 2018)
HH-17	Enhance CCC website to include hazards and atmospheric risk information.	Atmospheric Hazards	CCC	The CCC website has undergone a complete redesign in 2018. There is now information on many high-impact events, but we are still working to include more thorough hazard information.
HH-18	Increase participation in Fire-Adapted Communities and Firewise™ including education and outreach.	Wildfire	CSFS	Colorado has the 2 <sup>nd</sup> most Firewise™ communities in the nation. This action is ongoing.
HH-19	Develop materials for, and participate in, awareness and outreach for atmospheric hazards.	Atmospheric Hazards	CCC	To date, flood and drought materials have been developed. Work is ongoing to include other hazards.
HH-20	Evaluate statewide mined areas for subsidence.	Subsidence	CGS	This is an ongoing action.
HH-21	Increase inventory of historical avalanche data.	Avalanche	CAIC	There has been significant improvement on the collection of historical avalanche data in the GIS database. This is an ongoing action.
HH-B	Improve methodology to identify high priority statewide vulnerabilities in local jurisdictions and on state-owned lands.	All-Hazard	DHSEM	Action mostly complete as originally conceived and was deleted. Local HMPs address part of the action and new action 2018.31 will cover the unmet portions.
HH-C	Develop a statewide definition for the existing and improved related dataset of state and local level critical assets.	All-Hazard	DHSEM	This action has culminated from its origin in the 2007 update and was deleted. Unmet portions of the new action will be included in new action 2018.31.
HH-D	Improve methodology for estimating losses and identifying losses avoided for priority hazards.	All-Hazard	DHSEM	This is an ongoing action. Working with FEMA and the State Office of Risk Management (ORM) on improving the methodology. Improvements implemented as part of 2018 State Plan update. Action was modified in 2018 to specify mitigation effectiveness.

Action ID	Action Title	Hazard	Responsible Lead Agency	Status (May 2018)
HH-E	Strengthen coordination with the CRO Sectors as well as with technical assistance partnerships related to flood, drought, atmospheric, geologic, and wildfire that contribute to the mitigation of statewide natural hazards.	All-Hazard	DHSEM	This is an ongoing action. Along with DHSEM, the CRO was involved in updates to the 2018 State Plan and the separate Drought and Flood Plans. DHSEM cross sector coordination continues through active participation in the CRO via CRWG and CORIP efforts, as well as quarterly meetings. DHSEM is also a cooperating partner in flood, drought, atmospheric, geologic, wildfire, and statewide climate and resiliency efforts. DHSEM participates as a member of the Flood TAP and WATF, has helped to coordinate CRS and CWPP integration into the local HMP planning process, has promoted the High-Hazard Dam Release Database Tool, and participated in numerous cross sector facilitation & trainings, as well as webinar opportunities and field trips/site visits. See Section 8 – data call spreadsheet for additional information on sector and cross agency integration since 2013-present.

# PROGRESS ON COLORADO FLOOD HAZARD MITIGATION PLAN AND COLORADO DROUGHT MITIGATION AND RESPONSE PLAN ACTIONS

As discussed in Section 1, the State of Colorado updated its Flood Hazard Mitigation Plan and Drought Mitigation and Response Plan concurrently and in coordination with the SHMP update. During the update of these plans a concerted effort was made to track progress on previously identified actions, and to separate completed actions from those that will continue forward in each plan. For the Flood Plan, a completed and deleted action table documents 31 activities that have been completed, with at least one for each of the plan's original six goals. Of the 78 ongoing and new actions identified in the 2013 Drought Plan, 22 have been completed and 57 are ongoing, six of which are new actions developed as part of the 2018 planning effort. As evidenced by the number of completed and/or ongoing projects in the actions summary table, the state has demonstrated successful progress in implementation of flood and drought mitigation efforts. See the respective plans for more details.

## 2018 MITIGATION ACTIONS

The final piece of the state's updated Mitigation Strategy was the development of new or ongoing mitigation actions for implementation over the next five years. Developing the 2018 Mitigation Actions was a collaborative effort between the Core Planning Team and the overall SHMT.

Mitigation Action development began during the draft of the HIRA. Authors of the HIRA from the Core Planning Team's consultants identified several potential mitigation actions. These actions were based on gaps identified during creation of the hazard profiles, as well as identified consequences or key vulnerabilities. Key takeaways from the HIRA are described in Section 3 – Hazard Identification and Risk Assessment, Risk Assessment Summary, and helped guide Mitigation Actions to reduce the risks and vulnerabilities identified. Additionally, potential actions were added to this list from research on best practices in other state hazard mitigation plans. This initial draft of Mitigation Actions also considered results from polls conducted at the first SHMT workshop. For example, numerous SHMT members indicated that increased capabilities to implement mitigation actions was a critical gap. Additionally, from their experience a SHMT poll identified that planning and regulations were the most impactful types of mitigation actions.

Once a comprehensive list of potential Mitigation Actions was developed, the Core Planning Team utilized Colorado's Resiliency Framework methodology to prioritize and reduce the number of actions before presenting them to the SHMT. The criteria specifics are described in Table 5-3 below. This undertaking was used to 1) create a list of potential Mitigation Actions for the SHMT and 2) test the implementation of the Resiliency Framework process to prioritize actions for presentation to the SHMT.

TABLE 5-3 CRITERIA FROM COLORADO RESILIENCY FRAMEWORK

Criteria from Colorado Resiliency Framework	Definition
<b>Co-Benefits</b>	Provide solutions that address problems across multiple sectors creating maximum benefit.
<b>High Risk and Vulnerability</b>	Ensure that strategies directly address the reduction of risk to human well-being, physical infrastructure, and natural systems.
<b>Economic Benefit-Cost</b>	Make good financial investments that have the potential for economic benefit to the investor and the broader community both through direct and indirect returns.
<b>Social Equity</b>	Provide solutions that are inclusive with consideration to populations that are often most fragile and vulnerable to sudden impacts due to their continual state of stress.
<b>Technical Soundness</b>	Identify solutions that reflect best practices that have been tested and proven to work in similar regional context.
<b>Innovation</b>	Advance new approaches and techniques that will encourage continual improvement and advancement of the best practices serving as models for others in Colorado and beyond.
<b>Adaptive Capacity</b>	Include flexibility and adaptable measures that consider future unknowns of changing climate, economic, and social conditions.
<b>Harmonize with Existing Activity</b>	Expand, enhance, or leverage work being done to build on existing efforts.
<b>Long-term and Lasting Impact</b>	Create long-term gains to the community with solutions that are replicable and sustainable, creating benefit for present and future generations.

During the second SHMT workshop, the refined list of potential Mitigation Actions was presented to the SHMT to prompt Mitigation Action ideas from their own agency/organization. Additionally, during this workshop an overall prioritization process incorporating the Resiliency Framework was discussed. The Core Planning Team described the proposed prioritization method using Colorado’s Resiliency Framework and compared this method to FEMA’s STAPLE/E process. Table 5-4 compares the Colorado Resiliency Framework to FEMA’s STAPLE/E method. After the workshop, a database of Mitigation Action ideas was emailed to the SHMT requesting input prior to the final workshop. The SHMT was also asked to leverage and consider the updated and expanded HIRA to better assist identifying hazard risks agencies could reduce, or mitigation capabilities agencies could improve or support.

TABLE 5-4 COLORADO RESILIENCY FRAMEWORK - FEMA STAPLE/E COMPARISON

Criteria from Colorado Resiliency Framework	Definition	STAPLE/E Overlap
<b>Co-Benefits</b>	Provide solutions that address problems across multiple sectors creating maximum benefit.	Economic, Technical, Administrative
<b>High Risk and Vulnerability</b>	Ensure that strategies directly address the reduction of risk to human well-being, physical infrastructure, and natural systems.	Social, Environmental
<b>Economic Benefit-Cost</b>	Make good financial investments that have the potential for economic benefit to the investor and the broader community both through direct and indirect returns.	Economic
<b>Social Equity</b>	Provide solutions that are inclusive with consideration to populations that are often most fragile and vulnerable to sudden impacts due to their continual state of stress.	Social, Political
<b>Technical Soundness</b>	Identify solutions that reflect best practices that have been tested and proven to work in similar regional context.	Technical, Administrative, Legal
<b>Innovation</b>	Advance new approaches and techniques that will encourage continual improvement and advancement of the best practices serving as models for others in Colorado and beyond.	Technical
<b>Adaptive Capacity</b>	Include flexibility and adaptable measures that consider future unknowns of changing climate, economic, and social conditions.	Technical, Administrative, Social, Economic, Environmental, Legal
<b>Harmonize with Existing Activity</b>	Expand, enhance, or leverage work being done to build on existing efforts.	Technical, Administrative, Economic
<b>Long-term and Lasting Impact</b>	Create long-term gains to the community with solutions that are replicable and sustainable, creating benefit for present and future generations.	Social, Economic, Environmental

Between the second and final SHMT meetings, the Core Planning Team incorporated comments and new actions received via email from the SHMT into the Mitigation Action Database. During the final SHMT workshop, all members were asked to help identify actions proposed to be led by their respective agency or organization. Additionally, a brainstorming session was conducted regarding the final draft of the Mitigation Actions Database and funding prioritization for the actions. Discussions regarding prioritization made it clear that a one-size fits all approach would be difficult to implement across all state agencies/organizations. Therefore, it was decided the 2018 State Mitigation Actions would not be prioritized as a group, yet individual actions would be ranked per agency/organization using the Resiliency Framework guiding principles. New actions identified

during the update of the Flood and Drought plans were prioritized based on the Resiliency Framework criteria previously described.

DHSEM will implement a weighted numerical CRO prioritization methodology during the scoring process for current HMGP Post Fire projects as well as the 2018 PDM/FMA sub-application evaluations. DHSEM has incorporated FEMA and DHSEM state priorities into the weighted scoring instrument, and will follow-through with refining this SHMT-approved “guiding principles” CRO methodology in all future FEMA mitigation grants. DHSEM has also shared this numerically weighted project ranking tool, available to be adjusted as needed for other state agencies per grant guidelines and priorities, during recent CRO CORIP initial scoping meetings.

Additionally, a thorough analysis of local hazard mitigation plans (HMPs) in Colorado was conducted and they were integrated into hazard profiles in the HIRA. This included identifying which HMPs profiled each hazard, loss estimates, and future development trends noted in HMPs. Additional information, such as hazard rankings, were included if applicable in hazard profiles. A comprehensive analysis was performed to understand local jurisdictions’ vulnerability to hazards based on HMPs. The completed analysis of local HMPs resulted in the same “top four” natural hazards included in both the 2013 and 2018 State Plan based on local risk rankings and loss estimates. The top four hazards identified by HMPs remain winter weather, wildfire, flood, and drought. These findings align closely with the results of the statewide risk assessment and provide insight on local jurisdictions’ priorities for mitigation. This information contributed to creation of mitigation actions in alignment with local priorities and validates additional mitigation actions and planning associated with the Drought and Flood plans.

The overlap between state level and local risk rankings is the foundation for linking state and local mitigation strategies. Those linkages are also reflected in the similar Mitigation Goals found in this State Plan and local HMPs. SHMT agencies further strengthen those links while partnering with and mentoring local communities on plans or projects involving hazard mitigation. The prioritization guiding principles identified in Section 8, reinforce links between local and state mitigation strategies. Each state agency that funds local mitigation projects incorporates programmatic, departmental, and local factors into consideration when prioritizing funding support. DHSEM, for example, verifies specific connections between a proposed project and the HMP’s goals, objectives, and risk rankings. The Division then includes hazard significance and FEMA’s program priorities in the project prioritization process for each mitigation program’s grants.

Table 5-5 presents new and ongoing 2018 mitigation actions. This is only a snapshot of the living Mitigation Action Database that will continue to be updated as part of the State Plan’s maintenance and implementation.

## **1. FLOOD AND DROUGHT PLAN MITIGATION ACTION INTEGRATION**

The Colorado Flood and Drought plans include 28 and 53 Mitigation Actions, respectively. Actions rated as High Priority from both single-hazard plans are included below in Table 5-5, comprised of 13 from the Flood Plan and 12 from the Drought Plan. Actions from the Flood Hazard Mitigation

Plan are identified by “FHMP” and an Action ID number used in that plan; similarly, actions from the Drought Mitigation and Response Plan are identified by “DMRP” and utilize that plan’s Action ID number. The Core Planning Team will continue to coordinate with the Flood and Drought planning teams to ensure actions are being implemented and updated within all plans.

TABLE 5-5 NEW AND ONGOING MITIGATION ACTIONS

Action ID	Action Title	Status (May 2018)	Relevant Goal(s) & Objective(s)	Hazard(s) Addressed	Responsible Lead Agency or Working Group	Partnering Agencies or Working Groups	Type of Action
<b>Implementation Notes</b>							
2018.01	Continued development of and improvements to hazards data relating to climate change.	New and Ongoing	IV A	Multiple	CCC	DHSEM	Data & Studies
Currently focused on drought. Then will move to tornado and hail. Despite the coordinated effort to detail the relationship between climate change and hazards for this Plan, there will continually be improved science and knowledge of the relationship between climate change and natural hazards. Ongoing studies on the relationship between climate change and hazards will help improve the state's understanding of its risk and help better plan for future conditions.							
2018.02	Identify the best tool to disseminate hazards data in an on-line viewer.	New	I, V, VI C, F, J, K, P, Q	Multiple	CCC	DHSEM and local governments	Data & Studies
An updated GIS database of hazards has been developed as part of the 2018 SHMP update. This information can be shared with local governments to support mitigation planning efforts. Having the data in an on-line viewer would be a preferable way to raise awareness and share data. This effort can be aligned and coordinated with other state data web mapping efforts.							
2018.03	Continued coordination with producers on how to dispose of carcasses from incidents that cause a mass mortality of livestock.	New and Ongoing	II O	Animal Disease Outbreak	CDA - Animal Health Division	CDPHE CDOT	Technical Assistance
Proper disposal can help mitigate spread of animal disease. However, the capacity of local farmers and ranchers to dispose of dead livestock could be easily overwhelmed in a major incident.							
2018.04	Continue 'secure food supply' planning efforts to mitigate hazard's impacts on farming/ranching operations.	New	II O	Multiple	CDA - Animal Health Division	CDPHE and local providers	Planning & Regulations
The food and agricultural sector is heavily dependent on their ability to move their products to market in a timely manner, a process that can be easily disrupted by hazards. Additional planning can help ensure movement of products that are inside of hazard zones, but not impacted by an event.							
2018.05	Development of biosecurity plans to mitigate the risk posed by animal disease.	New and Ongoing	V D, L	Multiple	CDA - Animal Health Division	CDPHE and local providers	Data & Studies

Action ID	Action Title	Status (May 2018)	Relevant Goal(s) & Objective(s)	Hazard(s) Addressed	Responsible Lead Agency or Working Group	Partnering Agencies or Working Groups	Type of Action
<b>Implementation Notes</b>							
Effective biosecurity at the enterprise and industry level is considered extremely important in mitigating the risk of introduction or spread of animal diseases, and especially for an emergency animal disease. A biosecurity plan contains all the measures used to mitigate risks of disease entry or spread.							
2018.06	Continue to serve as a Ag liaison between producers and jurisdictions to integrate farmers and ranchers into disaster response and planning (incident management plans).	New and Ongoing	III D	Multiple	CDA - Animal Health Division	local providers	Planning & Regulations
Farmers and ranchers play a critical role in implementing actions that can reduce hazard impacts related to the Ag sector. However, they are often left out of the planning process and response plans. Including them up front helps ensure their needs and capabilities are accurately captured to make their mitigation activities more efficient and effective, as well as achieve greater buy-in.							
2018.07	Build a 'Colorado Ag-Ready' program.	New and Ongoing	II O	Multiple	CDA - Animal Health Division	local operators	Planning & Regulations
The Ag-Ready program would enhance coordination with large agriculture operators to mitigate hazard risk to animals.							
2018.08	Development of a geospatial historic properties database, to be integrated with the planned state asset and critical facility and infrastructure geospatial database.	New	III J	Multiple	History CO Office	DHSEM	Data & Studies
A GIS database of historic properties could be used to identify those that might be at risk to hazards such as flood, landslide, or wildfire. Refining the risk is the first step in identifying mitigation alternatives.							
2018.09	Continued development of GIS data identifying rockfall risk.	New and Ongoing	I, V F, H, K, P, Q	Rockfall	CDOT	DHSEM DOLA/DLG	Data & Studies
As noted in the HIRA Section on Landslides, Mud/Debris Flows, and Rockfalls (page 3-384 to 3-404), areas that may be prone to landslides are generally understood, but data is lacking on specific locations susceptible to rockfalls. Improving this data will increase awareness and further refinement of data contributing to the identification of higher risk areas. Internal funding will likely suffice to implement this action.							
2018.10	Identify the best tool to disseminate the rockfall risk in an on-line viewer.	New	I, V, VI C, F, J, K, P, Q	Rockfall	CDOT	DHSEM DOLA/DLG	Data & Studies

Action ID	Action Title	Status (May 2018)	Relevant Goal(s) & Objective(s)	Hazard(s) Addressed	Responsible Lead Agency or Working Group	Partnering Agencies or Working Groups	Type of Action
<b>Implementation Notes</b>							
In conjunction with Action 2018.09 above, as data is collected on rockfall areas it will be necessary to find the best way to visualize and disseminate that data. This will improve awareness of risk areas to assist decision makers regarding potential mitigation plans and activities. See also Action 2018.02. Internal funding will likely suffice to implement this action.							
2018.11	Formalize integration of Community Rating System (CRS) requirements into local HMP updates.	New	IV A	Flood	CDPS - DHSEM	DNR - CWCB	Planning & Regulations
There are several CRS elements where a community can receive credit for including certain elements in the planning process when updating their HMP. While many communities already include these elements, a number of others do not. This action would entail providing guidance and technical assistance with how the CRS Activity 510 requirements overlap with DMA mitigation planning requirements. This could aid communities with improving their CRS ratings, resulting in rate reductions for their flood insurance policy holders.							
2018.12	Update county/municipal level Community Wildfire Protection Plans (CWPPs) as part of local HMP updates.	New	IV A, M, N	Wildfire	CDPS - DHSEM	CSFS	Planning & Regulations
CWPPs are critical documents for reducing wildfire risk. In the past, they have typically been developed, maintained, and updated independent from local HMPs. Coordinating these two plans will enhance integration between the programs and improve effectiveness of wildfire risk reduction efforts. It will also help with keeping CWPPs updated as they would align with the five year DMA planning requirement.							
2018.13	Complete spillway/outlets mapping for high hazard dams.	New	VII C	Dam/Levee Failure	DNR - Dam Safety	CDPS - DHSEM	Data & Studies
As noted in the HIRA section on Dam and Levee Failure (page 3-511 to 3-531), mapping of spillway and outlet areas from high hazard dams is critical to understanding the location and extent of a possible dam failure. Completing this mapping will improve hazard awareness and should help identify future mitigation actions.							
2018.14	Evaluate options for potential regulation and increase outreach to communities about the risks posed by dam release and development below dams.	New	VIII K	Flood	DOLA – DLG and CDPS - DHSEM	local governments	Education, Awareness, & Outreach

Action ID	Action Title	Status (May 2018)	Relevant Goal(s) & Objective(s)	Hazard(s) Addressed	Responsible Lead Agency or Working Group	Partnering Agencies or Working Groups	Type of Action
<b>Implementation Notes</b>							
As noted in the HIRA section on Dam and Levee Failure (page 3-512) "Impacts to life and safety will depend on the warning time and the resources available to notify and evacuate the public." Increased outreach to those potentially affected will help people react quicker during an event. Currently there are no regulations regarding development below dams. This action would explore potential options and evaluate practices used in other states that might be applicable to Colorado.							
2018.15	Require integration of climate change considerations into local hazard mitigation plans.	New	IV A	Multiple	CDPS - DHSEM	DNR – CWCB and CCC	Planning & Regulations
Most local HMPs do an adequate job of incorporating data from historical events, but are not as detailed in analyzing how climate change may affect future incidents. The inclusion in the SHMP of climate change implications for each hazard profiled in the HIRA provides local jurisdictions a starting point, as does climate change information in the Colorado Drought Mitigation and Response Plan.							
2018.16	Continued public education aimed at increasing avalanche awareness to recreational users.	New	I H	Avalanche	DNR - CAIC	DHSEM Strategic Communications	Education, Awareness, & Outreach
As noted in the HIRA section on Avalanches (page 3-313), "90 percent of avalanche victims die in slides triggered by themselves or a member of their group." Increasing avalanche awareness is crucial to reducing avalanche fatalities.							
2018.17	Continued expansion of avalanche mitigation installations.	New and Ongoing	I H	Avalanche	DNR - CAIC	CDOT	Structure & Infrastructure Projects
Two installations have been erected so far, with one more planned for the summer of 2018.							
2018.18	Continued evaluations of avalanche risk to entire transportation system.	New and Ongoing	I F	Avalanche	DNR - CAIC	CDOT	Data & Studies
This is part of an ongoing 10-year process, beginning in 2013.							
2018.19	Development of tools to help better predict wet avalanche activity on a sub-year scale.	New	VIII K	Avalanche	DNR - CAIC	CCC Mountain Studies Institute	Data & Studies

Action ID	Action Title	Status (May 2018)	Relevant Goal(s) & Objective(s)	Hazard(s) Addressed	Responsible Lead Agency or Working Group	Partnering Agencies or Working Groups	Type of Action
<b>Implementation Notes</b>							
CAIC has noticed an increase in timing and magnitude of wet avalanches.							
2018.20	Continued development of GIS data identifying avalanche risk.	New and Ongoing	I F	Avalanche	DNR - CAIC	local governments Mountain Studies Institute	Data & Studies
While the CAIC has mapped some areas that are generally susceptible to avalanche risk, the mapping has been for specific purposes or areas. Expanded data on avalanche risk can help reduce avalanche fatalities and impacts, and inform safe siting of development and infrastructure.							
2018.21	Identify the best tool to disseminate avalanche risk in an on-line viewer.	New	I, V, VI C, F, J, K, P, Q	Avalanche	DNR - CAIC	DHSEM DOLA/DLG Mountain Studies Institute	Education, Awareness, & Outreach
In conjunction with Action 2018.20 and 2018.02 above, as data is collected it will be necessary to find the best way to visualize and disseminate that data. This will improve awareness of risk areas to assist decision makers regarding potential mitigation plans and activities. Can align with other state data web mapping efforts.							
2018.22	Institutionalize Resiliency into State of Colorado Investments and Operations' plan development.	New	IV A, B	Multiple	DOLA - CRO	CDPS - DHSEM	Planning & Regulations
Consultant to be hired to help facilitate this process in mid-2018. DHSEM is a participating and cooperative agency in the CORIP internal investments and budgeting using a resilience lens focus group.							
2018.23	Implement 'Institutionalize Resiliency into State of Colorado Investments and Operations' plan actions.	New	IV A	Multiple	DOLA - CRO	CDPS - DHSEM	Multiple
The CRO launched the Colorado Resiliency Institutionalization Project (CORIP) in 2018 to explore ways to more formally build resiliency into state operations and investments. Based on stakeholder input, CORIP is currently focusing on three initiatives: <ul style="list-style-type: none"> <li>• Developing a shared approach for guiding internal investments and budgeting using a resilience lens.</li> <li>• Developing a list of laws/regulations that can be adapted to include resiliency requirements or criteria.</li> <li>• Establishing a behavioral health capacity/workforce resiliency working group.</li> </ul>							

Action ID	Action Title	Status (May 2018)	Relevant Goal(s) & Objective(s)	Hazard(s) Addressed	Responsible Lead Agency or Working Group	Partnering Agencies or Working Groups	Type of Action
<b>Implementation Notes</b>							
2018.24	Develop guidance for local jurisdictions to integrate climate change into local planning efforts.	New	IV A	Multiple	DOLA - CRO	CDPS - DHSEM	Planning & Regulations
CO Resiliency Resource Center ( <a href="https://sites.google.com/a/state.co.us/coloradounited/coresiliency-resource-center">https://sites.google.com/a/state.co.us/coloradounited/coresiliency-resource-center</a> ); Planning for Hazards: Land Use Solutions for Colorado Guide ( <a href="http://www.planningforhazards.com">www.planningforhazards.com</a> ). DHSEM requires integration of climate change in all local HMPs.							
2018.25	Develop future conditions models starting with flood, drought, and wildfire that will quantify baseline change in vulnerability and then baseline metrics in mitigation actions to reduce that risk.	New	IV A	Multiple	DOLA - CRO	CDPS - DHSEM	Data & Studies
Anticipated to be two- to three-year effort concluding in 2021. Will help quantify losses avoided based on certain land use and hazard mitigation policies. DHSEM has partnered with the CRO on this effort.							
2018.26	Develop and facilitate a pilot day-long "Mitigating Hazards through Land Use Solutions" workshop for local governments in partnership with DHSEM and FEMA.	New	VII G, R	Multiple	DOLA - CRO	CDPS – DHSEM and local governments	Education, Awareness, & Outreach
The state is working to improve coordination between hazard mitigation and overall land use policy. These workshops encourage local government implementation of land use solutions to reduce risks to hazards. Two pilot workshops were conducted on June 7 and September 6 of 2018. Additional workshops could be held in the future.							
2018.27	Enhance the current structure of the SHMT by creating formal working groups focused on specific hazards and mitigation projects.	New	IV E	Multiple	SHMT	CDPS - DHSEM	Multiple

Action ID	Action Title	Status (May 2018)	Relevant Goal(s) & Objective(s)	Hazard(s) Addressed	Responsible Lead Agency or Working Group	Partnering Agencies or Working Groups	Type of Action
<b>Implementation Notes</b>							
The SHMT currently addresses all hazards and all projects. Formalizing focused working groups can enhance cross-agency communications, more efficiently implement mitigation projects, help lead mitigation/resiliency efforts across state agencies, and lead to development of new and refinement of existing mitigation actions. Topics may include: Planning/Policy, Data, Investments/Funding, Climate Change, Critical Infrastructure. Discussion and evolution of restructuring the SHMT will be a collaborative process taking place during scheduled Plan implementation & maintenance meetings, and align with the Phase I Road Map suggestions to better link DHSEM and existing CRO CRWG sectors CORIP efforts.							
2018.28	Promote integration of hazards into local government comprehensive plans and land use policies and regulations.	New	VII G, I, R	Multiple	DOLA - DLG	CDPS - DHSEM	Planning & Regulations
Some Colorado communities (Adams & Costilla Counties and Manitou Springs) have developed their FEMA-approved local HMPs as part of their comprehensive plans. This effort has potential to increase the use of land use solutions to reduce risks to hazards in local government plans and actions. See Section 6.3 for further discussion. Accomplished through DLG's Energy/Mineral Impact Assistance Fund (EIAF) Grant Program, FEMA/DHSEM planning grants, and other educational efforts.							
2018.29	Map and assess the vulnerabilities of individual nodes within the Critical Infrastructure Sectors, as defined by the US Department of Homeland Security, to natural, technological, and human-caused hazards in local, regional, and the state Threat and Hazard Identification and Risk Assessments (THIRAs).	New	II, V D, J	Multiple	CDPS - DHSEM	Regional and local governments	Data & Studies
Analysis of the impacts of hazards on critical facilities to date has focused primarily on state-owned facilities. This project would identify additional facilities beyond state owned or leased facilities, with a priority on those essential to be operational for disaster response and recovery.							
HH-1 (2013)	Implement fuels reduction and forest health projects.	Ongoing	-	Wildfire	CSFS	local governments POAs/HOAs	Natural Systems Protection
As discussed in the HIRA section on Wildfire, one of the major risk factors for wildfires is the availability of fuels. This project will drive activities that alter fire behavior and augment fire management and suppression, as well as promote activities that improve resiliency of forests and reduce direct risk reduction to life and property.							

Action ID	Action Title	Status (May 2018)	Relevant Goal(s) & Objective(s)	Hazard(s) Addressed	Responsible Lead Agency or Working Group	Partnering Agencies or Working Groups	Type of Action
<b>Implementation Notes</b>							
HH-2 (2013)	Complete hazard maps in areas where geologic mapping is complete.	Ongoing	-	Multiple	CGS	DHSEM DOLA/DLG local governments	Data & Studies
Allows better assessment of natural hazard exposure and vulnerability in future land use plans; provides enhanced assessment of natural hazard exposure on evacuation and sheltering; assists in identifying assets critical to continuity of state and local government, continuity of operations, and delivery of essential services.							
HH-3 (2013)	Assess risks associated with the Flood/Wildfire nexus and develop mitigating actions and projects.	Ongoing	-	Flood	DNR - CWCB	DHSEM DOLA/DLG local governments	Planning & Regulations
The CWCB has led several mapping efforts to identify heightened risk of flooding on wildfire burn scars. This is a long-term, ongoing process that will lead to better understanding of vulnerabilities associated with post-wildfire flood events, more effective characterization of post-wildfire flooding, and related prioritization of mitigation activities and resources.							
HH-6 (2013)	Evaluate the threat of avalanches to future projects and developments.	Ongoing	-	Avalanche	DNR - CAIC	CDOT DHSEM DOLA/DLG local governments	Data & Studies
This action will help prevent future impacts to projects and developments by establishing a process to assess risk and recommend mitigation at the program development stage. Risk assessments are performed when requested.							
HH-11 (2013)	Enhance the Colorado Wildfire Risk Assessment Portal (CO-WRAP).	Ongoing	-	Wildfire	CSFS	Water Availability Task Force	Data & Studies
Enhancements based on user comment will improve public and professional end-user experience and be more effective in conveying risk information; currently updating fuel model, weather, burn probability, WUI layers; 2018 data enhancements are pending.							
HH-12 (2013)	Assist communities in implementing CWPPs.	Ongoing	-	Wildfire	CSFS	DHSEM	Technical Assistance
There are currently 225 CWPP's of which 47 are counties. This project will continue technical assistance to communities in implementing their CWPPs, including identifying risk and appropriately prioritizing mitigation activities for protection of life and property; education of communities in management options and implications for the surrounding watershed.							

Action ID	Action Title	Status (May 2018)	Relevant Goal(s) & Objective(s)	Hazard(s) Addressed	Responsible Lead Agency or Working Group	Partnering Agencies or Working Groups	Type of Action
<b>Implementation Notes</b>							
HH-13 (2013)	Add earthquake monitoring stations to evaluate seismicity activity.	Ongoing	-	Earthquake	CGS	N/A	Structure & Infrastructure Projects
The network has been increased by two stations since the last status update. More stations will enhance overall seismic data collection and associated assessment of risk. Better understanding of this seismicity may lead to enhanced collaboration of partners and stakeholders.							
HH-15 (2013)	Participate in National Soil Moisture Network.	Ongoing	-	Drought	CCC	CWCB	Technical Assistance
Participation is ongoing in an advisory role. Further participation will lead to an enhanced understanding of short- and long-term impacts of drought on soil moisture, and identify potential impacts to forest fuels and crop production.							
HH-17 (2013)	Enhance CCC website to include hazards and atmospheric risk information.	Ongoing	-	Atmospheric Hazards	CCC	CWCB DHSEM	Education, Awareness, & Outreach
The CCC website has undergone a complete redesign in 2018. There is now information on many high-impact events, staff are still working to include more thorough hazard information and increase availability of state-collected atmosphere data to the public.							
HH-18 (2013)	Increase participation in Fire-Adapted Communities and Firewise™ including education and outreach.	Ongoing	-	Wildfire	CSFS	DHSEM local governments	Education, Awareness, & Outreach
Colorado already has the 2nd most Firewise™ communities in the nation. Additional involvement will augment private property owner vesting in structural and defensible space mitigation activities, increasing community preparedness to reduce negative impacts from wildfire to community infrastructure and natural resources.							
HH-19 (2013)	Develop materials for, and participate in, awareness and outreach for atmospheric hazards.	Ongoing	-	Atmospheric Hazards	CCC	CWCB DHSEM	Education, Awareness, & Outreach
To date, flood and drought materials have been developed. Work is ongoing to include other hazards. This <b>action</b> establishes the Colorado Climate Center as a multi-faceted source of information beyond data. Provides opportunity to create linkages and fill gaps between NWS, ReadyColorado, and other awareness providers.							

Action ID	Action Title	Status (May 2018)	Relevant Goal(s) & Objective(s)	Hazard(s) Addressed	Responsible Lead Agency or Working Group	Partnering Agencies or Working Groups	Type of Action
<b>Implementation Notes</b>							
HH-20 (2013)	Evaluate statewide mined areas for subsidence.	Ongoing	-	Subsidence	CGS	local governments	Data & Studies
Lack of data is the biggest challenge to mitigating against subsidence hazards. Better data will lead to a more thorough assessment of natural hazard exposure and vulnerability in future land use plans.							
HH-21 (2013)	Increase inventory of historical avalanche data.	Ongoing	-	Avalanche	DNR - CAIC	CDOT DHSEM local governments	Data & Studies
There has been significant improvement on the collection of historical avalanche data in the GIS database. The goal now is to fill gaps and enhance overall best available data for profiling of avalanche hazards, as well as provide for targeted education and outreach for avalanche prone areas of Colorado.							
HH-D (2013)	Improve methodology for estimating losses and identifying losses avoided/mitigation effectiveness for priority hazards.	Ongoing	-	All-Hazard	CDPS - DHSEM	ORM	Planning & Regulations
DHSEM, the State Office of Risk Management (ORM), and consultants have improved the methodology in the HIRA for estimating losses. Improvements to identifying losses avoided/mitigation effectiveness will be implemented as part of the 2018 State Plan update. Studies completed and additional pilot studies for mitigation effectiveness have been identified in Section 5 - Assessing Mitigation Effectiveness. Potential benefits: inform SMEs on return-on-investment of mitigation projects and activities; assist in hazard risk prioritization; required as part of being an Enhanced Plan state.							
HH-E (2013)	Strengthen coordination with the CRO Sectors as well as with technical assistance partnerships (TAPs) related to flood, drought, atmospheric, geologic, and wildfire that contribute to the mitigation of statewide natural hazards.	Ongoing	-	All-Hazard	CDPS - DHSEM	CRO, TAPs and associated CRWG sectors and agencies	Planning & Regulations

Action ID	Action Title	Status (May 2018)	Relevant Goal(s) & Objective(s)	Hazard(s) Addressed	Responsible Lead Agency or Working Group	Partnering Agencies or Working Groups	Type of Action
<b>Implementation Notes</b>							
CRO participated in updates to the 2018 State Plan and the separate Drought and Flood Plans. Better coordination will enable pooling of SME resources on specific hazards, resulting in more comprehensive and effective strategies. This may also help identify previously unknown mitigation resources. Ongoing coordination continues with DHSEM and CRO (CRWG & CORIP), DOLA Planning for Hazards, and participation in the Flood TAP as well as other statewide outreach. A formal method for formalizing coordination as discussed during the Plan update SHMT Workshops 1-3, will be established at the scheduled SHMT implementation & maintenance meetings as defined in this Plan with input and direction by the SHMT participants. Potential benefits of this action include pooling of SME resources on specific hazards, resulting in more comprehensive and effective strategies than agencies working alone. Additionally, it will help to identify previously unknown mitigation resources, required as part of the potential Enhanced Plan.							
FHMP 1.4	Improve emergency warning systems and encourage the installation of additional sensors and reporting devices to improve high flow measurement capabilities along flood prone streams in high risk areas.	Ongoing (2007)	-	Flood	DHSEM CWCB DWR UDFCD	NWS-GJ and local governments	Structure & Infrastructure Projects
CWCB and DHSEM provided funding for a CWCB project to study improvements in early warning capabilities by placing mobile radar trucks in Southwest Colorado and the Rio Grande Valley. This specific project was completed and demonstrated how more localized radar will improve storm prediction and early warning capabilities as compared to NWS facilities in Grand Junction. Data from the mobile radar was transmitted in real-time to the NWS Grand Junction office to improve their prediction capabilities. As a part of this project, NOAA and local communities are also funding the installation of a network of stream gages to further enhance prediction capabilities. Since 2012 for State declared disasters, DHSEM requests disaster recovery funding from the Disaster Emergency Fund that may be used by impacted jurisdictions to enhance stream emergency warning systems through additional sensors and reporting devices. UDFCD continues to maintain and improve the ALERT flood warning system and work with local emergency managers to utilize the tools during flood season.							
FHMP 2.1	Enhance the natural and beneficial functions of floodplains by promoting an increased awareness of stream ecosystem function and its benefits to flood hazard mitigation.	Ongoing (2007)	-	Flood	CWCB	DWR CPW CASFM UDFCD FEMA Region VIII	Natural Systems Protection

Action ID	Action Title	Status (May 2018)	Relevant Goal(s) & Objective(s)	Hazard(s) Addressed	Responsible Lead Agency or Working Group	Partnering Agencies or Working Groups	Type of Action
<b>Implementation Notes</b>							
This is part of the ongoing mission of the CWCB Watershed Restoration Program. The CWCB has provided funding and technical assistance for projects that promote natural and beneficial functions of stream ecosystems. This includes wetlands and habitat resources along with other biomes. Implementation should include ongoing Colorado Watershed Restoration Program initiatives, along with those that took place following the 2013 flood. UDFCD is actively promoting High Functioning Low Maintenance System channels and roadway crossing designs that are based on natural stream processes. Maintenance-eligible projects by the development community must be informed by geomorphology. UDFCD, CASFM, and CRA are offering the Stream Academy to provide educational opportunities for engineers and local government staff.							
FHMP 2.2	Promote public education on post-wildfire flood hazard potential in burned watersheds	Ongoing (2010)	-	Flood	CWCB	CSFS CPW FEMA Region VIII	Education, Awareness, & Outreach
This will be implemented regularly particularly following large burn events. CWCB has conducted workshops and participated in public outreach meetings in areas impacted by wildfires, particularly since the 2012 Waldo Canyon and High Park Fires and 2010 Fourmile Fire.							
FHMP 2.3	Provide newsletter articles, other relevant information on flood hazard mitigation, and other forms of information exchange to professional organizations and local governments.	Ongoing (2007)	-	Flood	DHSEM CWCB	UDFCD CASFM CDOT FEMA Region VIII CRO	Education, Awareness, & Outreach
DHSEM provides local agencies with examples of mitigation “best practices” to assist in local planning and mitigation project activities, including information on flood reduction strategies. CWCB has a regular column in CASFM’s newsletter. In addition, CWCB publishes the Floodstage newsletter. CDOT is in partnership with CWCB for sharing Post-2013 Flood hydrology updates. CRO published an article with the U.S. Green Building Council on the need to build resilience into state investments and operations to avoid future losses in events similar to the 2013 floods.							
FHMP 2.5	Continue to provide access to information, education, and tools on flood mitigation through Resiliency Resource Center and Planning for Hazards websites.	New	-	Flood	DOLA – DLG & CRO	CWCB	Education, Awareness, & Outreach
Activities specific to the action include the addition of Fluvial Hazard Zone model regulations, planned for 2019 as additional information in the Planning for Hazards website.							

Action ID	Action Title	Status (May 2018)	Relevant Goal(s) & Objective(s)	Hazard(s) Addressed	Responsible Lead Agency or Working Group	Partnering Agencies or Working Groups	Type of Action
<b>Implementation Notes</b>							
FHMP 3.2	Optimize potential state and federal funding sources to support mitigation initiatives which are part of the Colorado Flood Hazard Mitigation Plan to include additional coordination with Silver Jackets on State projects.	Ongoing (2007)	-	Flood	DHSEM CWCB	Flood TAP	Technical Assistance
Both the SHMP and Flood Plan have updated lists of current and potential federal, state, and local funding sources for hazard mitigation. DHSEM administers FEMA's PDM, FMA, and EMPG programs, and has helped multiple communities in Colorado leverage these funds. DHSEM has also provided state agencies and local governments with EMPG funding for drainage studies and education programs related to flood hazards. Updated in 2018 to include Silver Jackets reference which can include funding for flood risk studies and mitigation projects.							
FHMP 3.4	Colorado Hazard Mapping Program (CHAMP)	New	-	Flood	CWCB	CGS	Data & Studies
In 2015 the Colorado Legislature passed a funding bill for the Colorado Hazard Mapping Program (CHAMP) with the goal of providing a mitigation and land use framework in areas likely to be affected by future flooding, erosion, and debris flood events. Updated hazard information is provided for the streams most affected by the September 2013 flooding. Phase I and II of the project includes field reconnaissance and survey, creating terrain models from updated topographic datasets, evaluating hydrology, and modeling to produce flood hazard area limits reflecting the changed conditions. The updated information is intended to be used by community leaders to update hazard information to assess risk and identify mitigation opportunities in their community as well as used to update FEMA Flood Insurance Rate Maps. The website provides an overview of all hazard mapping projects the CWCB is managing within the state. This website contains downloadable data from field surveys, meetings, and resources communities may use for outreach purposes. <a href="http://coloradohazardmapping.com">http://coloradohazardmapping.com</a>							
FHMP 3.5	Continued LiDAR acquisition and management of data for flood and other hazard mapping.	New	-	Flood	CWCB	OIT CGS	Data & Studies
The CWCB has been actively leading efforts to obtain LiDAR-based terrain data for the entire State of Colorado since the September 2013 flood. Other state agencies collaborating in this effort include OIT and CGS. The CWCB has received over \$6.4 million from other federal, state, and local partners since 2013 specifically for LiDAR acquisitions.							

Action ID	Action Title	Status (May 2018)	Relevant Goal(s) & Objective(s)	Hazard(s) Addressed	Responsible Lead Agency or Working Group	Partnering Agencies or Working Groups	Type of Action
<b>Implementation Notes</b>							
FHMP 4.1	Digitize existing 100-year floodplain maps.	Ongoing (2013)	-	Flood	CWCB	consultants local governments	Data & Studies
See the discussion on DFIRM/Risk MAP mapping progress in the Flood plan. As of 2018, Digital Conversions of some counties remain and are in progress with assistance from the CWCB's mapping consultants.							
FHMP 4.3	Create a Dam Safety Inundation Map Database.	Ongoing (2013)	-	Flood	DNR-DWR	DHSEM local governments	Data & Studies
DWR has assembled a geodatabase of shapefiles that has been shared with the floodplain and emergency manager communities across the State. Data is not 100% complete as far as content, but it is updated as they add shapefiles to it.							
FHMP 5.1	Promote land use solutions to reduce risk to flood hazards through information, education, and technical assistance.	Ongoing (2007)	-	Flood	DOLA – DLG CWCB UDFCD	DHSEM	Technical Assistance
As a part of its technical assistance services, DHSEM provides background information and a comprehensive list of possible mitigation actions. This list includes suggestions for enhancing codes and land use regulations and integrating hazard mitigation plans into local land use and comprehensive planning efforts. DLG has developed various tools to support local communities' hazard reduction through land use regulations and the <i>Planning for Hazards: Land Use Solutions for Colorado</i> guide, website, and workshops. UDFCD promotes floodplain preservation to local governments and developers within the District with the idea that benefits of a preserved floodplain (recreation, wildlife habitat, et cetera) can be marketed by developers as amenities to their projects, but also become long term assets to the communities.							
FHMP 5.3	Incorporate new State floodplain standards into local standards.	Ongoing (2013)	-	Flood	CWCB	local governments	Technical Assistance
The State Flood Rule became effective January 2014. This action is nearly complete as of mid-2018. As of May 2018, 247 out of 252 communities (98%) participating in the NFIP have adopted the new Rules.							
FHMP 5.6	Promote a One Water approach and integrated water management into local water and land use planning.	New	-	Flood	CWCB DOLA	DHSEM local governments	Planning & Regulations

Action ID	Action Title	Status (May 2018)	Relevant Goal(s) & Objective(s)	Hazard(s) Addressed	Responsible Lead Agency or Working Group	Partnering Agencies or Working Groups	Type of Action
<b>Implementation Notes</b>							
CWCB and DOLA/DLG are partnering with organizations and local governments to help implement the Colorado Water Plan goal to increase water conservation in land use planning through training, technical assistance, guidance materials, and other resources.							
DMRP 1.1	Collect climatologic data at mid & lower elevations to fill existing gaps in the data collection network	Ongoing (2010)	-	Drought	WATF	NRCS CCC CoCoRaHS CAIC	Data & Studies
The NRCS has installed one new SNOTEL site at 8920' since 2010, Black Mountain. Three new sites are planned for Colorado, two of which are at low and mid elevations. Additional sites may be installed at a later date if funding is made available. Ongoing based on funding.							
DMRP 1.13	Continue to Support and Strengthen Intermountain West Drought Forecasting	Ongoing (2010)	-	Drought	CCC	NOAA NIDIS CWCB	Data & Studies
CCC, with support from NIDIS, continues to lead operational drought monitoring, including weekly monitoring for the state of Colorado, and conditions monitoring through CoCoRaHS that serves as a valuable drought calibration tool. CCC has improved and will continue to improve visibility and communication of drought monitoring and assessments through webinars, social media, press releases, YouTube, et cetera. It is important to invest in research to improve S2S forecasting, with the goal of providing actionable S2S information and data for better drought decision making.							
DMRP 2.1	Evaluate, improve, and coordinate the role and relationship of the CWCB public information and education efforts with those being conducted by local water authorities, utilities, users, and suppliers.	Ongoing (2003)	-	Drought	CWCB	local water authorities, utilities, users, and suppliers	Education, Awareness & Outreach
The CWCB hired a Public Engagement Specialist in 2013 to help develop Colorado's Water Plan and engage local stakeholders and partners in the process, and continue fostering public engagement after the plan's development. The goals include 1) creating a new outreach, education, and public engagement grant fund, which has been completed, 2) creating a data-based water education plan, which will be addressed in a few phases and is in progress, and 3) improving the use of existing state resources, which is an ongoing endeavor, but the state is working on a few projects to improve this coordination into the future. See additional details in the Drought Plan.							

Action ID	Action Title	Status (May 2018)	Relevant Goal(s) & Objective(s)	Hazard(s) Addressed	Responsible Lead Agency or Working Group	Partnering Agencies or Working Groups	Type of Action
<b>Implementation Notes</b>							
DMRP 3.1	Fund water system improvements for drought mitigation and resiliency.	Ongoing (2013)	-	Drought	DOLA CWCB WPA	DHSEM (FEMA RI Projects)	Funding
Funding that has been used include the Colorado Water Resources and Power Development Authority (CWRPDA, receives EPA funding), Water Project Loan Program, DOLA Energy/Mineral Impact Assistance Fund, funding out of Water Plan, and CWCB's loan program.							
DMRP 4.1	Make completion of local drought plans a priority; include vulnerability & risk assessments; incorporate info into next update.	Ongoing (2007)	-	Drought	CWCB	DHSEM DOLA/DLG local governments	Data & Studies
Local drought plan guidance document was developed in 2010 to help facilitate local plan development. Sample drought plan completed in 2011. Approximately eight local drought plans have been completed 2010-2018. The CWCB is continuing to encourage and fund the development of local drought plans.							
DMRP 4.2	Integrate results, tools, and methods from the 2010 Statewide Drought Vulnerability Assessment to improve and standardize drought risk assessments in local hazard mitigation plans.	Ongoing (2010)	-	Drought	DHSEM CWCB	local governments	Technical Assistance
Utilize in Plan update cycles or in new plans that are developed. Being incorporated by reference into new or updated plans since 2010, but no formal process. DHSEM to include template SOW for sub-applicants. DHSEM will engage early with in-house updates to encourage the incorporation of the Drought Plan.							
DMRP 4.3	Develop approaches and technology to help farmers adapt to drought.	Ongoing (2004)	-	Drought	CDA State Conservation Board USDA	CSU Extension	Technical Assistance
University research grants have been used to address grazing management, forage and crop systems, and irrigation strategies. The research will lead to improvements such as enhancing soil's ability to hold water and developing grazing systems that can tolerate drought and reduce the potential for dust storms. Increasing demonstrations and adoption of farming methods that improve soil health and water holding capacity, so lands will be more resistant/resilient to and during cyclic drought patterns.							

Action ID	Action Title	Status (May 2018)	Relevant Goal(s) & Objective(s)	Hazard(s) Addressed	Responsible Lead Agency or Working Group	Partnering Agencies or Working Groups	Type of Action
<b>Implementation Notes</b>							
DMRP 5.1	Continue development and the appropriate allocation of resources to the Office of Water Conservation and Drought Planning in providing technical assistance to covered entities, evaluating submitted water conservation and drought plans, administering fund programs, and disseminating information to the public	Ongoing (2003)	-	Drought	CWCB	DHSEM DOLA/DLG local governments conservation districts	Funding
Funds allocated through construction fund and severance tax fund; full time drought planner hired in 2008; full time water conservation technical specialist hired in 2009; \$1.1million non-reimbursable for statewide municipal distribution system water loss training commencing Spring 2018.							
DMRP 5.3	Encourage and provide incentives for more efficient municipal irrigation systems, including State-owned properties.	Ongoing (2010)	-	Drought	CWCB CRC Green CO Local Water Providers	DHSEM (FEMA RI Projects) state/local providers and conservation districts	Funding
Use water efficiency grant program; Center for Resource Conservation irrigation audits funded by CWCB; EPA Watersense specifications for outdoor irrigation technologies; Green Industries of Colorado (GreenCO) Best Management Practices; Colorado Waterwise's Guidebook of Best Practices for Municipal Water Conservation in Colorado. Use Colorado Water Plan grants to fund landscape retrofits and efficient irrigation implementation.							
DMRP 5.11	Encourage QWEL Certification.	New	-	Drought	CWCB City of Aspen South Metro Water Authority	local peer representatives	Education, Awareness & Outreach
The QWEL program provides landscape professionals with approximately 20 hours of education on principles of landscape water management including proper plant selection for the local climate, irrigation system design and maintenance, and irrigation system programming and operation. Potential benefit of action: Certifying landscapers in a proven certification program has resulted in an increase in water efficiency in urban landscapes as well as creation of more resilient urban landscapes. CWCB has approved two water efficiency grants to South Metro Water Authority and the City of Aspen. These grants will focus mainly on the preparation and implementation of the training session for the Qualified Water Efficient Landscaper (QWEL) professional certification. Certifications should be completed by end of 2018.							

Action ID	Action Title	Status (May 2018)	Relevant Goal(s) & Objective(s)	Hazard(s) Addressed	Responsible Lead Agency or Working Group	Partnering Agencies or Working Groups	Type of Action
<b>Implementation Notes</b>							
DMRP 6.1	Continue to pursue implementation funding for recommendations in this plan.	Ongoing (2007)	-	Drought	CWCB	Water Availability Task Force	Funding
Funding secured to implement some 2007 recommendations. \$200k funding for implementation was set aside through construction funds in 2010.							
DMRP 6.7	River restoration for streams that are most vulnerable to drought impacts.	New	-	Drought	CPW CWCB	local governments conservation districts	Watersheds & Natural Resources
In many streams in Colorado flows in normal water years are already below historical flows and thus the stream is more shallow, putting fish more at risk. High priority streams could be identified by CPW, CWCB, and other agencies and Non-Government Organizations (NGO). Funding could be made available for river restoration projects that would lower the risk of the stream running dry in the summer. Funding could be for projects implemented by state agencies, local government, NGOs.							
DMRP 8.1	Statewide Climate Change Initiatives.	Ongoing (2007)	-	Drought	CWCB USBR	all related state agencies	Planning & Regulations

Action ID	Action Title	Status (May 2018)	Relevant Goal(s) & Objective(s)	Hazard(s) Addressed	Responsible Lead Agency or Working Group	Partnering Agencies or Working Groups	Type of Action
<b>Implementation Notes</b>							
<p>The state has undertaken many statewide climate change initiatives since 2007. Over the course of the last decade the State's climate change efforts have become increasingly more coordinated. The items listed below are those that have a nexus with drought specifically and do not represent a comprehensive list of state climate actions. These include:</p> <ul style="list-style-type: none"> <li>2007 Governor's Climate Action Plan developed Dealing with Drought</li> <li>2008 Climate Change in Colorado synthesis report</li> <li>2009 Adapting to Climate Change workshops</li> <li>2010 Climate Change Impacts and Vulnerability Assessment</li> <li>2011 Colorado Climate Preparedness Project</li> <li>2012 CWCB Colorado River Water Availability Study</li> <li>2012 Joint Front Range Climate Change Vulnerability Study</li> <li>2012 Colorado Climate Action Plan</li> <li>2012 Colorado River Basin Water Supply and Demand Study</li> <li>2013 Colorado Drought Mitigation and Response Plan</li> <li>HB13-1293 Called for the development of a statewide climate plan and the appointment of a staff person to coordinate climate change efforts, this position is currently housed in CWCB.</li> <li>2014 Climate Change in Colorado Report</li> <li>2014 Colorado's Water Plan</li> <li>2015 Colorado Climate Plan</li> </ul> <p>In July 2017, the Governor put forth Executive Order D 2017-015 committing the state to reduce statewide greenhouse gas emissions by more than 26 percent from 2005 levels by 2025. These goals have been incorporated into the 2018 Colorado Climate Plan. The EO also called for coordination with local governments and utilities, the development of an EV Plan, and announced that the state would be joining the US Climate Alliance.</p>							

# ASSESSING MITIGATION EFFECTIVENESS

This section explains how the state systematically assesses the effectiveness of mitigation projects, both pre- and post-disaster. Mitigation effectiveness can be measured in a variety of ways, including Benefit Cost Analysis (BCA) during project scoping or assessing losses avoided from an actual event. The methodologies below are provided as guidance with FEMA funded projects, but the intent is to make it flexible for use across state agencies and could include non-FEMA funded mitigation projects. Other state agencies, namely CDOT, sometimes use public safety as the primary measure of effectiveness in consideration of mitigation investments in highway infrastructure (see the Interstate 70 Risk and Resilience Pilot in Subsection 3 below).

Some examples of assessments conducted are provided, followed by potential case studies for future assessments.

## 1. ASSESSMENT METHODOLOGIES

### 1. PRE-EVENT

A key criterion for mitigation projects to be eligible for funding is that they must be cost-effective. The primary method of estimating the cost-effectiveness of a proposed mitigation action is by conducting a Benefit Cost Analysis (BCA). BCAs will be conducted by project applicants with technical assistance from DHSEM and/or FEMA, or by technical assistance consultants.

To ensure a consistent approach in determining the cost-effectiveness of all mitigation projects, Colorado uses FEMA's BCA module and process, which is consistent with OMB Circular A-94 *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*. A BCA assesses a mitigation project based on the project, hazard, and benefit data provided in a grant application. DHSEM encourages applicants to pre-screen their proposed mitigation projects by using an upper-bound analysis, so an early determination of cost-effectiveness can be made. Upper-bound analyses are also used to identify projects that are not cost-effective.

DHSEM periodically conducts trainings and workshops for local and tribal governments on mitigation grants processes, to include how to conduct a BCA. DHSEM also provides technical assistance on BCAs to sub-applicants who may not be familiar with the process.

A positive benefit-cost ratio (greater than one) does not necessarily guarantee that a hazard mitigation project will be approved. However, by applying project specific information to the BCA module, it is possible to get a good look at the mitigation potential associated with a project. The results of this analysis can also help communities evaluate current and future mitigation projects and adjust their overall mitigation strategy accordingly.

The following section summarizes the three-step process used to determine a mitigation project's cost-effectiveness.

#### **Step 1 - Screen Project Application Data**

The first part of the process is screening the project application to gather data related to cost-effectiveness, to include economic, environmental, and engineering data. Because this data is

often limited or unavailable, the amount of data available often determines the type of benefit-cost analysis used. The screening process involves three separate but related tasks. Each task is conducted simultaneously and is essential to developing an overall profile of the project before conducting the benefit-cost analysis.

- **Engineering Review:** This review, conducted by the applicant, establishes whether the project is feasible from an engineering standpoint and whether it will reduce damage as claimed. The reviewer may suggest changes to make the project more efficient in reducing damage and loss.
- **Environmental Assessment:** This part of the screening process alerts reviewers to any potential environmental concerns raised by the project.
- **Project Application Data Review:** This part of the screening process determines whether the application contains sufficient information and data for input into the benefit-cost model.

**Error! Reference source not found.** shows the type of data that must be obtained from mitigation project applications in order to conduct a BCA. The examples below are key data used for analyzing flood, tornado, and earthquake hazard mitigation projects. Nevertheless, the same basic information and analysis is needed for mitigation projects related to any type of hazard.

**TABLE 5-6 EXAMPLES OF KEY DATA NEEDED TO ANALYZE PROJECT APPLICATIONS**

Subject	Flood Project Data	Tornado Safe Room Project	Earthquake Project Data
<b>Hazard Data (often not included in application)</b>	Flood insurance study data or historical flood data from application	Windspeed Zone	Seismic hazard data from a credible source
<b>First Floor Elevation</b>	Is this available from engineering surveys or can it be estimated from observed flood depths?	Not applicable	Not applicable
<b>Scope</b>	What problem does the project address? How vulnerable is the building, item, or area?	Same as flood	Same as flood
<b>Cost</b>	Is there a well-documented cost-estimate or only a rough estimate?	Same as flood	Same as flood
<b>Useful Lifetime</b>	How long will the project provide protection (mitigation) against damage and losses?	Same as flood	Same as flood
<b>Economic Considerations</b>	What is the square footage of the building? What are the replacement values of the building (or other facility) and contents?	Not applicable	Same as flood
<b>Occupancy</b>	Not usually applicable	Occupancy by hour	What are the levels of occupancy and visitors during various times throughout the day?
<b>Function</b>	What is the function of the facility and is it entirely or partially related to emergency response and recovery?	Same as flood	Same as flood

Subject	Flood Project Data	Tornado Safe Room Project	Earthquake Project Data
<b>Damage Estimates - With Mitigation</b>	<ul style="list-style-type: none"> <li>• What type of building is it?</li> <li>• Why does damage occur?</li> <li>• What is the historically-observed damage?</li> </ul>	Not applicable (life safety mitigation)	<ul style="list-style-type: none"> <li>• Same as flood</li> <li>• Are engineering reports available that describe building/ facility seismic vulnerabilities?</li> </ul>
<b>Damage Estimates - Without Mitigation</b>	How effective will the mitigation project be in reducing future damage? (Reduced damage can be percent or dollar values)	Not applicable (life safety mitigation)	Same as flood

Note that state agencies such as CDOT use public safety as the primary measure of effectiveness in consideration of mitigation investments in highway infrastructure.

### Step 2 - Conduct a Benefit-Cost Analysis

The second part of the process is determining which BCA tool to use based on the results of Step 1. If the data in the project application is complete, then a more robust method of analysis can be used. For project applications with incomplete or limited data, FEMA has developed a streamlined process for determining project cost-effectiveness without all data included.

At its most basic level, a BCA determines whether the cost of investing in a mitigation project today (the “cost”) will result in sufficiently reduced damage in the future (the “benefits”) to justify spending money on the project. If the benefit is greater than the cost, then the project is cost-effective; if the benefit is less than the cost, then the project is not cost-effective. The Benefit-Cost Ratio (BCR) is a way of stating whether benefits exceed projects costs, and by how much. It is figured by dividing the benefits by the costs. If the result is 1.0 or greater, then the project is cost-effective.

Example 1: The project cost is \$1,000, and the value of damage prevented after the mitigation measure is \$2,000. The BCR ( $\$2,000/\$1,000$ ) is 2.0. Because the dollar value of benefits exceeds the cost of funding the project, and the BCR is greater than 1.0, the project is cost-effective.

Example 2: The project cost is \$2,000, and the value of damage prevented after the mitigation measure is \$1,000. The BCR ( $\$1,000/\$2,000$ ) is of 0.50. Because the cost of funding the project exceeds the dollar value of the benefits, and the BCR does not meet the 1.0 required for cost-effectiveness, the project is not cost-effective.

While these examples are simplified, the process and the associated benefit-cost analysis calculations are basically the same for all mitigation projects. It is important to understand that benefit-cost analysis is essentially the same for each type of hazard mitigation project. The only differences are the types of data that are used in the calculations. The types of data depend on whether the project is for floods, tornadoes, or earthquakes.

Three approaches are used to determine a project’s benefit-cost ratio: lower-bound analysis, upper-bound analysis, and best estimate. The lower-bound and upper-bound methods are used in

many cases to make final determinations of cost-effectiveness when there is limited data. In other cases, quick screening analysis with these approaches yields inconclusive results and additional data and screening may be required. Best estimate analysis produces the most accurate results.

### Lower-Bound Analysis

Lower-bound analysis is a powerful tool that can demonstrate that projects are cost-effective even if the available data is not complete. A project's cost-effectiveness can sometimes be determined by using only one or two key pieces of data. The lower-bound analysis was developed with this in mind.

The lower-bound analysis considers only some of a project's benefits (those that are the most important or those for which data exist) and ignores other benefits that may be difficult to estimate or for which data may not be available. In other words, this analysis purposely uses only a few pieces of information, and undercounts or ignores other benefits that may be gained by implementing the project. If results indicate that a project is cost-effective, then no further analysis is needed, and no additional data has to be collected. Lower-bound analyses should not be used to rank or set priorities among projects, as they only determine broadly if a project is cost-effective.

Lower-bound analysis at a glance:

- It should be used when data is incomplete.
- It can determine that a project is cost-effective.
- It cannot determine that a project is not cost-effective.
- It uses data for one or two significant benefits.

### Upper-Bound Analysis

If a lower-bound analysis shows that a project is not cost-effective, then the next step is an upper-bound analysis. Sometimes an upper-bound analysis is used if, at first glance, the project appears not to be cost-effective. Like lower-bound analysis, upper-bound analysis relies on limited project data. Upper-bound analysis, however, also uses professional judgment to estimate which input data will produce the highest reasonable benefits.

It is extremely important to note that upper-bound analysis cannot determine if a project is cost-effective because it relies on the highest reasonable estimate of benefits. An upper-bound analysis can only determine whether the project BCR is less than 1.0 and thus is not cost-effective. As with lower-bound analyses, upper-bound analyses should not be used to rank or set priorities among projects.

Upper-bound analysis at a glance:

- It can only determine that a project is not cost-effective.
- It is often used as the next step if the lower-bound analysis is negative (not cost-effective).

- It is used if a project initially appears unlikely to be cost-effective.
- It uses the highest reasonable estimate of benefits for a project.
- It analyzes as many inputs as possible, assigning the highest reasonable value to each.

### Best Estimate Analysis

A best estimate analysis is used when the project application data is complete or nearly complete. This analysis provides a more accurate BCR because it considers more data in the analysis. Because this method of benefit-cost analysis provides the best estimate of cost-effectiveness, it can be used to rank or prioritize competing projects.

Best estimate analysis at a glance:

- It should be used when the project application data is complete, or almost complete.
- It produces a more accurate analysis than lower-bound and upper-bound analyses.
- It determines whether a project is cost-effective or not cost-effective.
- BCR can be used for ranking or setting priorities among projects.

### **Step 3 - Review the Results of the Analysis**

There are three possible outcomes to a benefit-cost analysis: the project is deemed cost-effective (BCR > 1.0), the project is deemed not cost-effective (BCR < 1.0), or there is not sufficient data to make a determination.

Typically, if the project is cost-effective as determined by a lower-bound or best estimate analysis, then no further analysis or additional data collection is required and the application moves to the next level in the funding process. If the project is not cost-effective as determined by an upper-bound or best estimate analysis, then no further analysis or additional data collection is required and the project is rejected. If the cost-effectiveness of a project cannot be adequately determined, then additional data must be collected.

### **2. POST EVENT**

Assessing the performance of hazard mitigation measures is critical to substantiate the value of mitigation efforts, and loss avoidance assessment results help assure prudent use of limited public resources. A loss avoidance assessment is a method of measuring the effectiveness of hazard mitigation projects. Projects completed in the past provide a return on investment (ROI), which communicates the value of mitigation measures and informs future allocation of resources for the highest and best use. Assessing the performance of hazard mitigation measures is critical to substantiate the value of mitigation efforts; evaluating effectiveness of mitigation efforts also helps assure prudent use of future resources.

DHSEM conducts a loss avoidance assessment after each Presidential Disaster Declaration and may do so after non-declared disasters where warranted. These post-event assessments use real event data to evaluate the impacts that were prevented by completed mitigation projects.

Specifically, the assessment reports dollars saved due to mitigation measures (losses avoided) and calculates a ROI by comparing the cost of the project to actual losses avoided over time.

Loss avoidance assessments demonstrate the fiscal benefits associated with mitigation activities and support sound decision making related to public funding. Moreover, this assessment provides insight that the state and local communities can use to identify effective mitigation activities, improve mitigation strategies, and increase communities' resilience to natural hazards.

This assessment is limited to evaluating losses avoided in terms of direct physical damages and displacement costs. The impacts of fatalities and injuries can be included using FEMA's Value of a Statistical Life (VSL). However, the analysis does not typically include other, less-quantifiable impacts such as loss of critical services, roadway closures, and human impacts (mental stress or lost productivity).

The methodology noted below will initially be applied to assess effectiveness of FEMA-funded hazard mitigation projects in the State of Colorado, but the process can be used for state-sponsored mitigation projects as well. For example, if CDOT upsizes a culvert which later prevents a highway from being flooded or washed out, this process can be used to capture losses avoided and mitigation effectiveness.

Efforts to include additional actions outside of those identified in this Plan will be determined during the scheduled May SHMT implementation and maintenance meetings. As well, expanding this specific loss avoidance methodology to other agencies and non-FEMA funded projects implemented at the state and local levels not utilizing a BCA/BCR analysis will be captured by initial questions directed to specific project managers for evaluation of effectiveness. See Section 8 for additional information.

This analysis follows a 4-phase process:

#### Phase 1: Project Identification and Selection

When a significant hazard event occurs anywhere in the state, DHSEM staff will compare the location of the event to a database of completed or ongoing mitigation projects. At the county level this information is captured nationwide on FEMA's HMA Snapshot web-based map viewer from 1989 to present [<http://bit.ly/2oJ72M9>].

If there is a project or projects within the impacted area, the next step is to review what data is available for the project. Project data may come from the application scope of work, BCA, or other sources.

- Review data from hazard event.
- Compare area affected by the incident/disaster to database of mitigation projects. Are there any completed or ongoing mitigation projects in the impacted area?
  - [OR] Are there any mitigation projects in areas not impacted by the incident/disaster, which could be used to extrapolate losses that could have been reduced if the incident/disaster had happened in that area?

- Is the mitigation project of a type that could potentially reduce losses from the incident/disaster?
- Was a pre-event Benefit Cost Analysis (BCA) done for the project?
- Is there adequate data for the project to calculate effectiveness?
- What was the cost of the mitigation project?

Projects that have adequate data available are advanced to Phase 2.

### Phase 2: Hazard Event Analysis

DHSEM then reviews data on the hazard event. This information may come from a variety of sources, such as local observation, local damage assessments, NOAA-NWS reports, and field investigation. First, it must be confirmed that the hazard did in fact affect the project area. Second, was the hazard event severe enough to have caused damage if the project had not been in place. Technical resources may be needed to support analysis of the event; for example, determining the recurrence interval of a rain or flood event. Technical resources may include:

- Flood: Flood TAP, CWCB, USGS, consultants.
- Wildfire: CSFS, local fire protection districts, consultants.
- Geologic Hazards: CGS, USGS, consultants.

Wherever possible, effectiveness should be measured in terms of interconnected hazards rather than simply looking at one event. For example, fire mitigation efforts may also be effective at decreasing flood losses.

- Was the hazard event severe enough to have caused damage if the project had not been in place?
- Has there been an estimation on the recurrence interval of the event? (i.e., – 100-year storm, 500-year flood, et cetera).

If the hazard caused damage to the project, or would have in the absence of mitigation, the project is advanced to Phase 3.

### Phase 3: Loss Avoidance Analysis

If sufficient quantitative data exists, an evaluation of the project is completed to compare the damage actually sustained with the damage that would likely have been sustained without mitigation.

- Is there enough information to make a quantitative evaluation?
  - [OR] Is there enough information to make a qualitative analysis and discussion summarizing the benefits (What would have been damaged if the project had not been in place?) and effectiveness (Did the project perform as intended?) of the mitigation action?

- Calculate the damage that actually occurred with the mitigation action in place, referred to as Mitigation Project Complete (MPc).
- Calculate or estimate the damage that would likely have occurred if the mitigation action had not been taken, referred to as Mitigation Project Absent (MPa).
- $MPa - MPc = \text{Losses Avoided}$ .

Note: MPa is most often calculated based on past incidents that impacted this or similar areas.

Injuries and fatalities can be incorporated into damage estimates using the Value of a Statistical Life (VSL). As of October 2018, FEMA uses the following VSLs:

- Deaths: \$6.6M per individual.
- Injuries: \$2.2M per individual.

#### Phase 4: Project Effectiveness and Documentation

The Loss Avoided is then compared to the project cost to determine the project's Return on Investment (ROI), similar to how the Benefit Cost Ratio (BCR) is calculated in a pre-event BCA (Section 5.4.1).

$$\text{Return on Investment (ROI)} = \frac{MPa - MPc}{\text{Cost of Project}}$$

The results of this assessment should then be documented by the sub-applicant in a memorandum or other report and provided to the DHSEM Mitigation Team.

If there is not enough information to make a quantitative evaluation, a qualitative analysis and discussion can be accomplished that summarizes the benefits (General losses avoided.) and effectiveness (Did the project perform as intended?) of the mitigation action. The results of the loss avoidance analysis will be documented in a memorandum and shared with SHMT members. Wherever possible, effectiveness should be measured in terms of interconnected hazards rather than simply looking at one event. For example, fire mitigation efforts may also be effective at decreasing flood losses.

## **2. INTEGRATING EFFECTIVENESS ASSESSMENTS INTO THE MITIGATION STRATEGY**

As described in further detail in Section 7, once a year the SHMT will review the mitigation actions as well as the overall state mitigation strategy. Part of this meeting will include a review of all mitigation effectiveness assessments completed since the previous meeting, to include losses avoided due to mitigation activities and calculated/projected savings from mitigation activities. The SHMT will use this information to evaluate the effectiveness and efficiency of the mitigation program, and either validate the strategy as is, or determine if any revisions should be made to the goals, objectives, and/or specific mitigation actions.

### 3. EXAMPLES OF ASSESSMENTS CONDUCTED

Following the 2013 Colorado Floods, the state participated in a FEMA case study: *Reducing Losses through Higher Regulatory Standards 2013 Colorado Floods Case Study FEMA-DR-4145-CO*. This study used loss avoidance methodology to determine how much damage would have been reduced if certain regulatory and policy actions had been in place, using both a 100-year (1% Annual) flood event, and the 2013 flood event as models. The results of the study are summarized in **Error! Reference source not found.** .

TABLE 5-7 SUMMARY OF THE REGULATORY LOSSES AVOIDED ANALYSIS

100-Year Flood	Best Practice/Scenario	2013 Colorado Floods
<b>Regulating floodplain development when the community entered the NFIP (referred to as “earlier”) would have resulted in 32% estimated losses avoided in Boulder County and more than 52% estimated losses avoided in Larimer and Weld Counties.</b>	Floodplain development regulations adopted earlier	Regulating floodplain development earlier would have resulted in 36% estimated losses avoided in Boulder County and more than 53% estimated losses avoided in Larimer and Weld Counties.
<b>Regulating floodway development earlier would have resulted in estimated losses avoided of \$32 million for Boulder County, \$64 million for Larimer County, and \$13 million for Weld County.</b>	Floodway development regulations adopted earlier	N/A
<b>Adopting freeboard earlier would have resulted in a 38% decrease in estimated losses for Boulder County and an over 18% decrease in losses for Larimer and Weld Counties.</b>	Freeboard adopted earlier	Adopting freeboard earlier would have resulted in a 10% decrease in estimated losses for Boulder County and an over 4% decrease in losses for Larimer and Weld Counties.
<b>If freeboard had never been adopted, there would be a 331% increase in estimated losses for Boulder County, 68% increase in losses for Larimer County, and 148% increase in losses for Weld County.</b>	Freeboard never adopted	If freeboard had never been adopted, there would be a 32% increase in estimated losses for Boulder County, 5% increase in losses for Larimer County, and 11% increase in losses for Weld County.
<b>If freeboard was increased by two feet, there would be a decrease in estimated losses in Boulder, Larimer, and Weld Counties of more than 70%.</b>	Freeboard regulated to a higher or lesser standard	If freeboard was increased by two feet, there would be a decrease in estimated losses in Boulder, Larimer, and Weld Counties of more than 74%.
<b>If critical facilities had been regulated earlier, there would have been a decrease in estimated losses in</b>	Critical facilities regulated	N/A

100-Year Flood	Best Practice/Scenario	2013 Colorado Floods
<b>Boulder, Larimer, and Weld Counties of more than 64%</b>		
<b>N/A</b>	Erosion setback (St. Vrain Creek)	If development of new structures were regulated in the new St. Vrain Creek erosion zone, Individual Assistance (IA) losses estimated at \$1.4 million would have been avoided.
<b>N/A</b>	Benchmark years	The overall ratio of damage costs to replacement costs declines over time, demonstrating a reduction in severity of losses with improvements in regulatory standards. The cost of damage per building generally increases over time as a result of overall higher replacement cost exposures.
<b>N/A</b>	NFIP claims and CRS outreach	High CRS outreach communities benefit from more extensive NFIP coverage both inside and outside the SFHA more than low-outreach communities.
<b>N/A</b>	Basements	Basement-only losses for the 2013 event were mostly outside the SFHA and accounted for 22% of all the IA losses, demonstrating the need to address or develop mitigation strategies for basements in all flood-prone areas.

Source: Reducing Losses Through Higher Regulatory Standards, 2013 Colorado Floods Case Study

Additionally, CDOT recently completed a white paper study on the economic impacts of geohazards on highway corridors as described below:

In 2015, CDOT published a white paper entitled *“The Economic Impacts of Geologic Hazard Events on Colorado Transportation Facilities”* (CDOT 2015). The document presents a detailed quantitative assessment of how rockfalls, rockslides, landslides, debris flows, and sinkholes affect the state’s transportation infrastructure. The statewide impacts from geologic hazards along CDOT highways can be grouped into two categories: (1) direct costs incurred by CDOT for maintenance labor and equipment, engineering, and construction activities, and (2) indirect costs including but not limited to property damage, injury or fatalities, traveler delay, lost productivity, loss of revenue to businesses and communities, and environmental impacts. Based on a review of CDOT program activities, the estimated annual direct costs to the department from geologic hazard events is in the range of \$17 million to \$20 million, which includes the Maintenance Program. From 2010 to 2015, CDOT maintenance staff input an average of 8,500 work orders for geologic hazard related response activities with an average cost of about \$600 per work order. This resulted in over \$4.5 to

\$5.5 million of annual expenses for high frequency but low-cost events. Based on an historical data review, the study estimates 50 geologic hazard events per year that require support above the CDOT maintenance level for non-routine work. Of these, approximately 20 percent have an indirect cost related to traffic impacts, property damage, and potentially injury.

The report goes on to summarize the economic impacts of three different events that occurred in 2014, ranging from short- to long-term closures with varying economic impacts. In 2014, the economic impact (including direct and user costs) from geologic hazards on CDOT roadways was estimated to be \$30 million. This study provides baseline information for measuring the effectiveness of mitigation actions along transportation corridors. See the landslide, mud/debris flow, and rockfall hazard analysis in this Plan for additional information on this study.

Other examples of actual or projected losses avoided due to mitigation actions taken are:

- The City of Longmont used \$5.7 million in pre-disaster mitigation funding to improve the flow capacity of Left Hand Creek through town. That project prevented \$22.5 million in damage during the 2013 flood. FEMA Administrator Long used this project as an example of the value of mitigation spending during testimony before the US Congress in 2018.
- Hayman Fire Fuel Treatment - Satellite images identify where the 2002 fire stopped right at an area that had undergone fuels treatment. A study on the effectiveness of different strategies from the Hayman Fire was conducted by the U.S. Forest Service in 2003.
- In 2017, CDOT completed the Interstate 70 Risk and Resilience Pilot, a first-of-its kind approach to address vulnerabilities in Colorado's highway infrastructure by quantifying the risk and developing mitigation measures. Analyzation of 450 miles of Interstate 70 from the Utah border in the west to the Kansas border in the east were examined for the potential of future damage and closures from physical threats. The pilot considers multiple significant threats - ranging from avalanche to wildfire, as well as human-made threats, such as high vehicle bridge strikes, and provides a quantitative, data-driven approach to quantifying risk and calculating benefit cost of alternative mitigation measures.

## 4. FUTURE CASE STUDIES

Moving forward, the state intends to initially focus this process on three types of mitigation projects:

1. Wildfire Fuels Treatments;
2. Flood/stormwater infrastructure or stream restoration; and
3. Flood Property Acquisition.

The following projects may warrant further assessment using the Post Event methodology described previously. These are projects funded by FEMA's HMA program and could demonstrate that mitigation works effectively and is worth continued investment in Colorado.

- City of Woodland Park Cottonwood Creek Stream Restoration/Erosion Control and Flood Mitigation Project

- This PDM funded project was tested shortly after it was built by a flood event in 2013.
- Waldo Canyon Fuels Treatment Project
  - A PDM funded effort reduced the severity of the Waldo Canyon Fire in 2012.
- Colorado Springs Cottonwood Creek Stream Stabilization Project
  - This project was funded by PDM in 2006, constructed in 2008, and protects a critical communications facility (911 relay facility) and sanitary sewer pipe from severe erosion threatening to undermine the bluff below the facility. Storms as small as the three-year recurrence interval were predicted to cause significant erosion and impacts to the facilities.
- City of Longmont Infrastructure and Stream Restorations along the St. Vrain River
- City of Durango Crestview Ditch Project
  - This drainage improvement project was tested by a heavy hail and rain event on September 29, 2017. The project is suspected to have saved an apartment building from flood damage based on information provided by the City.
- Summit County Buffalo Mountain Defensible Space
  - This project was funded by PDM funds in 2008-09 and helped reduce damages from a wildfire in June 2018.

The state currently utilizes EMGrants Pro as a centralized grants management system. Continuing the use of EMGrants Pro to track future mitigation projects will aid in analyzing mitigation effectiveness in a methodical and consistent manner. The state recognizes that EMGrants Pro only monitors FEMA-funded mitigation projects, however, it can be used as a foundation to examine methods for tracking effectiveness of non-FEMA-funded projects as well. As described previously, the state will utilize the Mitigation Actions Database to chart state hazard mitigation projects. This database can be utilized in the event of a disaster to pinpoint mitigation actions completed in the affected areas and aid in assessing mitigation effectiveness of those projects utilizing methods outlined above. Additionally, success stories will be conveyed to SHMT members during scheduled bi-annual standard implementation and maintenance meetings conducted every May (see Section 7), as well as at future potential enhanced plan compliance meetings, documented in this Plan in forthcoming updates, and modified as necessary in the Mitigation Actions Database.

## SECTION 6. LOCAL PLANNING

# SECTION 6. LOCAL PLANNING

## CONTENTS

Section 6. Local Planning .....	6-2
Introduction.....	6-3
Local Hazard Mitigation Plan Status .....	6-3
Technical Assistance and Funding .....	6-5
1. Technical Assistance.....	6-6
2. Funding .....	6-9
Local Plan Integration .....	6-9
1. Local Project Integration.....	6-10
2. Prioritizing Local Assistance .....	6-10

## LIST OF FIGURES

Figure 6-1 Local Hazard Mitigation Plan Status, June 2018 .....	6-5
Figure 6-2 Mitigation Section .....	6-6

## LIST OF TABLES

Table 6-1 Approved or Approvable Pending Adoption (APA) Local Hazard Mitigation Plans (HMP) as of June 2018.....	6-3
Table 6-2 State Agency Local Hazard Mitigation Plan Support .....	6-7

## INTRODUCTION

Since 2013, the Mitigation Team, along with our local partners, worked to achieve a number of major accomplishments within the state mitigation program. These accomplishments range from innovative local planning activities to integration with the Community Rating System. A number of these accomplishments are listed below.

- The Mitigation Team, in cooperation with FEMA, encouraged the integration of local comprehensive land use plans and local hazard mitigation plans. Two counties and one city have finished this integration. Thirteen counties have information related to hazard mitigation within their comprehensive or master plans according to a 2015 DOLA survey.
- In the fall of 2016, DHSEM hired a Mitigation Planning Specialist to augment the Mitigation Planning Team. This position works with and reports to the State & Local Mitigation Planning Program Manager and is a key Mitigation Team point of contact for local jurisdictions seeking technical assistance on mitigation planning and grants management.
- Between December of 2013 and April of 2018, the number of counties with mitigation plans increased by over 35 percent. The number of municipalities with mitigation plans increased by 50 percent.

## LOCAL HAZARD MITIGATION PLAN STATUS

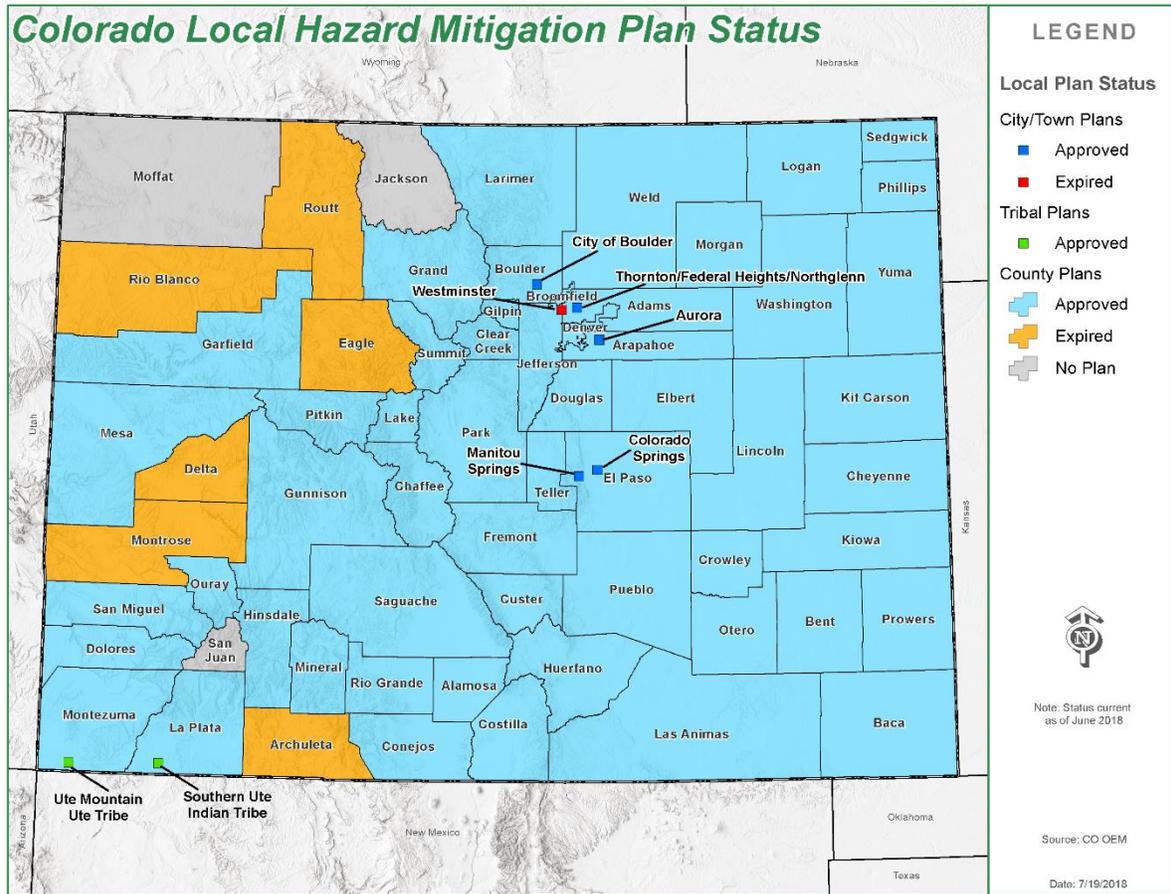
As of May 2018, 55 counties, five municipalities, and two Tribes have local hazard mitigation plans (HMPs) that are either FEMA approved or approvable pending adoption. The following Table 6-1 and Figure 6-1 summarizes this information. These 62 jurisdictions covered by FEMA approved or approvable plans encompass nearly 98% of the State’s total population.

**TABLE 6-1 APPROVED OR APPROVABLE PENDING ADOPTION (APA) LOCAL HAZARD MITIGATION PLANS (HMP) AS OF JUNE 2018**

Jurisdiction	Status	Jurisdiction	Status
<b>Adams County (Unincorporated)</b>	Approved	<b>La Plata County</b>	Approved
<b>Alamosa County</b>	Approved	<b>Lake County</b>	Approved
<b>Arapahoe County</b>	Approved	<b>Larimer County</b>	Approved
<b>Archuleta County</b>	Expired	<b>Las Animas County</b>	Approved
<b>Aurora, City of</b>	Approved	<b>Lincoln County</b>	Approved
<b>Baca County</b>	Approved	<b>Logan County</b>	Approved
<b>Bent County</b>	Approved	<b>Manitou Springs, City of</b>	Approved
<b>Boulder County</b>	Approved	<b>Mesa County</b>	Approved
<b>Boulder, City of</b>	Approved	<b>Mineral County</b>	Approved
<b>Broomfield, City &amp; County of</b>	Approved	<b>Moffat County</b>	N/A
<b>Chaffee County</b>	Approved	<b>Montezuma County</b>	Approved

<b>Jurisdiction</b>	<b>Status</b>	<b>Jurisdiction</b>	<b>Status</b>
<b>Cheyenne County</b>	Approved	<b>Montrose County</b>	Expired
<b>Clear Creek County</b>	Approved	<b>Morgan County</b>	Approved
<b>Colorado Springs, City of</b>	Approved	<b>Otero County</b>	Approved
<b>Conejos County</b>	Approved	<b>Ouray County</b>	Approved
<b>Costilla County</b>	Approved	<b>Park County</b>	Approved
<b>Crowley County</b>	Approved	<b>Phillips County</b>	Approved
<b>Custer County</b>	Approved	<b>Pitkin County</b>	Approved
<b>Delta County</b>	Expired	<b>Prowers County</b>	Approved
<b>Denver, City &amp; County of</b>	Approved	<b>Pueblo County</b>	Approved
<b>Dolores County</b>	Approved	<b>Rio Blanco County</b>	Expired
<b>Douglas County</b>	Approved	<b>Rio Grande County</b>	Approved
<b>Eagle County</b>	Expired	<b>Routt County</b>	Expired
<b>El Paso County</b>	Approved	<b>Saguache County</b>	Approved
<b>Elbert County</b>	Approved	<b>San Juan County</b>	N/A
<b>Fremont County</b>	Approved	<b>San Miguel County</b>	Approved
<b>Garfield County</b>	Approved	<b>Sedgwick County</b>	Approved
<b>Gilpin County</b>	Approved	<b>Southern Ute Indian Tribe</b>	Approved
<b>Grand County</b>	Approved	<b>Summit County</b>	Approved
<b>Gunnison County</b>	Approved	<b>Teller County</b>	Approved
<b>Hinsdale County</b>	Approved	<b>Thornton/Federal Heights/Northglenn, Cities of</b>	Approved
<b>Huerfano County</b>	Approved	<b>Ute Mountain Ute Tribe</b>	Approved
<b>Jackson County</b>	N/A	<b>Washington County</b>	Approved
<b>Jefferson County</b>	Approved	<b>Weld County</b>	Approved
<b>Kiowa County</b>	Approved	<b>Westminster, City of</b>	Expired
<b>Kit Carson County</b>	Approved	<b>Yuma County</b>	Approved

FIGURE 6-1 LOCAL HAZARD MITIGATION PLAN STATUS, JUNE 2018



The continuing progress in local hazard mitigation planning can be attributed to several factors, including an increased staff in the Mitigation Section, the correlating growth of technical assistance and coordination, and, most importantly, strong planning efforts at the local level.

## TECHNICAL ASSISTANCE AND FUNDING

The Colorado Division of Homeland Security and Emergency Management (DHSEM) Mitigation Section is the primary state entity responsible for coordinating and facilitating technical assistance for local hazard mitigation planning. The mission of the Mitigation Section is to promote community resiliency and sustainability for residents of Colorado by fostering partnerships and maximizing the availability of mitigation resources.

The Mitigation Section is comprised of six employees with varying levels of responsibility and program area focus (see Figure 6-2). Since the last plan update, the Mitigation Section has increased and enhanced the technical assistance it provides to local partners.

FIGURE 6-2 MITIGATION SECTION



## 1. TECHNICAL ASSISTANCE

The Mitigation Planning Team provides enhanced planning and project-related technical assistance. Mitigation Team staff is available to attend local planning committee meetings and frequently meet with local emergency managers to provide technical assistance upon request throughout the entire local mitigation planning process. Mitigation Team personnel also support local staff at public hearings related to local plan adoption.

The DHSEM Mitigation Project Team assists local communities with identifying and implementing mitigation solutions to address natural hazards which impact their stakeholders. Much of the team's focus is geared towards FEMA Hazard Mitigation Assistance (HMA) grant funding, however, due to the team's knowledge and experience assisting communities with mitigation projects, the team is often asked to consult on mitigation projects outside of FEMA's HMA grants. For projects funded with FEMA HMA funding, the DHSEM Mitigation Project Team assists communities with the grant process from inception; scope of work and application development, through full project closeout. The Mitigation Team works closely with both federal and local partners to ensure mitigation plans and projects meet the communities' needs and are successfully completed.

The Mitigation Planning Team has developed training materials and provides local planning workshops and presentations for communities interested in or engaged in the local mitigation planning process. For example, the Mitigation Planning Team instructs a one-day course, G-318

- *Mitigation Planning Workshop for Local Government*, during the annual DHSEM Emergency Management Academy, attended by local emergency managers, other state & county government departments, city staff, law enforcement, regional council members, FEMA, and other staff.

In addition to classroom trainings, the Mitigation Team partners with subject matter experts (SMEs) to present information on pertinent mitigation and recovery topics at the annual Colorado Emergency Management Conference.

Other state agencies have provided valuable technical assistance during local hazard mitigation planning processes. The following Table 6-2 provides an overview of these activities:

**TABLE 6-2 STATE AGENCY LOCAL HAZARD MITIGATION PLAN SUPPORT**

Agency	Technical Assistance Provided
<b>CAIC</b>	Data and avalanche statistics have been used to inform the avalanche hazard profile and risk assessment in plan updates.
<b>CGS</b>	Improvements in geologic hazard mapping and available data posted online; this data is being utilized in local risk assessment improvements.
<b>CSFS</b>	The CO-WRAP data has been used to support wildfire risk assessment data in local hazard mitigation plans.
<b>CWCB</b>	Improvements in floodplain mapping through RiskMAP and CHAMP programs that can be used to improve flood risk assessments in plan updates. Updates and improvements to the Drought Mitigation and Response Plan can be referenced to enhance drought and climate change vulnerability discussions in local mitigation plans.
<b>DWR</b>	Recent work done to analyze risk from dam outlet structure flooding has been integrated in local mitigation plan updates including the City of Boulder and Archuleta County plans.

The Mitigation Planning Team has developed materials to assist local communities throughout the planning process. These materials include “best practices” for implementing a planning process that conforms to the FEMA Review Tool, tables, information and research resources related to conducting comprehensive risk assessments, and sample mitigation action strategies.

The state floodplain administrators, state foresters, state geologists, state hydrologists, cooperative extension representatives, state mitigation planners, and state Regional Field Managers (RFMs) work with communities developing safety, preparedness, and mitigation plans. State agencies financially and technically support mapping and assessment efforts designed to improve local planning efforts as well as provide training for local mitigation planners. Employees from higher education institutions have also developed tools to help communities complete more accurate assessments. The state continues to work towards having a complete multi-hazard mitigation plan training program that will be available to all communities

In addition to providing tools, the Mitigation Planning Team provides on-site support both proactively and upon request to support local mitigation efforts. The Mitigation Planning Team attends planning meetings on a regular basis. Early on in federal or state supported mitigation plan processes, Mitigation Planning Specialists provide grant management assistance to local project managers and finance staff. Just within the last year, this team has assisted the planning process in more than 20 counties, tribes, and municipalities. Outreach to more than 20 additional counties and tribes that require an updated mitigation plan is ongoing. The Mitigation Planning Team reminds jurisdictions of needed HMP updates 18-24 months in advance of their expiration date and correspondence provides information on possible grant funds for supporting the planning process. The Mitigation Planning Team also works cooperatively with jurisdictions to obtain adoptions within six months of FEMA APA.

The Mitigation Project Team has instituted many programmatic improvements since the last State Plan update in 2013. Many of these improvements are direct outcomes of the 2013 flooding event which stretched the Team's existing capabilities and required increased use of technological and other efficiencies to be identified to meet the demands of managing the large sum of funding made available through HMGP. Improvements include but are not limited to the following:

- Use of EMGrants for application development, quarterly reporting, submission, and review of requests for reimbursement and closeout processing.
- Improved technical assistance documents for application development as well as an application checklist to ensure completeness of applications.
- Greater knowledge and experience implementing and overseeing a multitude of mitigation projects to include property acquisition and elevation, wildfire, generators, five percent projects, etc.
- A separation of duties for Requests for Reimbursements (RFRs), which allows for greater efficiencies to be realized. Briefly, the Mitigation Team reviews RFRs for programmatic eligibility, to include the following:
  - Ensuring work was completed within the approved scope of work and in accordance with Environmental and Historic Preservation (EHP) requirements.
  - Work was performed within the approved Period of Performance (POP).
  - A cursory review of documentation to ensure invoices, proof of payment, and other relevant documentation has been included in the RFR.
- Upon completion of this review, the RFR is then submitted to personnel from the Office of Grants Management to perform a thorough review of procurement. This review includes, but is not limited to, the following:

- Ensuring procurement was done in conformance to local and federal procurement requirements (44 CFR § 13.36 and 2 CFR § 200 as applicable).
- Open and competitive procurement was demonstrated to the greatest extent practicable.
- All documentation required to demonstrate compliance with applicable procurement requirements has been submitted.

Additionally, the Team is responsible for reviewing quarterly reports to ensure ongoing progress and compliance with grant requirements, performing site visits as appropriate, assisting with project closeout, and maintaining ongoing and proactive engagement with our project partners throughout the project.

## 2. FUNDING

For specific information related to funding provided through FEMA's PDM and FMA programs, refer to the Capabilities Section. The Mitigation Team also provides grants management technical assistance in order to help communities maintain accurate records and maximize local match funding sources.

### LOCAL PLAN INTEGRATION

The Mitigation Planning Team, along with agency partners, provides technical assistance throughout the local mitigation planning process. In some cases, Mitigation Planning Team staff will review individual sections of plans or provide feedback on specific passages dependent upon community needs and requests. Once a plan is in final draft form, the Mitigation Planning Team will review a plan for its compliance with the FEMA Local Mitigation Plan Review Tool. The State review process will generally take 30 days or less. If the plan has met FEMA's planning requirements, it will be forwarded to FEMA for review. If the Mitigation Planning Team finds that a community needs to improve certain aspects of their plan, it will provide detailed comments and suggested revisions. Once a community has addressed the suggested revisions, the Mitigation Planning Team will forward the plan to FEMA for official review. In cases where FEMA requires revisions for final approval, the state will work closely with a community to identify potential solutions and make revisions.

All local hazard mitigation plans currently approved by FEMA are available on the DHSEM website. Making these local plans available benefits local communities who are engaged in the planning process, as a number of ideas and methodologies are available to review and incorporate. Information from the State Plan such as demographic data, localized hazard information, and incident occurrence is available for use.

The Mitigation Team reviews, catalogues, and incorporates information from local plans into the State Plan during the planning process.

## 1. LOCAL PROJECT INTEGRATION

The Mitigation Project Team works with many partners to identify and fund mitigation projects. A brief synopsis of this integration is described below.

Throughout the year the Mitigation Project Team communicates with partners from the Colorado Water Conservation Board (CWCB), Colorado Department of Transportation (CDOT), Colorado Department of Local Affairs (DOLA), Colorado State Forest Service (CSFS), Colorado Department of Natural Resources (DNR), Colorado Division of Dam Safety, Colorado Geologic Survey (CGS), Urban Drainage and Flood Control District (UDFCD), Colorado Municipal League (CML), Colorado Counties, Inc. (CCI), and Special Districts Association of Colorado, in addition to many others to inform them of HMA funding opportunities and to further amplify DHSEM Mitigation Team messaging to ensure the broadest dispersal and awareness of these grants.

As the Mitigation Team is notified of mitigation needs at the local level, an initial outreach conference call or in person meeting/site visit is scheduled. This allows the Mitigation Team to determine needs and potential solutions. If the project is potentially eligible for FEMA HMA funding that is discussed, if it is not, other opportunities are discussed. The DHSEM Mitigation Project Team is building knowledge of other mitigation and resilience programs to ensure it is capable of providing mitigation technical assistance across the spectrum of state and federal programs so it is able to best meet a local communities' need. This requires ongoing engagement with other program representatives and subject matter experts from a myriad of local, state and federal agencies and non-profits.

Additionally, the Mitigation Project Team works with appropriate partners when reviewing and prioritizing HMA projects for funding. This allows for evaluation of projects with subject matter experts whom are able to identify best practices, share experiences working with subapplicants, and provide suggestions for improvements to a proposed project. This also has the added benefit of increasing our partners awareness of mitigation efforts across the state.

See Section 8.3 Funding Prioritization for additional details.

## 2. PRIORITIZING LOCAL ASSISTANCE

Many state agencies provide technical assistance and funding for local mitigation plans and projects as resources become available. Each agency has different criteria, dependent on agency rules, and if applicable, the rules of the federal grant-making agency. In recognition that all local governments are customers of the state, agencies make every attempt to make technical assistance available to all communities who seek it. Some grants provided by state agencies are delivered based on need. Others are based on demonstrated risks or development pressures.

Many additional grants are reliant on a competitive application process. In all cases, any hazard related grant funding provided to a local community must be able to effectively and demonstrably show that the funding will help prepare a community for or mitigate against a potential risk.

The Mitigation Team continues to assist communities in applying for multi-hazard mitigation planning and project, and flood hazard mitigation planning and project, grants. When a community is unable to obtain a FEMA PDM or FMA grant to write plans, mitigation staff will evaluate additional funding opportunities. The Mitigation Team also coordinates with partner agencies such as the CWCB and CSFS to secure supplemental funding or technical assistance to the local community. The Mitigation Team has also frequently supported local planning efforts to achieve StormReady® and Firewise™ designation.

When FEMA releases Hazard Mitigation Assistance (HMA) program guidance, the Mitigation Team advertises for the availability of funds and requests that qualified communities submit a Notice of Interest (NOI) for any projects they would like to apply for. In general, these projects must meet the following criteria:

- Communities must have a FEMA approved local hazard mitigation plan.
- Projects must meet all Hazard Mitigation Assistance program requirements.
- Projects must demonstrably mitigate a well-defined problem.
- Projects must have a comprehensive Scope of Work (SoW).
- Projects must meet FEMA Benefit-Cost Analysis (BCA) criteria.

The Mitigation Team provides technical assistance and encourages Scope of Work and associated application development year-round via Colorado's EMGrants Pro system so communities are well positioned and prepared in advance to submit an NOI and complete application within short timeframes. The Mitigation Team staff review state agencies' documents and websites to identify programs and policies that promote or could potentially further mitigation initiatives around the state. The most current list is presented in detail in Section 4 – Capabilities.

## SECTION 7. PLAN MAINTENANCE

# SECTION 7. IMPLEMENTATION, MAINTENANCE, & REVIEW

## CONTENTS

Section 7. Implementation, Maintenance, & Review .....	7-2
Introduction.....	7-3
Evaluation of Previous Plan Maintenance Process.....	7-3
Monitoring & Updating the Plan .....	7-4
1. Implementation Tracking.....	7-4
2. Plan Updates.....	7-5
3. Schedule of Activities.....	7-5
Enhanced Mitigation Planning .....	7-6
1. Coordination & Integration.....	7-6
2. Mitigation Effectiveness.....	7-7
3. Funding Prioritization.....	7-8
4. HMA Grants Compliance.....	7-8
5. Mitigation In Post-Disaster Recovery .....	7-8

## LIST OF TABLES

Table 7-1 Plan Maintenance Schedule.....	7-5
--	-----

## INTRODUCTION

Given the dynamic nature of hazard risks and events, an effective mitigation program requires a coordinated, collaborative, and adaptive approach. This approach includes monitoring for changes in risk conditions, as changes in development and demographics might place people, property, and infrastructure at greater risk, and state capability changes might either enhance or detract from an effective mitigation program. Likewise, this approach requires that mitigation plans and strategies be monitored and updated as conditions change.

CFR § 201.2 states that the State Hazard Mitigation Officer (SHMO) is the official representative of state government who is the primary point of contact with FEMA, other Federal agencies, and local governments in mitigation planning and implementation of mitigation programs and activities required under the Stafford Act. The Colorado SHMO within DHSEM, along with the State Hazard Mitigation Team (SHMT), is responsible for the implementation, maintenance, and review of the Colorado State Hazard Mitigation Plan, with support from the DHSEM State & Local Hazard Mitigation Planning Program Manager.

In this spirit of statewide cooperative integration and adhering to the 2018 Mitigation Strategy and coordinated efforts as outlined in Sections 5 & 8, any potential future discussions related to proposed reformation or realignment of the current SHMT, or a return to the original core natural hazard SME-based organization, will be conducted during the Implementation & Maintenance Schedule (Table 7-1) with all team members to ensure inclusion, integration, coordination, collaboration, participation, recommendations, and overall agreement from the established SHMT members for a successful outcome.

## EVALUATION OF PREVIOUS PLAN MAINTENANCE PROCESS

The 2018 Plan Maintenance Section is very different from the 2013 Plan. Although the 2013 Plan created a prescriptive schedule of update and maintenance actions, the SHMT did not complete them as designed, primarily due to the long-term recovery and post-disaster mitigation actions following the devastating floods, fires, and other disasters that occurred in Colorado between 2013 and 2015. Additionally, state government changes to mitigation-related roles and responsibilities that began in 2012 and accelerated in 2013 detracted from full implementation of the 2013 Plan's maintenance process.

There were planned and unplanned successes to the 2013 process. DHSEM and Phase I consultant (Acclivity) conducted two meetings on January 12, 2016 with both the CRO and FEMA. The purpose of the meeting with the CRO was to brief staff on the Plan update project, and discuss integration opportunities with the Colorado Resiliency Framework and other CRO activities; the meeting with FEMA targeted HMA Grants Management Performance evaluation expectations, how each enhanced plan requirement will be reviewed, and any specific areas of

improvement to focus on related to the update. The SHMT convened on August 24, 2016 to review and update the 2013 mitigation strategy, be briefed on the *Colorado Enhanced Mitigation Plan: Phase I Road Map* report project findings, and commit to a process for this update and its enhanced plan elements. The SHMT met again on February 15, 2017 for a status update on Phase II of the project and discussion included: receipt of Phase II funds on February 7, 2017, report on the consultant Scope of Work (SoW) and request for proposal (RFP) process, a brief review of the element components required for the Plan update, identification of and strategy for integration of current state coordinating structures (e.g., SHMT, TAPs, CRO, USACE Silver Jackets) to demonstrate Colorado's comprehensive statewide mitigation program, selection of future SHMT meeting dates for 2017, and introduction of DHSEM's new Mitigation Team nine-month temporary employee hired in January 2017 and dedicated to the State Plan update.

CWCB, CDOT, and DHSEM also improved their routine coordination through the Flood Technical Assistance Partnership. DHSEM's Mitigation Team has continued to work more closely with Dam Safety, the Colorado Geological Survey, CWCB, State Forest Service, and the Colorado Climate Center on hazard mitigation. DOLA's Division of Local Government and the Mitigation Team was invited by FEMA planning staff into a joint effort with FEMA Region VIII to create a pilot program that helps local communities address hazards through land use solutions. The Governor established the Colorado Resiliency & Recovery Office (CRRO) following the 2013 floods. The CRRO became part of the Division of Local Government in 2017 (and renamed the Colorado Resiliency Office [CRO] in 2018) and brought a fresh perspective to the process for this update. Finally, DHSEM enhanced its support and assistance for local mitigation planning, increasing the SHMT's ability to incorporate local assessments and strategies in to the maintenance process.

These changes to the state government's integrated mitigation efforts have laid a strong foundation for implementation and maintenance of this Plan update.

## **MONITORING & UPDATING THE PLAN**

The Colorado State Hazard Mitigation Plan is considered to be a living document. The SHMT has agreed to follow a comprehensive plan maintenance approach moving forward that supports this living document assertion. All portions of this Plan will be reviewed and revised as appropriate on a regular basis, and when conditions under which the plan was developed change, such as new or revised capabilities, a major disaster, availability of funding, and refinements to the SHMT coordination process.

### **1. IMPLEMENTATION TRACKING**

The monitoring of mitigation action implementation is vital to keeping the Plan relevant and useful. Although only a few mitigation actions undertaken by state agencies may be funded through FEMA programs administered by DHSEM, it is important to monitor the progress of all projects to ensure they are being implemented as planned. A Mitigation Action Database was

produced as part of this Plan update to allow for improved action tracking. Annually, the SHMT has committed to report on mitigation action progress along with any issues that may be preventing successful implementation. This will occur at the May meeting and result in progress updates recorded in the Mitigation Action Database. This provides the SHMT an opportunity to collectively work to find solutions in overcoming implementation obstacles. In addition, newly identified or implemented mitigation actions will also be added to the Mitigation Action Database. Regular tracking of mitigation action implementation will allow the SHMT to remain cognizant of progress made by the state’s mitigation program.

Separately, completed mitigation actions may also be evaluated for effectiveness. See Section 5.6 - Assessing Mitigation Effectiveness for additional details.

## 2. PLAN UPDATES

In addition to edits and updates to the state’s Mitigation Action Database, the SHMT will likewise evaluate the State Plan itself for necessary changes. This regular update process will be split between two annual SHMT meetings detailed in the following section. One meeting will focus on potential updates to the mitigation strategy portion of this Plan, the other will look towards the HIRA and any other relevant Plan sections. These scheduled updates will also allow for the timely incorporation of Emergency Management Accreditation Program (EMAP) requirements, as necessary.

## 3. SCHEDULE OF ACTIVITIES

The SHMT has agreed upon the following bi-annual meeting schedule (see Table 7-1), to ensure that the state’s mitigation program continues to succeed and remains comprehensive across all agencies. Assuming FEMA approval of the 2018 SHMP in December, the SHMT plans to convene each May and November. The spring meeting will be an opportunity for SHMT members to review and assess mitigation actions and the state’s overall mitigation strategy, while the fall meeting will focus on the HIRA and Enhanced Plan compliance.

TABLE 7-1 PLAN MAINTENANCE SCHEDULE

Year	May	November
2019	Mitigation Action Review and Assessment	HIRA Review and Update Enhanced Compliance Evaluation
2020	Mitigation Strategy Review Mitigation Action Review and Assessment	HIRA Review and Update Enhanced Compliance Evaluation
2021	Mitigation Strategy Review Mitigation Action Review and Assessment	HIRA Review and Update Enhanced Compliance Evaluation

Year	May	November
2022	Mitigation Strategy Review Mitigation Action Review and Assessment	HIRA Review and Update Enhanced Compliance Evaluation
2023	<i>2023 Plan Update Process</i>	

## ENHANCED MITIGATION PLANNING

As Colorado works towards achieving enhanced plan status, clearly developing and defining a method to ensure continued enhanced compliance is vital. As outlined in the maintenance schedule, evaluating compliance on an annual basis will help the state’s mitigation program to retain this important designation.

There are many related topics to plan implementation, maintenance, and review that contribute to a robust and comprehensive state mitigation program. The following headers provide a brief overview of those subjects. Additional information on this subject can be found in the Enhanced Plan portion of this document, located in Section 8. Additionally, related checklists and worksheets can be found in Appendix D of this document.

### 1. COORDINATION & INTEGRATION

Clearly defining the state’s coordination and integration of its collective hazard mitigation program is vital for successful implementation. This includes looking at other state and regional planning initiatives across all sectors in addition to FEMA programs that advance mitigation, which include FEMA’s mitigation division’s grant programs. Recent and current coordination and integration activities in support of Colorado’s hazard mitigation program are discussed in more detail in Section 8.1.

Going forward, a critical part of monitoring the SHMP for continued compliance will be to verify that the state continues to coordinate with all mitigation program stakeholders, and that local, state, regional, and federal mitigation efforts stay integrated with the SHMP. The following structures will be critical:

- As detailed in Section 4, the Colorado Resiliency Office (CRO) coordinates post-disaster recovery and resiliency efforts across all state agencies.
- The creation of SHMT working groups focused on specific hazards or projects, as described in mitigation action 2018.27, would help ensure meaningful coordination takes place. Evolution of these potential working groups will involve full SHMT buy-in and a coordinated development process agreed upon by the SHMT to identify selected groups and associated tasks.

- The Mitigation Strategy Review and Mitigation Action Review held annually in the Spring will assess the mitigation strategy, goals, objectives, and actions to verify they address all stakeholders and are inclusive of other mitigation programs and activities. See Appendix 9 Enhanced Compliance Tools for a sample meeting agenda.
- The HIRA Review & Update and Enhanced Compliance Evaluation held annually in the Fall will ensure the HIRA reflects the best information available from all stakeholders. The meeting will also specifically review changes to agency responsibilities, capabilities, and coordination specific to mitigation. See Appendix 9 Enhanced Compliance Tools for a sample meeting agenda.
- The SHMT Meeting held annually concurrent with one of the CRO quarterly meetings will review the status of integration with local, state, regional, and federal/national planning initiatives in detail. See Appendix 9 Enhanced Compliance Tools for a sample meeting agenda.
- Other tools in Appendix D that will be useful to tracking continued coordination and integration include:
  - Record of Mitigation Coordination
  - Local Mitigation Capabilities Tracker
  - Mitigation Action Tracker
  - Post-Event Assessment of Mitigation Effectiveness Checklist
  - Annual Mitigation Progress Report Template

## 2. MITIGATION EFFECTIVENESS

A key part of the Plan maintenance process is evaluating the effectiveness of the state's mitigation actions to gauge how well the current strategy is working and whether any modifications need to be made. During the SHMT's annual Mitigation Strategy Review and Mitigation Action Review and Assessment meeting (see Table 7-1), a key agenda item will be a review of all mitigation effectiveness assessments completed since the previous meeting, to include losses avoided due to mitigation activities and calculated/projected savings from mitigation activities. The SHMT will use this information to evaluate the effectiveness and efficiency of the mitigation program, and either validate the strategy as is, or determine if any revisions should be made to the goals, objectives, and/or specific mitigation actions.

The process used to assess the effectiveness of mitigation actions can be found in Section 5. Related checklists and worksheets, including a checklist for post-event assessment of mitigation effectiveness and a draft agenda for the Mitigation Strategy Review and Mitigation Action Review and Assessment meeting, can be found in Appendix D.

### **3. FUNDING PRIORITIZATION**

Having a consistent process for prioritizing mitigation funding is necessary to have a successful state mitigation program. As part of this Plan update, the SHMT has developed a flexible process to be used across all agencies. Details pertaining to this topic can be found in the Enhanced Plan portion of this document, located in Section 8.

### **4. HMA GRANTS COMPLIANCE**

The ability and commitment to manage HMA grants effectively is necessary to achieve and maintain enhanced plan status. Details pertaining to this topic can be found in the Enhanced Plan portion of this document, located in Section 8.

### **5. MITIGATION IN POST-DISASTER RECOVERY**

The recovery period after a disaster presents a unique opportunity to address hazard mitigation, while both attention and funding are often at their highest. Section 406 grants in particular are highly useful for implementing hazard mitigation as part of Public Assistance (PA) program projects, following declared disasters. Details pertaining to this topic, to include the state's past use of 406 funding and strategies for maximizing effectiveness of post-disaster mitigation, can be found in the Enhanced Plan portion of this document, located in Section 8.

# SECTION 8. ENHANCED PLAN

## **SECTION 8. ENHANCED PLAN**

Section 8 – Enhanced Plan is forthcoming.

# SECTION 9. APPENDICES

# APPENDIX A: STATE AND LOCAL GOVERNMENT MITIGATION RESPONSIBILITY ANALYSIS

# SECTION 9. APPENDIX A: STATE AND LOCAL GOVERNMENT MITIGATION RESPONSIBILITY ANALYSIS

## CONTENTS

Section 9. Appendix A: State and Local Government Mitigation Responsibility Analysis .....	2
Overview .....	4
1. Home Rule .....	4
2. Unincorporated/Statutory .....	5
State, County, and Local Government Responsibility .....	5
State Level (Statutes and Regulations) .....	7
1. Statutes .....	7
2. Regulations .....	7
3. Summary .....	8
Local Level (Municipal Codes/Ordinances) .....	8
1. Boulder .....	10
2. Colorado Springs .....	11
3. Denver .....	12
4. Durango .....	12
5. Estes Park .....	13
6. Fort Collins .....	13
7. Longmont .....	14
8. Manitou Springs .....	14
9. Silverthorne .....	15
10. Sterling .....	16
11. Summary .....	16
County Level (Codes) .....	19
1. Boulder County .....	19
2. La Plata County .....	20
3. Larimer County .....	21
4. Logan County .....	21
5. Summit County .....	22
6. Summary .....	23
Key Takeaways .....	23

Case Histories of Hazard Mitigation Challenges.....	24
1. High Dam Hazard Release (Dam Safety Program – DWR).....	24
2. Landslide (City of Colorado Springs).....	26
3. Wildfire (Hayman Fire – Pike National Forest).....	27
Case History of Hazard Mitigation Successes.....	29
1. Losses Avoided Study (FEMA).....	29
2. Colorado Hazard Mapping (CWCB).....	31
3. Planning for Hazards (DoLA).....	34
4. Interstate 70 Risk and Resilience Pilot (CDOT).....	35
5. Larimer County Resiliency Framework (Larimer County).....	37
6. Resilient Design Performance Standards (Boulder County).....	39
7. Rist Canyon (Larimer County).....	40
8. Drainage Improvement – Left Hand Creek (City of Longmont).....	40
References.....	41

## LIST OF FIGURES

Figure 9A-1 Structure of State Statutes and Regulations.....	4
Figure 9A-2 Home Rule Municipalities Reviewed.....	9
Figure 9A-3 Code References to Hazards.....	18
Figure 9A-4 Spillway Overflow at the Button Rock Dam, Lyons.....	24
Figure 9A-5 snapshot of the High Hazard Dam Release Tool Database.....	25
Figure 9A-6 Landslide Risk Zone in Colorado Springs.....	26
Figure 9A-7 Hayman Fire.....	28
Figure 9A-8 CHAMP Webpage.....	33
Figure 9A-9 Planning for Hazards: Land Use Solutions for Colorado.....	35
Figure 9A-10 Interstate 70 Corridor Analysis.....	36

## LIST OF TABLES

Table 9A-1 Summary of Statutes and Regulations for Hazards.....	7
Table 9A-2 Hazards Identified in Municipalities' Code.....	9
Table 9A-3 Summary of Hazards Identified in Municipal Codes.....	17
Table 9A-4 Summary of Counties Reviewed.....	19
Table 9A-5 Losses Avoided.....	30

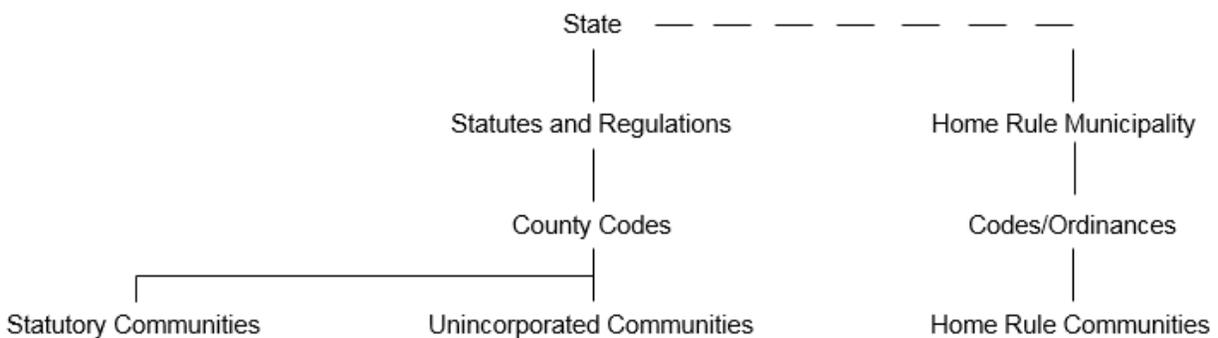
# OVERVIEW

The purpose of this assessment is to analyze where responsibilities lie across the state and local jurisdictions for implementing hazard mitigation strategies and actions. A separate, similarly relevant, review of the state’s existing land use review and referral process is also being conducted in order to identify successful practices and opportunities to reduce hazard impacts. The results of these combined analyses will serve as useful tools as the state works toward achieving an Enhanced State Hazard Mitigation Plan (E-SHMP) and further improves its resiliency to hazards.

This first assessment, the *State and Local Government Mitigation Responsibility Analysis*, provides analysis regarding state and local government responsibilities for the implementation of mitigation strategies and actions in Colorado. The research includes references to relevant statutes and regulations, case histories of select mitigation challenges, and a summary of historic incidents that may have benefited from mitigation.

When looking at the responsibilities of the state and local government in relation to hazard mitigation, relevant legislation can be divided roughly into state statutes and regulations at the state level, and county and municipal codes and ordinances at the local level. According to the legal dictionary, a statute can be defined as “an act of legislature that declares, proscribes, or commands something; a specific law, expressed in writing passed by a legislature on the state or federal level.” In contrast, local government codes and ordinances are the rules and regulations enacted into law by local government. The following diagram (Figure 9A-1) is a depiction of the organization of structure of state statutes and regulations in comparison to statutory county and municipal and home rule governments local land use and mitigation powers.

**FIGURE 9A-1 STRUCTURE OF STATE STATUTES AND REGULATIONS**



## 1. HOME RULE

In this analysis, it is important to highlight Colorado’s distinction as a “Home Rule” state. Home rule is the power of a local jurisdiction to set up its own system of self-government without

receiving a charter from the state. Home rule is allowed under some state constitutions. The authority to act in local affairs is transferred from state law to a local charter, adopted and, as needed, amended by the voters through referendum. Home rule shifts much of the responsibility for local government from the state legislature to the local community. While they command a large amount of power delegated to them by the state, home rule cities and counties can still be subjected to restrictions found in the United States Constitution and state constitutions. Home rule counties can do anything not specifically forbidden by state or federal law.

## **2. UNINCORPORATED/STATUTORY**

In Colorado, communities that are not home rule, fall under statutory designation of powers. According to the Colorado Municipal League, statutory cities and towns are limited to exercising powers that are granted by the state and are subject to provisions and limitations imposed by the state. Lands and communities that are not within an incorporated municipality are under the jurisdiction of a county and are subject primarily to state legislation.

### **STATE, COUNTY, AND LOCAL GOVERNMENT RESPONSIBILITY**

Both state and local governments have specifically defined responsibilities as they relate to hazard mitigation. In regards to state level responsibilities, C.R.S. 24-65.1 302 describes the functions of state agencies in relation to hazard mitigation. State agencies are tasked with:

1. Sending recommendations to local governments relating to designation of matters of state interest on the basis of current and developing information; and
2. Providing technical assistance to local governments concerning designation of and guidelines for matters of state interest.

Major state agencies that are responsible for these duties include: The Colorado Water Conservation Board (flood hazards), Colorado State Forest Service (wildfire hazards), and the Colorado Geological Survey (geological hazards).

Local level responsibilities vary by jurisdiction. A common section of Colorado State legislation referenced throughout the municipal codes is Title 29, Article 20. This section of legislation contains statutes that grant municipalities the authority to regulate land use. Statute 29-20-104, for example allows municipalities to regulate development in hazardous areas. Many of the municipal codes that were examined also contain statements of purpose which provide the intent of the code. For example (and as documented further in this document), in Sterling's Municipal Code, under the Flood Prevention and Protection's statement of purpose it reads "It is the purpose of this chapter to promote public health, safety and general welfare, and to minimize public and private losses due to flood conditions in specific areas." It is important to note that even though a statement of purpose is provided, the code also contains a liability clause that states "this chapter shall not create liability on the part of the community or any

official or employee thereof for any flood damages that result from reliance on this chapter or any administrative decision lawfully made thereunder.” Therefore, while the many of the codes contain a statement of purpose that entails how the code is meant to ensure public safety and wellbeing, it is by no means a guarantee. The codes contain liability clauses to maintain legal protection in cases that the code is not sufficient during and after disaster events.

Much like with municipalities, the two types of county designations in the State of Colorado include, home rule counties and statutory counties. Home rule counties do not have as much independence and separation from state legislation as home rule municipalities. There are only two home rule counties in Colorado, those being Weld County and Pitkin County. The remainder of the counties in Colorado are statutory counties. Counties are tasked with providing mandatory services, explicitly conferred to them by state law, as well as, discretionary powers for the provision of certain services or control of certain activities.

County discretionary powers include mitigation tactics, such as, providing water and sewer services (storm drainage) and wildfire planning and response services. Much like their municipal counterpart, Colorado counties contain regulations in the form of codes and ordinances that help incorporate hazard mitigation strategies into areas that are outside of municipal boundaries. These types of areas are often unincorporated sections of the county. Because counties have discretionary powers, each county goes about implementing hazard mitigation in different ways. Some counties contain comprehensive county codes which include direction on land use, zoning, and building codes. Other counties have mitigation strategies in several different documents, such as, flood mitigation addressed in the county building code and county land use plan. A commonality amongst all counties however, is the emphasis put on regulating hazard mitigation policy through land use and building codes.

In light of this analysis of where government responsibilities lie, it is also important to acknowledge the discrepancy between state population and land area. The State of Colorado has a total population of approximately 5,538,180 people. Of that total, approximately 5,142,955, roughly 93 percent, live in incorporated areas (home rule and statutory municipalities). This is a stark contrast when comparing the land area of these incorporated areas to non-incorporated land. Of the 104,177 square miles that make up Colorado, only 1.8 percent of that land consists of incorporated areas. Putting these two statistics together reveals that 93 percent of the state’s population lives in only 1.8 percent of the state’s land area.

This population to land area dynamic can create challenges for a state. Municipal governments, particularly home rule, possess the power granted to them by the state to implement hazard mitigation practices they deem appropriate. Municipalities and their populations also cover less land, so the hazards they address can be prioritized and specific to the area. Conversely, even though unincorporated areas contain much less of the state’s population, they cannot be forgotten about. County and state level governments still have an obligation to ensure residents are provided with the necessary regulations to help mitigate any number of hazards.

## STATE LEVEL (STATUTES AND REGULATIONS)

The Colorado Revised Statutes were consulted to determine state legislation relating to hazard mitigation. The state’s online database was consulted using key terms including: hazard, mitigation, flood, wildfire, drought, etc. A list of statutes and regulations related to hazard mitigation were compiled. Because of this approach, the list is by no means all encompassing, but does serve as a good representation of the types of hazards addressed state statutes. The following table (Table 9A-1) provides a brief summary of the statutes and regulations identified and the hazards they pertain to.

TABLE 9A-1 SUMMARY OF STATUTES AND REGULATIONS FOR HAZARDS

	All Hazard	Flood	Wildfire	Drought	Total
<b>Statutes</b>	4	2	14	4	24
<b>Regulations</b>		1	1		2

### 1. STATUTES

Statutes are defined as a law enacted by a legislative body of government at either the state or federal level. For the most part, the Colorado State statutes fall into the following categories: legislative declarations, creation of specialized hazard mitigation committees and positions, creation of dedicated mitigation funds, and the expansion of duties for already established hazard mitigation committees. The specialized hazard mitigation committees generally address one hazard, for example, wildfire, and are comprised of subject matter experts. They serve as policy advisory committees and sometimes possess power to distribute mitigation funds.

Statute organization generally consists of a title section followed by a purpose and introduction, what department or committee is responsible for oversight and implementation, and then a detailed body entailing the various components of the statute. The majority of statutes are concerned with wildfire mitigation. Many of the statutes detail responsibilities of specific committees, mitigation strategies, and specific funds dedicated to wildfire mitigation. The remainder of the statutes include flood and drought mitigation strategies and general hazard mitigation practices.

### 2. REGULATIONS

State regulations are the means by which state executive agencies enforce state laws. The regulations themselves are typically authorized by specific statutes. Colorado’s state regulations are rather limited with regards to hazard mitigation. The only two relevant regulations pertain to flood and wildfire. The lone flood regulation is 2 CCR 408-1 which contains the rules and regulations for regulatory floodplains in Colorado. The regulation contains 20 subdivisions which entails parties involved, responsibilities, rules, and enforcement of the regulation. This

regulation is promulgated and overseen by the Colorado Water Conservation Board (CWCB). Regulation 8 CCR 1507-32 details prescribed burning in Colorado and the Division of Fire Prevention and Control is responsible for oversight and compliance. The regulation dictates the rules and regulations that constitute the minimum standards for all prescribed burning conducted in the State of Colorado.

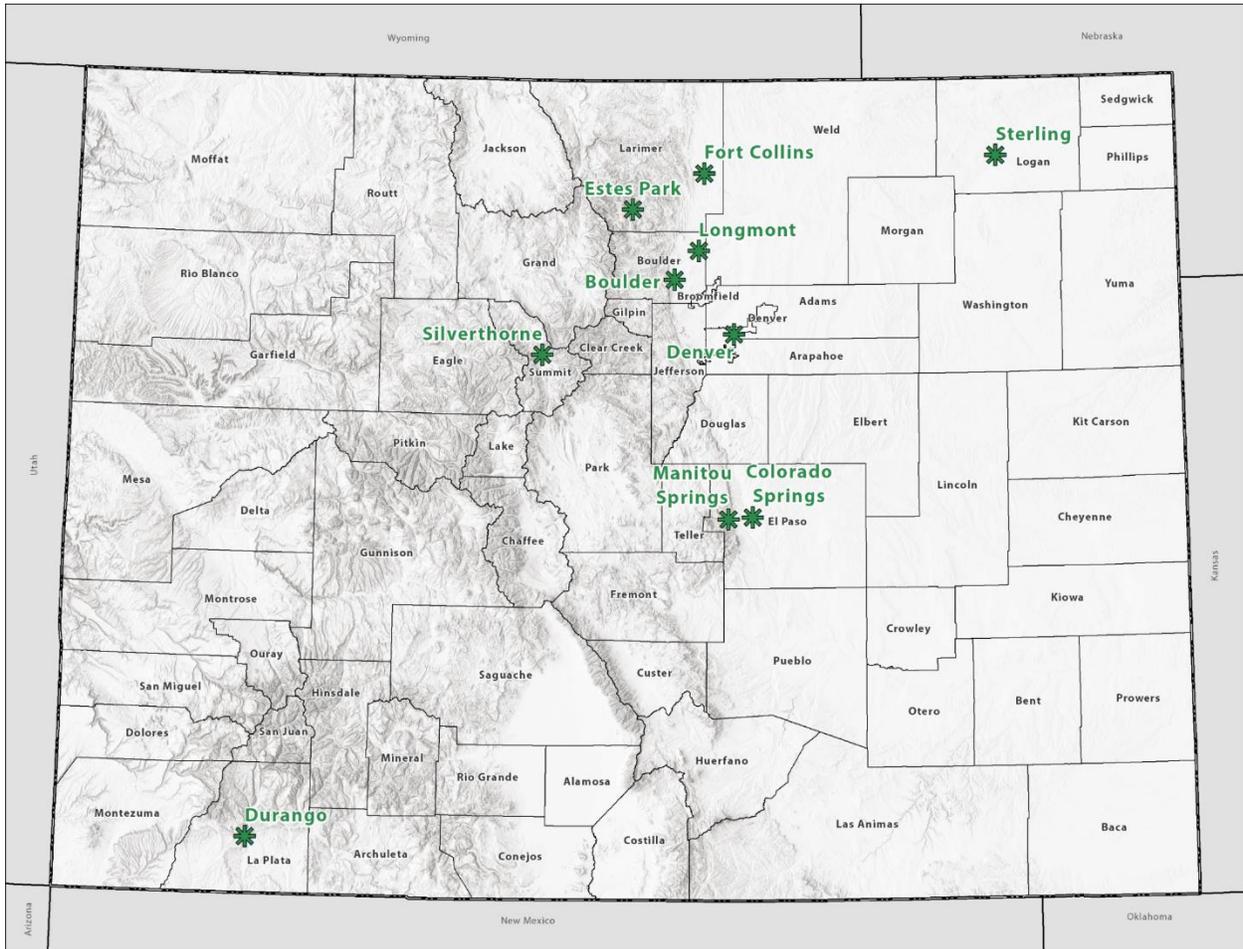
### **3. SUMMARY**

Overall, Colorado's state level legislation on hazard mitigation is limited to general statutes. There are a number of statutes relating to wildfire mitigation but far fewer when it comes to other hazards such as flooding and drought. State regulations are extremely limited with only one regulation related to flood and one for wildfire. As previously stated, the method used to research these statutes and regulations is by no means all encompassing, but it was determined to be the best search methodology to utilize as part of this research.

#### **LOCAL LEVEL (MUNICIPAL CODES/ORDINANCES)**

As part of this review of government responsibilities at the municipal level, 10 home rule municipalities were chosen (see Figure 9A-2). The goal was to include a diverse sample spanning various population sizes, geographical locations, and climates throughout the state. Because these municipalities are all home rule they have their own governing laws separate from the state by way of ordinances. These ordinances are enforced by the municipalities in the form of codes and each municipality has a distinct set of codes. It should be noted that the application of home rule limits the state's ability to control certain land use and planning regulations that could result in safer growth and development.

FIGURE 9A-2 HOME RULE MUNICIPALITIES REVIEWED



For the purpose of this assessment, each municipality’s code was consulted to determine what hazards are addressed and to what degree this occurs. It’s important to note that many of these municipalities have sections of their code specifically devoted to mitigating specific hazards, but it should also be noted that the adoption of building codes is also a distinct, valuable tool towards mitigating hazards (additional analysis of building codes in Colorado was also conducted as part of the E-SHMP). The following table (Table 9A-2) is a summary of the 10 municipalities and which major hazards they address in their code.

TABLE 9A-2 HAZARDS IDENTIFIED IN MUNICIPALITIES' CODE

Municipality	Flood	Wildfire	Drought	Landslide	Earthquake	Wind	Total
<b>Boulder</b>	X	X	X	X		X	5
<b>CO Springs</b>	X	X	X	X		X	5
<b>Denver</b>	X					X	2
<b>Durango</b>	X	X	X				3
<b>Estes Park</b>	X					X	2
<b>Ft. Collins</b>	X		X			X	3

Municipality	Flood	Wildfire	Drought	Landslide	Earthquake	Wind	Total
Longmont	X		X		X	X	4
Manitou Springs	X	X		X			3
Silverthorne	X	X	X	X		X	5
Sterling	X	X	X			X	4

The following sub-sections provide a detailed summary of the ordinances and codes, relevant to hazard mitigation, for each of the 10 jurisdictions evaluated.

## 1. BOULDER

**Hazards Addressed: Flood, Wildfire, Drought, Landslide, Wind**

**Building Codes: ICC 2012**

### 1.1 FLOOD (EXTENSIVE)

Boulder contains an extensive list pertaining to flood mitigation strategies throughout its code. While the term “flood” is found in the majority of titles in the municipal code, there are two titles that explicitly detail flood mitigation strategies. In Title 9 “Land Use Code”, under Chapter 3 “Overlay Districts”, there are five sections that relate to flood hazard mitigation. These sections include: Floodplains (9-3-2), Regulations Governing the One Hundred-Year Floodplain (9-3-3), Regulations Governing the Conveyance Zone (9-3-4), Regulations Governing the High Hazard Zone (9-3-5), and Floodplain Development Permits (9-3-6).

The second area of the municipal code that details flood mitigation strategies, is in Title 11 “Utilities and Airport”. Chapter 5 contains codes related to storm water and flood management utility. Relevant sections of this chapter include information related to master drainage plan s, storm water management and utilities, as well as, flood channel maintenance. A number of ordinances were updated in 2013, undoubtedly due to the catastrophic flooding that took place in the month of September that year. Out of all the municipalities analyzed, Boulder’s municipal code is one of the more extensive, with regards to flood mitigation ordinances. It was also the only municipality to have its mitigation strategies split into two separate titles.

### 1.2 WILDFIRE (LIMITED)

The term “wildfire” is only referenced in the municipal code three times and all three are in different titles. There is no dedicated section for wildfire mitigation in the code, nor are there any specific mitigation related codes. Wildfires are considered a “civil emergency” and do pose a risk to the City but the code does not entail any specific mitigation measures as it does with flood hazards.

### 1.3 DROUGHT (MEDIUM)

Title 11 contains a number of ordinances addressing drought hazards. Because of the nature of droughts, all of the mitigation practices are referred to as drought response measures. The code

addresses specific drought response measures, as well as enforcing drought response measures and associated consequences due to violations of those measures. In Boulder, the City Manager is responsible for implementing drought response measures. Typical drought response measures found in the code include: imposing drought surcharges, reducing monthly water budgets for customers, and imposing moratoriums on out of city water permits.

#### **1.4 LANDSLIDE (LIMITED)**

The code only makes one reference to landslides and mudflows in the Land Use Code. In the “Site Review” section (9-2-14) new construction should minimize erosion, slope instability, landslide, mudflow, or subsidence.

#### **1.5 WIND (MEDIUM)**

There are numerous references to wind throughout the code, however much of the regulation in regards to addressing wind as a hazard are found in Title 9 “Land Use Codes” and Title 10 “Structures”. Many of the ordinances relate to ensuring manufactured homes, signs, and other accessories are reasonably anchored to resist a certain amount of wind force.

## **2. COLORADO SPRINGS**

**Hazards Addressed: Flood, Wildfire, Drought, Landslide, Wind**

**Building Codes: Pikes Peak Regional Building Code 2011**

#### **2.1 FLOOD (MEDIUM)**

Colorado Springs’ code is quite concise when it comes to flood mitigation regulation. Article 8 of Chapter 7 “Planning and Development and Building” contains all of the codes pertaining to floodplain management. Article 8 begins with floodplain management followed by amendments, liability, and penalties for noncompliance. There are more references to flood mitigation throughout Chapter 7 in the land use section and subdivision regulations section.

#### **2.2 WILDFIRE (LIMITED)**

Colorado Springs’ code contains wildfire mitigation regulation throughout Chapter 7 but particularly in land use zoning (Article 3) and site development standards (Article 4). Most of the codes regard removing wildfire “fuel” surrounding structures in hazard areas.

#### **2.3 DROUGHT (LIMITED)**

Colorado Springs contains several drought provisions throughout its code. Codes vary from imposing water restrictions in times of drought, utilizing drought resistant vegetation in development, and authoritative powers to declare drought emergencies and protocols.

#### **2.4 LANDSLIDE/ROCK SLIDE/AVALANCHE (LIMITED)**

The code only makes one reference to landslides in the site development section of Chapter 7. The project must not be subject to significant risk from natural hazards including landslides, rocks slides, and mudslides.

### **2.5 WIND (LIMITED)**

Wind mitigation regulations are limited in the code. The few that do exist relate to ensuring manufactured homes, signs, and other accessories are reasonably anchored to resist a certain amount of wind force.

## **3. DENVER**

**Hazards Addressed: Flood**

**Building Codes: ICC 2015**

### **3.1 FLOOD (MEDIUM)**

Denver contains a rather short list pertaining to flood mitigation strategies throughout its code. The term “flood” is found primarily in Chapter 56 which deals with utilities. Article V addresses floodplain management throughout the City and County. The majority of the mitigation strategies are in the regulatory floodplain use and limitations section. Topics such as design limitations and flood storage tactics are laid out in detail in this section.

### **3.2 WIND (LIMITED)**

While there are multiple references to wind in the City’s code, none address it as a hazard to be mitigated against.

## **4. DURANGO**

**Hazards Addressed: Flood, Wildfire, Drought**

**Building Codes: ICC 2012**

### **4.1 FLOOD (LIMITED)**

Durango contains limited flood mitigation strategies throughout its code. Floods are defined as a local disaster in Chapter 9 of the code “Response to Emergencies, Civil Emergencies, or Local Disasters”. The only flood mitigation strategies detailed in the code relate to storm sewer pipe size and adequate site drainage to the 10-year floodplain.

### **4.2 WILDFIRE (LIMITED)**

Durango’s code contains an entire chapter on Fire Prevention and Protection (Chapter 8). While most of the chapter pertains to duties of the Department of Fire Prevention and the storage of flammable liquids and materials, there is a code that relates to creating “wildfire defensible zones” around structures. It states that “Vegetation clearance requirements in urban-wildland interface areas shall be in accordance with the Colorado State Forest Service”.

### **4.3 DROUGHT (LIMITED)**

Chapter 25, “Utilities”, contains one ordinance addressing drought hazards. The code only refers to an “emergency drought surcharge” that is applied to all residential water usage when the City Manager determines that an emergency drought exists.

## 5. ESTES PARK

**Hazards Addressed: Flood, Wind**

**Building Codes: ICC 2015**

### **5.1 FLOOD (EXTENSIVE)**

Nearly all of Estes Park’s regulations regarding flood mitigation are found in Title 17 (Zoning), under section 7.28 entitled Floodplain Regulations. The section is fairly comprehensive, covering topics such as: duties of the floodplain administrator, establishing flood hazard areas, developing in the floodplain, floodproofing, and enforcing floodplain rules and regulations. Estes Park, like several other municipalities in this analysis, keeps all of its flood mitigation related regulations confined to one section in the code. This makes referencing different codes easier and documentation more precise.

### **5.2 WIND (LIMITED)**

Wind mitigation regulations are limited in the code. The few that do exist relate to ensuring manufactured homes, signs, and other accessories are reasonably anchored to resist a certain amount of wind force.

## 6. FORT COLLINS

**Hazards Addressed: Flood, Drought, Wind**

**Building Code: ICC 2015**

### **6.1 FLOOD (EXTENSIVE)**

Fort Collins contains an extensive list pertaining to flood mitigation strategies through out its code. The term “flood” is found in the majority of chapters in the Municipal Code, however the is a dedicated section, Chapter 10, to “Flood Prevention and Protection”. Chapter 10 is very detailed and contains three articles with multiple divisions and sub divisions within each division. Many of the codes related to flood mitigation can be found in Article II “Flood Hazard Areas”. Within Article II is a division for flood hazard analysis and reduction and within that division numerous sub divisions relating to flood risk reduction, building in the floodplain, and floodway evaluations.

### **6.2 DROUGHT (LIMITED)**

The term “drought” is only found in Chapter 2 under Division 34 – Water Board, in which one of the duties of the board is to advise the City Council in drought emergency situations.

### **6.3 WIND (MEDIUM)**

There are numerous references to “wind” throughout the code, however much of the regulation addressing wind as a hazard are found in Chapter 26 “Utilities”. Similar to other municipalities in this analysis, most of the ordinances relate to ensuring manufactured homes, signs, and other accessories are reasonably anchored to resist a certain amount of wind force.

## 7. LONGMONT

**Hazards Addressed: Flood, Drought, Earthquake, Wind**

**Building Codes: ICC 2015**

### **7.1 FLOOD (EXTENSIVE)**

Longmont contains a large list pertaining to flood mitigation strategies throughout its code. The term “flood” is found in the majority of titles in the Municipal Code, however there is a dedicated section (Title 20) to floodplain regulations. Title 20 is very detailed and contains five sub chapters with multiple subsections within each chapter. Many of the codes related to flood mitigation can be found Chapters 20.12 “General Provisions” and 20.20 “Provisions for Flood Hazard Reduction”. These two chapters spell out regulations for building in the floodplain, establishing special flood hazard areas, as well as, duties of the floodplain administrator. Aside from a dedicated title in the code, flood mitigation regulations also appear in land development codes and building and construction codes.

### **7.2 DROUGHT (LIMITED)**

Longmont contains minimal drought provisions. Title 14 “Public Services” and 15 “Land Development Code” reference three drought response actions including implementing water restrictions, surcharges, and utilizing nonemergency restrictions.

### **7.3 EARTHQUAKE (LIMITED)**

Longmont is the only municipality in this analysis that contains any reference to earthquake related mitigation regulations. Title 16 references dangerous structures as having less resistance to winds or earthquakes.

### **7.4 WIND (MEDIUM)**

There are several references to “wind” throughout the code, however much of the regulation in regard to addressing wind as a hazard are found in titles relating to development and building codes. Similar to other municipalities in this analysis most of the ordinances relate to ensuring manufactured homes, signs, and other accessories are reasonably anchored to resist a certain amount of wind force.

## 8. MANITOU SPRINGS

**Hazards Addressed: Flood, Wildfire, Landslide**

**Building Code: Pikes Peak Regional Building Code 2011**

### **8.1 FLOOD (MEDIUM)**

Manitou Springs contains limited flood mitigation strategies throughout its code. There is no dedicated flood mitigation title or chapter within the code. Title 14 contains regulations for stormwater quality management and discharge control, however very little in that section relates to flood mitigation strategies. There are several regulations in the “Utilities” Title that address

floodwater management, as well as land use strategies that combat flooding that are found in Title 18 “Zoning”.

### **8.2 WILDFIRE (LIMITED)**

The term “wildfire” is referenced twice in the municipal code. There is no dedicated section for wildfire mitigation in the code. Titles 16 and 18, which focus on subdivisions and zoning, contain regulations that address wildfire suppression methods and requirements that new development provides ample protection from wildfire hazards.

### **8.3 LANDSLIDE (LIMITED)**

Similar to wildfire, the term “landslide” is only referenced a few times in the municipal code. There is no dedicated section for landslide mitigation in the code. Titles 16 and 18, which focus on subdivisions and zoning, contain regulations that address landslide prevention methods and requirements that new landslide reports be created to address hazardous areas.

## **9. SILVERTHORNE**

**Hazards Addressed: Flood, Wildfire, Drought, Landslide, Wind**

**Building Code: ICC 2012**

### **9.1 FLOOD (EXTENSIVE)**

Although Silverthorne is one of the smaller municipalities in this analysis, its code is quite comprehensive and in depth when it comes to flood mitigation regulation. Article 8 of Chapter 3 “Public Works” contains all of the codes pertaining to flood damage prevention. Article 8 is well laid out and follows a very local progression. It begins with the statutory authorization and proceeds to define the purpose for the section, definitions, and methods for reducing flood loss. The remainder of the section includes: establishing the flood hazard area, design standards in the floodplain, violations and liabilities, and various permitting and variance procedures. The Silverthorne Code also contains a few codes pertaining to flood risk reduction regulations in Chapter 4 “Community Development”.

### **9.2 WILDFIRE (MEDIUM)**

Silverthorne’s code contains one division (Division 5) devoted to “Fire Hazard Mitigation”. The purpose of the division is to “establish permitted fire mitigation standards for the protection of life and property from wildfires by reducing the hazards from threat of wildland fires on structures.” The division contains various mitigation rules, such as, roofing material standards, removing potential wildfire “fuel” that may be in close proximity to structures, and certain building appliance compliance (chimneys, wood burning stoves, etc.). The division also contains regulations regarding the enforcement of fire hazards along with the penalties of failing to comply.

### **9.3 DROUGHT (LIMITED)**

Silverthorne contains minimal drought provisions. The division addressing wildfire speaks to droughts in the context of their relation to increasing wildfire hazard conditions. The only other

reference to droughts is in Chapter 3 “Public Works” of the code, where it grants the Public Works Director the ability to impose water restrictions in times of drought.

#### **9.4 LANDSLIDE/ROCK SLIDE/AVALANCHE (LIMITED)**

The code only makes one reference to landslides and mudflows in Chapter 4 “Community Development”. In the permit application approval criteria, the project must not be subject to significant risk from natural hazards including landslides, rocks slides, and avalanches.

#### **9.5 WIND (LIMITED)**

Wind mitigation regulations are limited in the code. The few that do exist relate to ensuring manufactured homes, signs, and other accessories are reasonably anchored to resist a certain amount of wind force.

## **10. STERLING**

**Hazards Addressed: Flood, Wildfire, Drought, Wind**

**Building Code: ICC 2012**

#### **10.1 FLOOD (EXTENSIVE)**

Much like Silverthorne, Sterling is one of the smaller municipalities in this analysis. Its code is quite comprehensive and in depth when it comes to flood mitigation regulation. Chapter 8 “Flood Prevention and Protection contains all of the codes pertaining to flood damage prevention. Similar to Silverthorne, the Chapter includes: establishing the flood hazard area, design standards in the floodplain, violations and liabilities, and various permitting and variance procedures.

#### **10.2 WILDFIRE/DROUGHT (LIMITED)**

Sterling’s code contains one reference to wildfire and drought mitigation in Chapter 7 “Fire Prevention and Protection”. It states that the fire chief shall “also have the authority to declare and lift any emergency fire ban due to drought or other emergency conditions to ensure the proper safeguards against a catastrophic wildfire event.”

#### **10.3 WIND (LIMITED)**

Wind mitigation regulations are limited in the code. The few that do exist relate to ensuring manufactured homes, signs and other accessories are reasonably anchored to resist a certain amount of wind force.

## **11. SUMMARY**

Table 9A-3 shows the summary of the above findings.

TABLE 9A-3 SUMMARY OF HAZARDS IDENTIFIED IN MUNICIPAL CODES

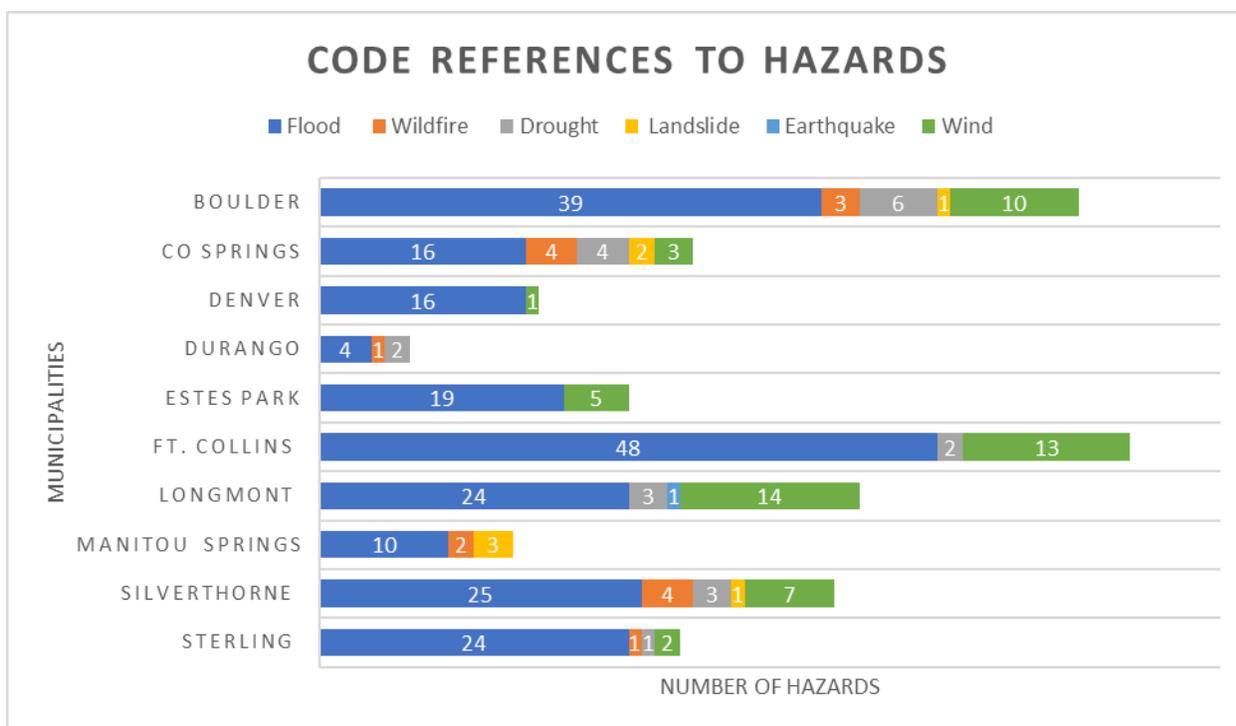
Municipality	Geography	Total Hazards	Hazards Addressed	Extent Hazards are Addressed	Building Codes
<b>Boulder</b>	Foothills	5	Flood Wildfire Drought Landslide Wind	Extensive Limited Medium Limited Medium	ICC 2012
<b>CO Springs</b>	Front Range	5	Flood Wildfire Drought Landslide Wind	Medium Limited Limited Limited Limited	Pikes Peak Regional Building Code 2011
<b>Denver</b>	Front Range	2	Flood Wind	Medium Limited	ICC 2015
<b>Durango</b>	Western Slope	3	Flood Wildfire Drought	Limited Limited Limited	ICC 2012
<b>Estes Park</b>	Northern Rockies	2	Flood Wind	Extensive Limited	ICC 2015
<b>Ft. Collins</b>	Front Range	3	Flood Drought Wind	Extensive Limited Medium	ICC 2015
<b>Longmont</b>	Front Range	4	Flood Drought Earthquake Wind	Extensive Limited Limited Medium	ICC 2015
<b>Manitou Springs</b>	Foothills	3	Flood Wildfire Landslide	Medium Limited Limited	Pikes Peak Regional Building Code 2011
<b>Silverthorne</b>	Central Rockies	5	Flood Wildfire Drought Landslide Wind	Extensive Medium Limited Limited Limited	ICC 2012
<b>Sterling</b>	Eastern Plains	4	Flood Wildfire Drought Wind	Extensive Limited Limited Limited	ICC 2012

Upon review of the 10 municipal codes, several conclusions can be drawn. Every municipality contains moderate to extensive flood hazard mitigation. This is in part due to the heavy federal regulation of flood programs through the National Flood Insurance Program (NFIP) and related FEMA disaster and mitigation funding requirements. While each municipality contains flood regulations, some divide the regulations into different sections while others choose to consolidate into a single section. Municipalities also vary in terms of the hazards they address.

Some municipalities, such as Silverthorne, contain five out of the six major hazards while other municipal codes, like Denver, only reference a single hazard. It is worth noting that building codes were not included in this particular analysis, which enforce hazard mitigation specific to a number of hazards. An assessment of building codes has been conducted as part of the E-SHMP and can be found in Appendix C. The following chart (Figure 9A-3) provides a summary of the hazards each municipality's code references and the number of codes addressed by the particular hazard.

From the data, it is clear that flood is the hazard most referenced in municipal code across Colorado, both by total count and the fact that every municipality researched included flood codes. This is not surprising however, as participation in FEMA's NFIP program requires this fact. High winds are seen as the second most cited hazard in code, again both from a total count and by the number of municipalities that have wind code. Beyond those two generalizations, no other direct connections can be made between hazards specifically addressed by code across the state's municipalities.

**FIGURE 9A-3 CODE REFERENCES TO HAZARDS**



It is important to note that the mere existence of statutes, regulations, and ordinances relating to hazard mitigation is only the first step towards reducing the risk to hazards. Enforcement of these regulatory tools is the only way to ensure that these mitigation tools are implemented properly and in alignment with how the rules were originally intended. The responsibility for ensuring adequate enforcement is ultimately in the hands of the local communities. Therefore,

public education relating to hazard mitigation is an important action, one which can be implemented at the state level and that is not solely reliant on local communities.

## COUNTY LEVEL (CODES)

The following section examines five different counties, each of which contains county level codes in various documents. For comparison’s sake, the five counties were taken from the locations of six of the previously examined municipalities. Each county was examined to determine the system used to organize and communicate the code, which hazards the counties addressed, and the degree to which the hazards were addressed. The following Table 9A-4 is a summary of the five counties examined.

TABLE 9A-4 SUMMARY OF COUNTIES REVIEWED

County	Documents Containing Mitigation	Hazards Addressed	Amount of Regulation
<b>Boulder</b>	3	Flood Geological Wildfire Wind	Extensive Limited Limited Limited
<b>La Plata</b>	1	Flood Geological Wildfire Wind	Extensive Limited Limited Medium
<b>Larimer</b>	2	Flood Geological Wildfire Wind	Extensive Medium Medium Medium
<b>Logan</b>	1	Flood Geological Wind	Medium Limited Limited
<b>Summit</b>	1	Flood Geological Wildfire Wind	Extensive Limited Medium Limited

### 1. BOULDER COUNTY

**County documents containing mitigation: 3**

**Hazards addressed: Flood, Geological, Wildfire, Wind**

Boulder County’s hazard mitigation regulations are dispersed throughout several documents including the Boulder County Building Code, County Land Use Code, and the County Ordinances. The Boulder County Building Code Amendments are adopted by the Board of

County Commissioners and apply to construction properties located in unincorporated parts of Boulder County. The County Land Use Code and County Ordinances determine how unincorporated parts of the County will look in the future by the way they guide new construction and development.

### **1.1 FLOOD (EXTENSIVE)**

Flood mitigation regulations are addressed in both the County Building Codes and the Land Use Codes. While there are some building codes related to mitigating flood hazards, the majority of flood related mitigation can be found in Boulder's Land Use Code. Article 4 of the code contains section 4-400 which entails the Floodplain Overlay District. Its purpose is to provide unincorporated areas of the county with land use controls to qualify for flood insurance, protect from flooding hazards and minimize losses from flooding.

### **1.2 GEOLOGICAL HAZARDS (LIMITED)**

Geological hazards are fairly sparse throughout the three documents. The land use code provides several regulations on identifying and limiting the effects geological hazards that are generally found in the "Site Review Criteria" of most sections of the code.

### **1.3 WILDFIRE (LIMITED)**

Wildfire is covered extensively in the County Building Code. ICB Chapter 7, Section R327 "Building code Ignition resistant materials and construction" provides numerous regulations regarding wildfire hazards. Wildfire is also covered in the land use code, but similarly to geological hazards, is only referenced in development and site plan review standards.

### **1.4 WIND (LIMITED)**

Wind is only covered extensively in the building code in reference to IBC Section 1609. There are very few wind related mitigation regulations in the land use code.

## **2. LA PLATA COUNTY**

**County documents containing mitigation: 1**

**Hazards addressed: Flood, Geological, Wildfire, Wind**

La Plata County's mitigation regulation is confined to one comprehensive document, entitled *La Plata County Comprehensive Code*. All county level regulation including, building codes, and land use codes are contained within the document.

### **2.1 FLOOD (EXTENSIVE)**

Flood mitigation regulation is the only hazard with a dedicated section (Chapter 78) in the comprehensive code. Division 3 of Article II of the chapter entails standards for flood hazard reduction including: general standards, floodways, alterations of watercourses etc.

### **2.2 WIND (MEDIUM)**

Wind regulations can be found in at length in Chapter 18 which serves as the code's amendments and additions to the IBC standards.

### **2.3 ADDITIONAL HAZARDS (LIMITED)**

Chapter 82 (Land Use Development) and Chapter 90 (Natural Resources) contain review standards under which a variety of hazards including geological (earthquake, landslide avalanche), wildfire, and flood can be found. While these hazards are mentioned, none contain their own section nor is much depth given on a particular hazard in regards to comprehensive mitigation strategies.

## **3. LARIMER COUNTY**

**County documents containing mitigation: 2**

**Hazards addressed: Flood, Drought, Geological, Wildfire, Wind**

Larimer County's hazard mitigation regulations are contained within a single two-part document entitled *Code of Ordinances and Land Use Code*. The document's first section contains the general county code, which also includes buildings and regulations. This section contains specific county amendments from the IBC with a few codes referencing hazard mitigation tactics. The second half of the document contains the county land use code. The majority of county level mitigation regulation is contained within the land use code.

### **3.1 FLOOD (EXTENSIVE)**

Flood hazards are referenced in both sections of the document, however the majority of mitigation regulation is contained in the land use code section. Sections 4.0 (Zoning) and 8.0 (Standards for all development) contain 80% of flood mitigation regulation. Like all of the other counties in this examination the regulations for flood are by far the most comprehensive of any of the hazards discussed.

### **3.2 WIND (MEDIUM)**

Wind hazard regulations are found throughout the document, both in the "Building and Building Regulations" chapter, as well as, land use. Similar to flood mitigation, wind regulations in the land use code are confined mostly "Zoning" and "Standards for all development"

### **3.3 ADDITIONAL HAZARDS (MEDIUM)**

Under Section 8.0 (Standards for all development) a number of hazards are addressed including, drought, geological and wildfire hazards. Though it does not contain its own subsection section, wildfire hazard regulation is the most thoroughly addressed of the aforementioned hazards.

## **4. LOGAN COUNTY**

**County documents containing mitigation: 1**

**Hazards addressed: Flood, Geological, Wind**

Logan County is rather sparse in documentation when it comes to hazard mitigation regulation. The county has a zoning resolution document that it adopted in 1990 and it contains all matters related to zoning, including a few hazard mitigation topics.

#### **4.1 FLOOD (MEDIUM)**

Flood hazards are referenced in section 7.7 (Floodplain Regulations) of the document. This section covers topics including: methods of reducing flood loss, establishing the special flood hazard area, duties of the floodplain manager, floodways and permitting procedures.

#### **4.2 WIND (LIMITED)**

Wind hazard regulations are limited in the document. The few references are related to sign standards and anchoring of manufactured homes. These requirements are in addition to applicable State and local anchoring requirements.

#### **4.3 GEOLOGICAL HAZARDS (LIMITED)**

An additional hazard that is addressed is the geological hazard, within the context of PUD development site reviews. PUD design and construction plans must take into account characteristics of soils, slopes and potential geological hazards in order to protect the health, safety, and welfare of potential users of the PUD.

## **5. SUMMIT COUNTY**

### **County documents containing mitigation: 1**

#### **Hazards addressed: Flood, Drought, Geological, Wildfire**

Summit County's hazard mitigation regulations are contained within a single document entitled *Summit County Land Use & Development Code*. The document categorizes unincorporated areas of the county into zoning districts. For each district, the code specifies which land uses are permitted. The Code also includes regulations on signs, lot sizes, minimum setbacks, proportion of a lot allowed to be developed, open space, parking and the location, height and size of buildings.

#### **5.1 FLOOD (EXTENSIVE)**

Flood mitigation regulation is contained in Chapter 4 "Zoning Regulations/Overlay Districts". The overlay district applies to any areas in the county that are "subject to flooding which may cause serious property damage and threaten the welfare of its residents." The section includes numerous regulations for floodproofing, floodways and development permits.

#### **5.2 WILDFIRE (MEDIUM)**

While small, the Summit County Code does contain a dedicated section to wildfire hazard areas (Sec. 3202.05). It includes regulations for creating defensible spaces, appropriate densities and fire protection districts.

### **5.3 ADDITIONAL HAZARDS (LIMITED)**

Chapter 3 (Zoning Regulations) contains standards under which a variety of hazards including geological (earthquake, landslide, avalanche), mining, and environmental can be found. While these hazards are mentioned, none contain their own section nor is much depth given on a particular hazard in regards to comprehensive mitigation strategies.

## **6. SUMMARY**

Upon review of the five counties, several conclusions can be drawn. Compared to municipal level codes, county codes related to hazard mitigation are not as uniform in their organization. Certain county level regulations are confined to a single document, while others are spread out over multiple documents. Another key takeaway is that much of the county level regulation for hazards is administered by land use. A common theme amongst all counties, is that the land use code for the county contains the bulk of its hazard mitigation regulation. Unlike municipalities, each county addresses virtually the same hazards, although the degree to which the hazards are addressed varies. Counties cover larger land areas than municipalities and therefore have the potential to be susceptible to more hazards. In this regard, it is appropriate for counties to address a variety of hazards in their codes, even if the degree to which they are addressed is less in-depth than their municipal counterparts.

### **KEY TAKEAWAYS**

Upon analyzing the three levels of governing bodies that regulate hazard mitigation policy and when considering the levels of power each body contains, spelled out in Colorado State statutes, a hierarchy becomes clear. Due to the state's system of government and home rule laws, there is a distinct level of authority when determining land use policy. Home rule municipalities have the most power when deciding land policy while the state has the least say, impart because it has delegated so much power to counties and municipalities.

The state level contains the least amount of regulation and least amount of hazards addressed, while the municipal level is just the opposite, containing a high level of policy and number of hazards addressed. This land use hierarchy is different from the traditional power structure of government in Colorado. For most governing issues, the state has a tremendous amount of power in determining legislation and implementation. When it comes to land use however, Colorado has delegated a great deal of its power. If the state wants to implement overarching hazard mitigation strategies using land use policy, one of the most powerful hazard mitigation tools available, its hands are somewhat tied. This delegation of land use control to local level and county level government has led to a discrepancy of hazard mitigation regulation across the state.

Addressing this discrepancy will require a great deal of intergovernmental collaboration and political will. Fortunately, there are already several instances that have provided opportunities for collaboration on various government level and state referral agencies. The next section

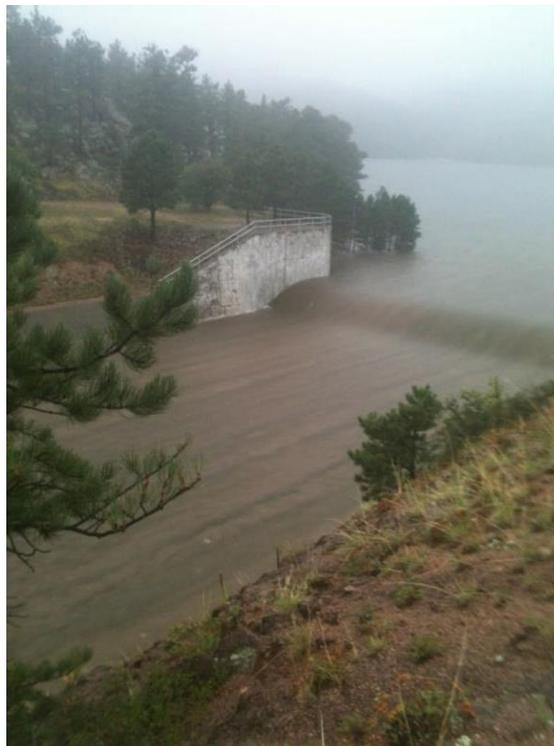
discusses several case studies in Colorado that show both the challenges and successes of implementing hazard mitigation at the local and state level.

## CASE HISTORIES OF HAZARD MITIGATION CHALLENGES

### 1. HIGH DAM HAZARD RELEASE (DAM SAFETY PROGRAM – DWR)

While current policy addresses numerous hazards, there are gaps that are being discovered, in part because of Colorado’s rapidly growing population and expansion into more hazard prone areas. New development near Colorado’s many dams is becoming a problem due to the potential of a high hazard dam release. In order to adequately address this issue, the Colorado Dam Safety (CDS)/Department of Natural Resources lead the creation and development of the High Hazard Dam Release Tool Database.

FIGURE 9A-4 SPILLWAY OVERFLOW AT THE BUTTON ROCK DAM, LYONS



Spillway overflow at the Button Rock Dam

Dams provide essential services that include: storing water for household use, irrigation, energy production, recreation, and minimizing flooding impacts. However, large amounts of water may be released even when dams are functioning properly due to intense rainfall, rapid snowmelt, or other unforeseen circumstances. This can result in flooding to downstream communities.

Although all high-hazard dams in Colorado have dam failure inundation maps to outline flooding

limits for dam failures, no mapping exists for the range of releases that might be anticipated to occur during flooding events. While flood impacts downstream of dams are less likely in rural areas, the potential for flooding there is generally unknown due to a lack of available data (CDS).

To begin to address this need, the project team has developed the Colorado High-Hazard Dam Release - Downstream Floodplain Impacts Database and Ranking Tool. The tool can be used to support public awareness, planning, and emergency preparedness activities, as well as during emergency response situations involving high hazard dams throughout Colorado. CDS is the first state dam safety program in the nation to systematically evaluate their portfolio of 400 high-hazard dams related to operational and flood release capabilities. Ultimately, this database and ranking tool provides a screening-level assessment of the potential for hazardous conditions downstream of high hazard dams. Figure 9A-5 shows an example of the database.

**FIGURE 9A-5 SNAPSHOT OF THE HIGH HAZARD DAM RELEASE TOOL DATABASE**

General Info		Spillways	Outlet Works	Dam	Streamflow Statistics at Dam	Ranking	Consequence Analysis	FEMA	Hydraulic Analysis
Dam Name	Dam ID / NID ID / kmz	Controlled Capacity (cfs)	Outlet Capacity (cfs)	Total Max. Controlled Discharge (cfs)	Dam and/or Main Channel Drainage Area (mi <sup>2</sup> )	Dam Not Considered / Composite Ranking	First Impacted Downstream Road kmz	FIS Profile	Hydraulic Analysis Performed:
RUETER HESS	080450 CO02940	648	594.7	1242.7	10.52	1	Google Earth	FIS Profile	
MAPLE GROVE	070219 CO00203	13365	102.0	13467.0	10.40	2	Google Earth	FIS Profile	X
BEAR CREEK	090112 CO00004	0	2000.0	2000.0	235.67	3	Google Earth	FIS Profile	X
CHATFIELD	080324 CO01281		8300.0	8300.0	3020.77	4	Google Earth	FIS Profile	X
KELLY ROAD DETENTION	020809 CO02345		690.0	690.0	10.65	5	Google Earth	FIS Profile	X
BLUNN	070302 CO00980		420.0	420.0	48.29	6	Google Earth	FIS Profile	X
STANDLEY LAKE	020326 CO00101		700.0	700.0	15.95	7	Google Earth	FIS Profile	X
RALSTON	070224 CO00205		650.0	650.0	46.41	8	Google Earth	FIS Profile	X
TRINIDAD	190122 CO00090		5500.0	5500.0	671.86	9	Google Earth	N/A	
SOUTH PLATTE RESERVOIR	080446 CO02858	0	110.0	110.0	0.30	10	Google Earth	FIS Profile	X
MONTGOMERY	230134 CO00372		1243.0	1243.0	7.84	11	Google Earth	No Profile	
CHERRY CREEK	080116 CO01280		8100.0	8100.0	385.67	12	Google Earth	FIS Profile	X
ANTERO	230102 CO00351		1800.0	1800.0	190.51	13	Google Earth	No Profile	
LOWER CABIN CREEK	070110 CO01240		549.0	549.0	13.65	14	Google Earth	FIS Profile	
HOLLY	080335 CO02214		195.0	195.0	2.05	15	Google Earth	FIS Profile	
LEGGETT & HILLCREST	060131 CO00232		385.0	385.0	1.52	16	Google Earth	FIS Profile	
DILLON	360104 CO00875		4400.0	4400.0	334.09	17	Google Earth	No Profile	

Snapshot of the High Hazard Dam Release Tool Database

February

To serve as a pilot and to help to identify potential next steps, the team leveraged existing state and FEMA data sets and studies, along with high-resolution LiDAR, to conduct some two-dimensional hydraulic analysis for 27 high-hazard dams across the state. The resulting analysis and associated mapping can now provide state and local officials with an idea of those areas that may be impacted by future dam releases during flood events.

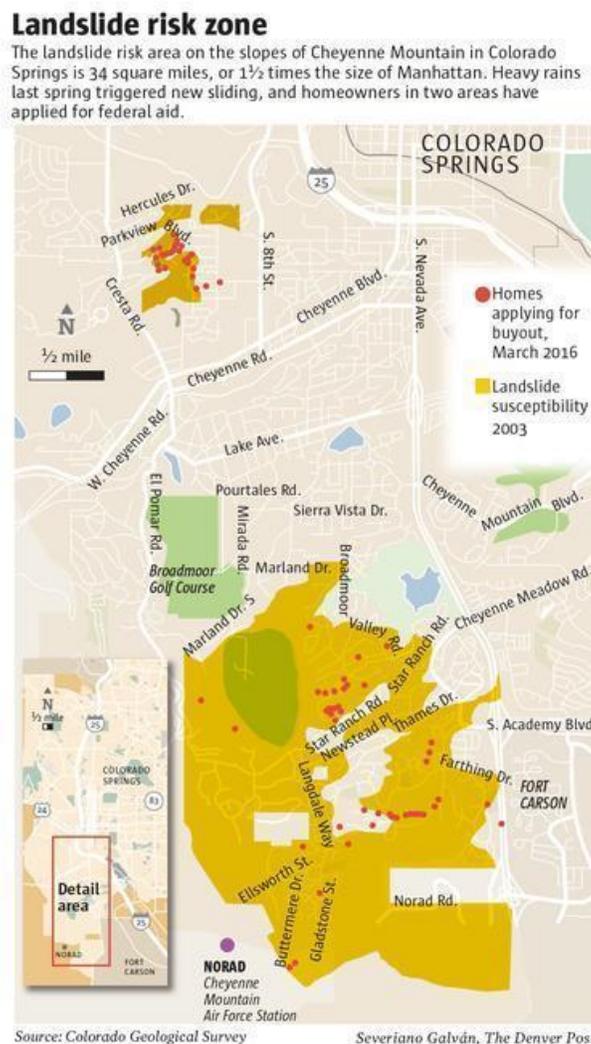
The plan moving forward is for this tool to be used by public agencies responsible for floodplain management and emergency response flooding. As problem sites and dams are identified, programs can be developed to prevent potential losses and inform the necessary parties responsible for infrastructure, community awareness, and resiliency planning. The creation of this database is a perfect example of intergovernmental and private sector collaboration. With the existing discrepancy between land use control and governmental power that the state holds,

this type of collaboration is necessary to allow for increased hazard resiliency throughout the state, both in municipalities and unincorporated areas.

## 2. LANDSLIDE (CITY OF COLORADO SPRINGS)

The threat of landslides has been a continual risk to the City of Colorado Springs. Heavy rains in the spring of 2015 triggered new slides resulting in homeowners in two areas applying for federal aid for property buyouts. Of the roughly 80 homes on this potential buyout list, at least 28 have seen their property value decrease. Figure 9A-6 provides an overview of the landslide risk zone in Colorado Springs.

FIGURE 9A-6 LANDSLIDE RISK ZONE IN COLORADO SPRINGS



Landslide risk on the slopes of Cheyenne Mountain cover 34 square miles and have been documented for decades. Some of this history was documented by the Colorado Springs Gazette, in an article on April 29, 2016, and is included below:

- A 1968 report for one landowner says the east face of Cheyenne Mountain exhibited landslide characteristics. More than half of the homes applying for federal buyouts are on the east face of Cheyenne Mountain.
- A 1974 federal study recommended "building and road construction be prohibited in landslide hazard areas."
- Maps made in 1977 show the city's landslide risks, pointing out Broadmoor Bluffs and Skyway Park as problematic.
- A 1985 study by University of Colorado at Colorado Springs geographers warned of the risks as building ramped up in the foothills.
- A 1994 letter from the state geologist asked the city to take "immediate administrative action" to protect potential landslide victims in the Mountain Shadows area. The city responded by saying the issue was a "private matter."
- A year after three houses on Regency Drive were destroyed by the 1995 Garrison landslide, **the city adopted a geological hazards ordinance**. It required developers to hire an engineer or geologist to assess potential hazards, including landslides, on building sites. If problems are found, the reports are forwarded to the Colorado Geological Survey, which provides its opinion and recommendations. City planners say they weigh the two reports to decide whether to build. The success of the ordinance is up for debate. Of the homes on the buyout list, almost 40 percent were built in 1996 or later. The city plans to examine these issues.

To help residents through this buyout process, the City developed its Landslide Acquisition Program. This program's goal is to help to facilitate and prioritize buyout. Currently, the city has developed, in close concert with State/DHSEM and FEMA, a prioritized list of homes based upon assessed risks as compiled by an outside engineering firm. In addition, the city has issued bid requests on asbestos testing and mitigation (if necessary, depending on the property) and the overall demolition of the homes.

### 3. WILDFIRE (HAYMAN FIRE – PIKE NATIONAL FOREST)<sup>1</sup>

In 2002 much of the Front Range of the Rocky Mountains in Colorado was rich in dry vegetation as a result of fire exclusion and the drought conditions that prevailed in recent years. These dry and heavy fuel loadings were continuous along the South Platte River corridor located between Denver and Colorado Springs on the Front Range. These topographic and fuel conditions combined with a dry and windy weather system centered over eastern Washington to produce ideal burning conditions. The start of the Hayman Fire was timed and located perfectly to take advantage of these conditions resulting in a wildfire run in one day of over 60,000 acres and

---

<sup>1</sup> From the Hayman Fire Case Study

finally impacting over 138,000 acres. The Hayman Fire Case Study, involving more than 60 scientists and professionals from throughout the United States, examined how the fire behaved, the effects of fuel treatments on burn severity, the emissions produced, the ecological (for example, soil, vegetation, and wildlife) effects, the home destruction, postfire rehabilitation activities, and the social and economic issues surrounding the Hayman Fire. The Hayman Fire Case Study revealed much about wildfires and their interactions with both the social and natural environments. As the largest fire in Colorado history it had a profound impact both locally and nationally. The full report can be access from the [following link](#). Figure 9A-7 shows a picture during the Hayman Fire.

**FIGURE 9A-7 HAYMAN FIRE**



# CASE HISTORY OF HAZARD MITIGATION SUCCESSES

In September of 2014, FEMA and DHSEM authored a document titled *Best Practices: Promoting Successful Mitigation in Colorado*. This publication represented a sampling of flood mitigation activities resulting from lessons learned, after action reports and identified needs. The stories in that document provide insight on mitigation projects that have been executed in north-central and north-eastern Colorado in preparing for future flooding events.

The publication was developed to serve as an invaluable resource to:

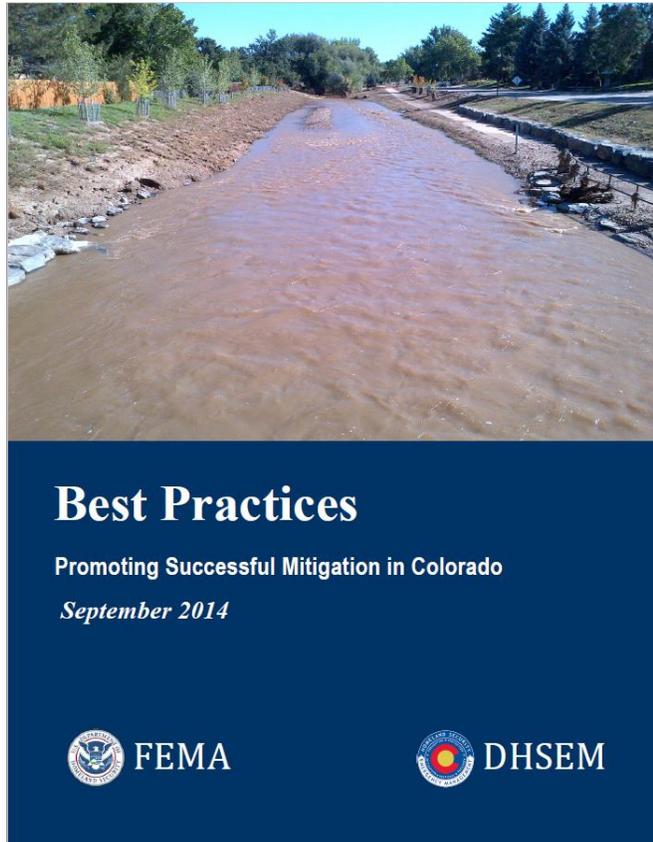
- Communicate the importance of identifying flood risks and ways to minimize risks
- Identify mitigation ideas to show how mitigation is effective and affordable
- Demonstrate how mitigation makes communities more stable and productive

A copy can be found at the [following link](#).

During development of the 2018 E-SHMP, additional mitigation successes have been identified, some of which are highlighted on the following pages.

## 1. LOSSES AVOIDED STUDY (FEMA)

While there are different levels of regulations (State, County, Municipal), the primary goal of all hazard mitigation policy is to reduce the risks hazards pose to life and property loss. Under the direction of FEMA, a *Loss Avoidance Study* was conducted to determine how mitigation regulations found in building and land use codes reduced the financial toll disasters had on communities. The study area consisted of three Colorado counties: Boulder, Larimer, and Weld. The catastrophic flooding that took place in those counties in September of 2013 provided an opportunity to study and compare how flood mitigation regulations operate and what the direct savings are to the community.



The study found that if communities had adopted or updated mitigation practices upon entering the National Flood Insurance Program, they would have experienced tremendous savings when base flood events occurred. By regulating flood mitigation policy, in the form of land use regulation and building regulation, the flowing savings were estimated (Table 9A-5).

**TABLE 9A-5 LOSSES AVOIDED**

<b>Land Use Regulation</b>	<b>Savings</b>	<b>Building Regulation</b>	<b>Savings</b>
<b>Development Restrictions</b>	\$486 Mil	Freeboard Restrictions	\$206 Mil
<b>Critical Facility Restrictions</b>	\$23 Mil		

### **1.1 LAND USE REGULATION**

The study found that if communities restricted all development in the Special Flood Hazard Area (SFHA), the area subject to flooding during a base flood event, the savings in avoided losses would have been \$486 million. Combine that with policy that locates critical facilities outside of the SFHA, and another \$23 million in savings would have been realized.

### **1.2 BUILDING REGULATION**

Freeboard is the requirement that involves raising a building’s ground flood level above the base flood elevation. The study found that if communities had adopted a two-foot freeboard requirement prior to experiencing a base flood event, post flood savings for the three counties would have been \$206 million.

### **1.3 MITIGATION SUCCESSES**

Since the 2013 floods, a number of counties and municipalities have implemented policies to try and mitigate the financial impacts of hazards. Three communities in particular have implemented successful mitigation strategies to allow for better resiliency the next time a disaster takes place. These mitigation strategies vary from outreach to better land use management.

The City of Boulder has developed a successful outreach program that allows citizens to utilize a comprehensive floodplain management website. The website provides floodplain hazard maps, flood recovery, resilience, and preparedness information, progress on flood-related city projects, property protection methods, and city technical support resources. In addition to the online resource residences have access to, the city has also posted more signage related to flood mitigation preparation on trails and public spaces around Boulder.

Land use and building regulations are the two tools that local, county, and state government can use to mitigate against hazards. Due to their high level of policy regulation, granted to them by their home rule status, municipalities are making the most strides, in terms of mitigating against hazards by utilizing these tools. Estes Park and Fort Collins currently enforce a land use code that includes regulations for flood mitigation. Estes Park regulates stream setbacks and limits construction inside the SFHA. There are also building requirements that require structures to

have a one-foot freeboard. For the past few decades Fort Collins has preserved open space along the Poudre River and has acquired critical structures along the river. Both of these land-use strategies have resulted in savings for both municipalities.

This study provides a great example as to how much of an impact hazard mitigation regulation, whether through outreach or land-use, can have in minimizing property losses for a community. It operates on the principal that spending more money on mitigation strategies before a disaster strikes and implementing more stringent land use policies will ultimately save the community money and resources in the long run.

## **2. COLORADO HAZARD MAPPING (CWCB)**

### **2.1 CHALLENGE**

A significant amount of damage caused by the 2013 floods took place in areas that were outside the mapped regulatory floodplain, known as the Special Flood Hazard Area (SFHA). Estimates indicate that as many as half of the damages and losses to private structures occurred outside SFHA. New hydrology studies conducted after the floods revealed that a number of Colorado communities were at a higher level of risk to flood-related threats than previously known. Recognizing the critical need to update hazard mapping and help inform local and state efforts to reduce such losses in future events, the state set out to reexamine various flood risks throughout the communities that were impacted by the 2013 floods.

### **2.2 SOLUTION**

Governor Hickenlooper signed Senate Bill 15-245 into law in May 2015. This bill created a three-year natural hazard mapping program to be implemented by the Colorado Water Conservation Board (CWCB) and the Colorado Geological Survey (CGS). The state's method of addressing the vulnerability to hazards is unique due to its integrated, multi-hazard approach, including the development of new methodologies, coupled with the state's proactive approach to funding this initiative during the rebuilding process, rather than waiting for federal funds to become available long after the recovery is complete.

### **2.3 FLOODPLAIN MAPPING**

The CWCB coordinates the Colorado Hazard Mapping Program (CHAMP). New floodplain maps are currently being developed with updated hydrology and acquiring new topographic information using optical remote-sensing technology or referred to as Light Detection and Ranging (LiDAR) for the streams that were most affected by the 2013 floods. This information will provide communities access to the latest science and hazard information to make the risk-informed decisions, assess risks, and identify mitigation opportunities as post-flood rebuilding continues. This new information will eventually be used to update FEMA's Flood Insurance Rate Maps, which are used to determine flood insurance requirements.

In addition, there are 28 counties in Colorado with paper-only floodplain maps, generally developed in the 1970s and 1980s. Through CHAMP, these maps will be digitized and incorporate best available information.

#### **2.4 EROSION AND DEBRIS FLOW MAPPING**

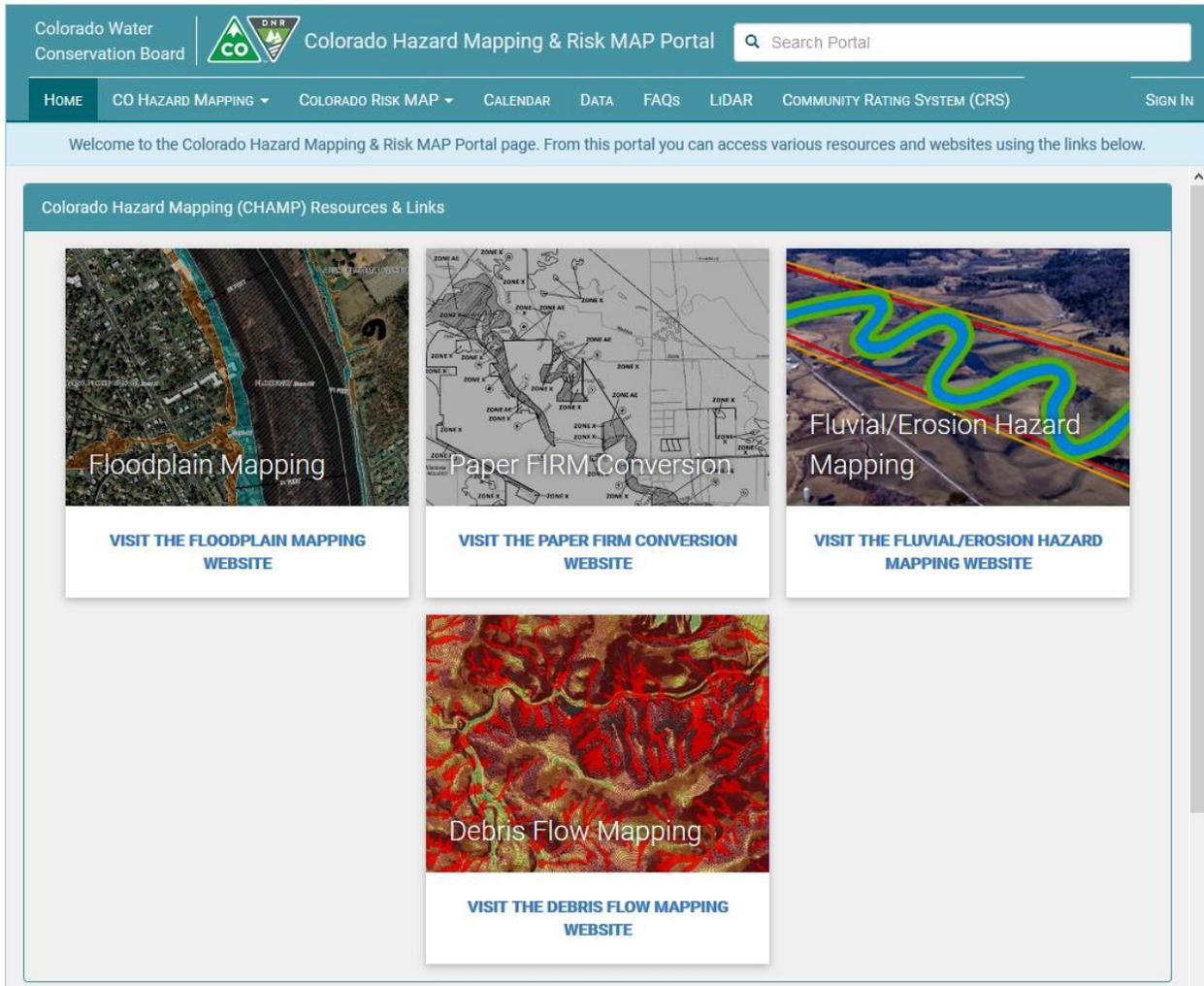
Colorado's unique topography, geology, and geography means that communities face geologic watershed-related hazards such as debris flows, erosion, degradation, and avulsion. As such, CHAMP enables the development of a new erosion hazard identification process and continuation of the identification of debris flow areas.

Erosion and avulsions magnified the impacts of the 2013 floods and demonstrated the need to consider watershed factors beyond hydrology and hydraulics.

In response to this need, the state is working to develop a scientific methodology to delineate fluvial hazard zones, and to develop pilot mapping products. This will help communities to not only consider flooding risk, but to holistically consider hydrologic, hydraulic, and geomorphic characteristics and how they could impact lives, property, infrastructure, and watershed health. As part of this effort, the project teams will work to develop mitigation strategies, model land use codes, and guidance for how communities can incorporate erosion hazard mapping into their planning processes.

In addition to impacts from erosion and avulsions, there were as many as 1,000 debris and mud flows that occurred outside of the mapped floodplain areas. While the 2013 event demonstrated the risk of debris flows along the Front Range, the hazard could impact communities throughout mountainous regions of the state. Through CHAMP, the state is investing in identifying high-risk areas in additional communities, which will help inform land use decisions and support efforts to reduce future damages and losses. Figure 9A-8 shows a snapshot of the CHAMP webpage.

FIGURE 9A-8 CHAMP WEBPAGE



### 2.5 OUTCOMES AND BENEFITS

The work that CWCB and CGS are doing represents the most comprehensive update to state floodplain maps since the creation of the National Flood Insurance Program, and will greatly improve the information that Colorado communities need to rebuild and grow in a safe and resilient manner. Updated floodplain, erosion hazard, and debris flow areas will allow local communities to make better-informed decisions to protect lives, identify where to locate future development to minimize damage in future disaster events, and enhance water quality and river functionality. Specifically, a Flood Risk Review process allows for early engagement with local communities to review draft floodplain maps with a comment period. This effort is closely coordinated with FEMA to ensure a more accurate and timely final map product or otherwise known as the Flood Insurance Rate Map (FIRM). Coordinating this information can allow local governments to choose to adopt what is considered best available information from FEMA. As part of the hazard mapping program, the CWCB launched and maintains the Colorado Hazard Mapping and Risk MAP Portal, allowing users to explore and stay informed about hazard mapping activities.

### 3. PLANNING FOR HAZARDS (DOLA)

Planning for Hazards: Land Use Solutions for Colorado enables counties and municipalities to prepare for and mitigate multiple hazards by integrating resilience and hazard mitigation principles into plans, codes, and standards related to land use and the built environment. This guide (and associated website) provides detailed, Colorado-specific information about how to assess a community's risk level to hazards and how to implement numerous land use planning tools and strategies for reducing a community's risk.

Several categories of specific land use planning tools and strategies are explored, including individual profiles for each tool that describe what hazards the tool addresses, how to use the tool, and which communities have already implemented the tool. For many of the planning tools and strategies, model code language and commentary is provided to illustrate how to implement the various tools through regulatory mechanisms. Figure 9A-9 summarizes all the planning tools and strategies profiled in this guide.

FIGURE 9A-9 PLANNING FOR HAZARDS: LAND USE SOLUTIONS FOR COLORADO

Summary of Planning Tools and Strategies											
	Avalanche	Drought	Earthquake	Flood	Hazardous Material Release	Extreme Heat	Landslide, Mud/Debris Flow, & Rockfall	Soil Hazards	Wildfire	Wind Hazards	Severe Winter Storm
<b>Addressing Hazards in Plans and Policies</b>											
Comprehensive Plan	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Climate Plan	✓	✓		✓		✓	✓		✓	✓	✓
Community Wildfire Protection Plan (CWPP)									✓		
Hazard Mitigation Plan	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Parks and Open Space Plan	✓	✓		✓			✓	✓	✓		
Pre-Disaster Planning	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<b>Strengthening Incentives</b>											
Community Rating System				✓							
Density Bonus	✓			✓			✓	✓	✓		
Development Agreement	✓			✓	✓		✓	✓	✓		
Transfer of Development Rights	✓			✓			✓	✓	✓		
<b>Protecting Sensitive Areas</b>											
1041 Regulations	✓	✓	✓	✓	✓		✓	✓	✓		
Cluster Subdivision	✓			✓			✓	✓	✓		
Conservation Easement	✓			✓			✓	✓	✓		
Land Acquisition	✓			✓			✓	✓	✓		
Overlay Zoning	✓			✓			✓	✓	✓		
Stream Buffers and Setbacks				✓			✓				
<b>Improving Site Development Standards</b>											
Stormwater Ordinance		✓		✓			✓	✓			
Site-Specific Assessment	✓			✓			✓	✓	✓		
Subdivision and Site Design Standards	✓	✓		✓	✓		✓	✓	✓		
Use-Specific Standards	✓			✓	✓		✓	✓	✓		
<b>Improving Buildings and Infrastructure</b>											
Building Code	✓	✓	✓	✓			✓	✓	✓	✓	✓
Critical Infrastructure Protection	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Wildland-Urban Interface (WUI) Code									✓		
<b>Enhancing Administration and Procedures</b>											
Application Submittal Requirements	✓			✓	✓		✓	✓	✓		
Post-Disaster Building Moratorium			✓	✓	✓		✓	✓	✓		

## 4. INTERSTATE 70 RISK AND RESILIENCE PILOT (CDOT)

### 4.1 CHALLENGE

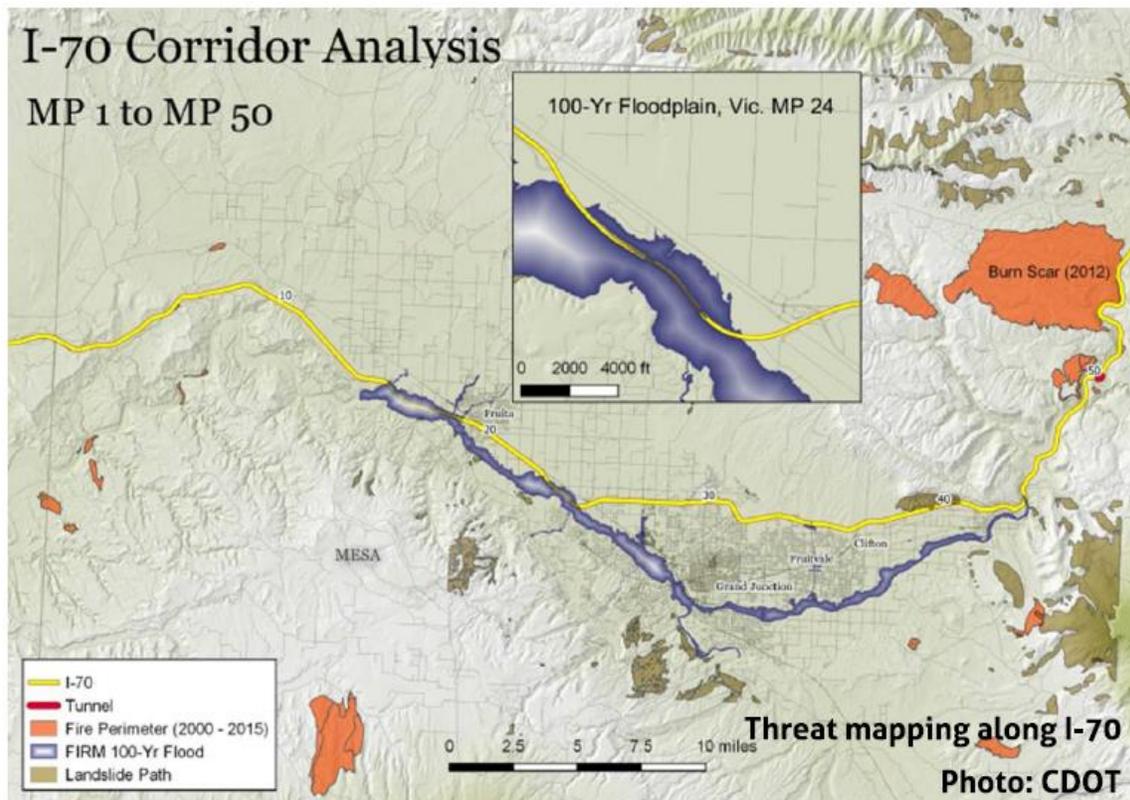
Traversing the Rocky Mountains and serving as the primary east-west corridor, Interstate 70 is a vital corridor in the Colorado transportation system, that enables commercial and personal travel central to Colorado’s economy and transportation network. Due to Colorado’s unique topography, there is little redundancy for Interstate 70 in many locations. It is therefore imperative that CDOT determine the vulnerability and resiliency of this critical corridor so that the state is better situated to resist, absorb, and recover from the impact of any potential future shock event.

## 4.2 SOLUTION

Building on the lessons learned from the 2013 flood event, CDOT has partnered with AEM to launch a pilot project known as the I-70 Risk and Resilience Pilot. Beginning in August 2016, this year-long project will assess hazards along the entire Interstate 70 corridor from border to border to identify: areas with high probability of losses from a range of threats, both natural (e.g., flooding) and direct (e.g., bridge strikes); the anticipated damages from these potential threats; and, the corridor's ability to adapt to these threats.

Employing similar processes as to those used on the flood recovery effort, the team has worked to create a blueprint that will facilitate the identification of the most vulnerable assets and cross-referenced them against the likelihood of specific threats from adverse events on the Interstate 70 corridor. The project team is made up of a wide range of CDOT staff from all five agency regions, staff from its Division of Transportation Development, technical experts from AEM, and department executives. By engaging a wide range of engineering, maintenance, operational, planning, and executive staff, the project is benefiting from the collaboration and shared knowledge across multiple areas of expertise. This will help build buy-in across the agency for the proactive approach to system resilience and risk management. Figure 9A-10 shows an example of threat mapping along Interstate 70.

FIGURE 9A-10 INTERSTATE 70 CORRIDOR ANALYSIS



### **4.3 INITIAL FINDINGS**

The I-70 Risk and Resilience Pilot is anticipated to be completed in fall 2017. When completed, it will help provide CDOT with risk and resilience information for assets along Interstate 70 and to prioritize work at key locations where risk is high and resiliency is currently low. Preliminary results have already provided three key pieces of information important to CDOT for decision-making:

- Criticality rating reflecting each asset's impacts on overall system performance.
- Annualized monetary risk from potential threats for each analyzed asset.
- Measure of resilience of each analyzed asset reflecting the impact to the traveling public from potential threats.

CDOT is beginning to explore how the information gained from the pilot project can help them make informed decisions regarding future asset management and prioritization processes, as well as infrastructure maintenance, operational planning, and project design. In addition, CDOT will assess the usefulness of the information provided by the process and determine if future analyses should be conducted.

## **5. LARIMER COUNTY RESILIENCY FRAMEWORK (LARIMER COUNTY)**

### **5.1 CHALLENGES**

The Larimer Community Resiliency Steering Committee, took the lead on developing a resiliency framework. The committee faced a number of challenges throughout the process:

Because this was a new process, there was no guide. The committee used the state's Resiliency Framework as a reference.

Developing a comprehensive framework that reflects the needs of Larimer County meant bringing together members of the community that traditionally may not work with one another. The group included representatives from the county, municipalities, community organizations, the private sector, and various stakeholders.

The timeline for developing the resiliency framework needed to be expedited due to its tie to the NDRC application. In the future, the team would benefit from a longer process and the opportunity to engage more with stakeholders and the community.

### **5.2 FRAMEWORK DEVELOPMENT**

Step one in the Larimer Community Resiliency Framework process was forming a steering committee to lead the process. In August 2015, representatives from a wide variety of stakeholders from local, state, and federal governments; community-led coalitions; non-profit organizations; and private businesses formed the Larimer Community Resiliency Steering Committee. This group led the development of the Larimer Community Resiliency Framework,

with support from the state's Resiliency and Recovery Office, and a multi-disciplinary consulting team.

### **5.3 OUTCOMES AND BENEFITS**

The Larimer Community Resiliency Framework was completed in February 2016. The Larimer County Board of Commissioners passed a resolution formally adopting the resiliency framework's goals in May 2016. With the formal adoption, Larimer County's Office of Emergency Management took over coordination of the framework and implementation of its projects. The framework is not a standalone plan, but rather was built on the momentum of existing planning efforts within Larimer County, including:

- 2016 Larimer County Hazard Mitigation Plan Updated (December 2015)
- Larimer County Strategic Plan Update (2013-2018)
- Larimer County Comprehensive Emergency Management Plan (2015)
- Unmet Needs and Community Fragility Study (December 2015)

The framework is meant to complement existing efforts, finding ways to build resilience into ongoing activities to reduce vulnerabilities to shocks and stresses. The resiliency plan is not an exhaustive list of actions that will burden the county. Rather it is a plan that compliments existing initiatives, collaborates with community projects and works to build upon and enhance the community's vision for a more resilient Larimer County. The resiliency framework is a living document that will be updated as projects are completed, and adjusted as needed to meet the changing needs of the community and region. The framework has provided a number of benefits for Larimer County in its pursuit of becoming more resilient:

- An actionable path for success. The framework contains specific, stakeholder-developed projects and actions the county and Larimer County communities can take. These actions identify project owners and make clear which County departments need to be involved.
- Increased collaboration. The cross-sector nature of the framework and projects create new opportunities to work across sectors, departments, and levels of government for a more holistic approach towards community resiliency.
- Buy-in from leaders. When Larimer County Commissioners adopted the Framework's goals, the county demonstrated its commitment to resilience and the methodology behind developing the framework.

A number of projects are currently underway to address the strategies and goals laid out in the Larimer County Resiliency Framework.

## **6. RESILIENT DESIGN PERFORMANCE STANDARDS (BOULDER COUNTY)**

### **6.1 CHALLENGE**

The Boulder County Collaborative received CDBG-DR funds from HUD for work that addresses the long-term disaster recovery needs from the 2013 floods. As part of their responsibilities in administering this funding, the Collaborative needed to develop resilience performance standards to any infrastructure projects the funds would be used for. Because of this requirement, the Boulder County Collaborative set forth on developing the Resilient Design Performance Standard.

### **6.2 SOLUTION**

Through a series of workshops in December 2015 and January 2016, participants developed time-to-recovery goals for critical infrastructure systems and facilities throughout the county. Time-to-recovery goals allow a community to prioritize infrastructure and facility assets based on how quickly they need to return to a functional state after a disaster. The time-to-recovery goals for all hazards were developed based off the National Institute of Standard and Technology's Community Resilience Planning Guide for Buildings and Infrastructure Systems. The performance standards are what communities use to achieve the time-to-recovery goals, and are adjustable to each project's level of hazard and impact, accompanied by policy and budget requirements.

### **6.3 OUTCOMES AND BENEFITS**

The Resilient Design Performance Standard allows Boulder County communities to define long-term time-to-recovery goals that are adaptable to specific hazards and each community's needs. By incorporating resiliency into the design, infrastructure throughout the county will be better poised to withstand future shocks and stresses, allowing communities to recover faster after a disaster event. Though the Standard was originally developed for CDBG-DR projects, the Boulder County Collaborative envisions it being adaptable and scalable to other types of projects.

After completion of the performance standard, the City of Boulder was the first to apply it to the Wonderland Creek Greenways Improvement Project. Rather than creating additional work for project team members, the performance standard expanded the process to include a resiliency focus. As various projects apply the criteria to their existing performance standards, iteration will ensure the standards are used appropriately and effectively. The City of Longmont will be the first community to apply the resiliency performance standards to regular capital improvement projects, with plans to incorporate the criteria into an existing sustainability checklist for locally-funded projects.

## 7. RIST CANYON (LARIMER COUNTY)

The High Park Fire dramatically impacted the landscape of the Rist Canyon area of Larimer County. Knowing that the burn scar would result in increased runoff during rainfall events, the county quickly moved to upsize seven culverts across the canyon. The hope was to reduce the threat of culverts getting plugged, which would have resulted in road over-topping by flood waters. The fact that there are many residents in the canyon with single egress routes amplified the need to act quickly. In addition to the culverts, helicopters were used to drop cargo nets of mulch over the scar to stabilize soils on the steeper slopes.

Only a few months later, the 2013 floods proved these projects to be mitigation successes. The work done in Rist Canyon ensured that the roads in this area remained passable during and following the large flooding event.

## 8. DRAINAGE IMPROVEMENT – LEFT HAND CREEK (CITY OF LONGMONT)<sup>2</sup>

### 8.1 CHALLENGE

Longmont had not seen a 1-percent-chance-annual flood since the late 1960s, but city leaders knew it could happen again. In 2010, the city proposed the Left Hand Creek flood project as a pre-disaster mitigation project. Some community members were initially resistant to the project, owing to concerns about the environment and damage to recreational paths.

The city had originally planned to build \$800,000 worth of new bridges along the South Pratt Parkway to divert the damaging effects of the floodplain. However, once FEMA released new flood maps for the area, Longmont determined that the mitigation project would have to be far bigger and more costly to have the same effect. The city did not have the funds to cover such a costly project.

### 8.2 SOLUTION

Most of the community had never experienced a major flood event, according to Hollingsworth. By providing data at community meetings about floodplain risks and the impact a 1-percent-annual-chance flood would have on the area, city leaders were able to make the case that this mitigation effort was important. In the end, the project encompassed channel improvements that increased the flow capacity of the channel and of two culverts at road crossings.

The project was jointly funded by the city's monthly residential and commercial stormwater fees and by a FEMA grant. In total, the project cost \$5.7 million and took nearly a year to complete.

---

<sup>2</sup> Summarized from an article published on their website by The Economist: Intelligence Unit (<https://floodeconomics.com/communities/longmont-co/>)

### **8.3 OUTCOMES AND BENEFITS**

In 2012, the Left Hand Creek channel in Longmont was expanded, removing 110 properties from the Special Flood Hazard Area (SFHA) and reducing the risk of flood damage to a key highway and the downtown area. Nine months after the expansion was completed in December, a 1-percent-annual-chance flood hit the town - the worst flash flood in the city's history.

Residents were evacuated as creeks overtopped, but 87 percent of the 204 homes in the SFHA experienced less or no damages.

The total losses avoided as a result of the mitigation project were tallied at \$22.5 million, the majority of which were savings in building, content, and displacement costs. The figure also includes losses from mental anxiety and loss of productivity, which were assessed to be over \$1 million.

Longmont is currently pursuing a program of flood mitigation projects along St. Vrain Creek to reduce the size of the floodplain. Projects include resizing the creek channel and restoring the St. Vrain greenway. The timeline for the Resilient St. Vrain program is 7-10 years, and the projects are estimated to cost up to \$140 million. The city continues to seek grants and other financial partners to help fund the projects.

## **REFERENCES**

- Boulder County Land Use Code
- Code of Colorado Regulations/Colorado Secretary of State
- Colorado High-Hazard Dam Release Program
- Colorado Local Government Handbook
- Colorado Revised Statutes (Colorado Legal Resources)
- Colorado Springs City Code, Sterling Codifiers
- La Plata County Code
- Logan County Zoning Resolution
- Loss Avoidance Study FEMA Region VIII
- Municode Library
- Summit County Land Use Code
- The Economist: Intelligence Unit
- USDA USFS Hayman Fire Case Study

# APPENDIX B: STATE REFERRAL PROCESS

# SECTION 9. APPENDIX B: COLORADO STATE LAND USE REFERRAL PROCESS

## CONTENTS

Section 9. Appendix B: Colorado State Land Use Referral Process .....	2
Introduction.....	3
Community Planning Elements in Hazard Mitigation .....	4
1. Planning Considerations.....	4
Referral Agencies .....	5
1. The Referral Process.....	5
2. Statutory Referral Agencies .....	5
Effectiveness of the Referral Process .....	6

## INTRODUCTION

The State of Colorado has a two-fold process for encouraging the incorporation of hazard mitigation into land use planning. The Division of Homeland Security & Emergency Management - Office of Emergency Management (DHSEM/OEM) is charged with working with communities to foster the development and adoption of FEMA-approved local hazard mitigation plans (HMPs). At present, greater than 90 percent of the state's population live in a county, municipality, or Tribe with a FEMA-approved hazard mitigation plan.

The Colorado Department of Local Affairs (DOLA) plays a key role in advancing hazard mitigation considerations in land use planning. DOLA's Division of Local Government (DOLA/DLG) developed a program to help communities plan for and implement strategies for hazard avoidance and mitigation. In the spring of 2016, DOLA/DLG launched the *Planning for Hazards: Land Use Solutions for Colorado* guide and website to help local communities, particularly those impacted by disaster, implement hazard mitigation into their land use planning process. The guide includes information on how to conduct a local hazard identification and risk assessment (HIRA) and identifies over 20 land use strategies specific to Colorado communities that can be used to further hazard planning. A key goal of the project is to assist communities in the development of land use strategies to reduce the risk of damage or destruction due to known hazards.

A key issue Colorado continues to address is how elected officials obtain information regarding known and potential hazards during the land use decision-making process. Local elected officials are charged with making decisions regarding the location and types of development allowed in their communities. Three key sources of data typically convey information to decision-makers regarding the land use review process to include:

- local community planners with knowledge provided via a local hazard and mitigation planning process;
- expert referral agency consultations as required by state law; and
- the general public and other local referral bodies as may be required in local codes.

Land use planners play a key role in the conveyance of hazard and mitigation information. They typically have responsibility for gathering and evaluating local hazard information, other local government comments, and state agency referrals for decision-maker review. Most significant land use decisions in Colorado are quasi-judicial, requiring a public process and the presentation of issues at public meetings and hearings. The format of the public process is determined by local officials and may include potential developer presentations, public workshops, and formal hearings before planning commissioners and/or local elected officials.

# COMMUNITY PLANNING ELEMENTS IN HAZARD MITIGATION

## 1. PLANNING CONSIDERATIONS

Local planners typically consult with other local governments, community and regional experts, and community advocates. The key information sources regarding natural and technological hazards at the local level include a local planning commission, engineering and public works officials, emergency managers, and the Local Emergency Planning Committee (LEPC). Advisory plans may include a comprehensive land use plan, a local hazard mitigation plan, and an emergency operations plan.

Colorado counties are an arm of state government and are therefore required to develop comprehensive land use plans pursuant to state statute. Municipalities may have similar requirements under a Home Rule Charter or are otherwise bound by state planning laws. While the nature and extent of comprehensive land use plans vary across the state, the fundamental components of many plans include information on natural and technological constraints on various types of land uses. A survey of comprehensive land use plans across Colorado completed by DOLA indicates that all counties surveyed include hazard information identifying local hazard constraints. The comprehensive land use plans evaluated covered approximately 90 percent of Colorado's population. Information contained in a comprehensive land use plan is typically a key element in the land use decision process.

Local zoning and subdivision codes may also contain hazard information and avoidance requirements. They may require that site-specific mitigation plans be developed for consideration by officials during the review process. Hazard information required in local codes typically includes flood and floodplain information, geologic hazards, and wildland fire risks. Other hazard data may be also required based upon local conditions such as mining hazards in mountain communities.

Certified land use planners have a duty to make aspects of a potential project a part of the public review process. They also have a responsibility to address the long-term consequences of present actions. Planners typically have a commitment to educate the public about planning issues and their relevance to the lives of residents in their communities. Knowledge regarding local natural and technological hazards are key to the success of communities. There is a natural partnership between planners and emergency managers that is fostered through information sharing and technology transfer. The State of Colorado recognizes this critical relationship and has tasked DHSEM/OEM and DOLA to assist in this work.

# REFERRAL AGENCIES

## 1. THE REFERRAL PROCESS

The Colorado General Assembly recognizes that local land use bodies can benefit from information known by a number of local, regional, and state agencies. Key issues of concern include water supply availability, geologic hazard conditions, wildland fire potential, and flood hazards.

The statutory referral process takes place upon receipt of a complete preliminary subdivision plan submission. Planners or the development applicant then submit the proposed plan for review by referral agencies according to their local process and/or state law and agency rules. Referral agencies consist of state agencies that specialize in specific areas of regulation or policy. The Colorado state referral process is entailed in the Colorado Revised Statutes Title 30 Government County § 30-28-136 “Referral and review requirements.” The statutes call for a review of any preliminary plan submission to a county. Municipalities often follow a referral process that is dictated in their local standards or charter.

The purpose of the referral process is to transfer key information to local decision-makers for their consideration. In having referral agencies review a proposed development plan, the referral agency can help inform the planning process to assist in identifying issues and hazards that may affect the proposal and current or future residents.

Issues addressed by referral agencies typically include the availability of critical services and infrastructure, geological conditions and hazards, water supply availability, and the availability of adequate school capacity. The goal is often to ensure that new development does not negatively impact the community or place residents at risk.

## 2. STATUTORY REFERRAL AGENCIES

Colorado law requires that counties consult with several state, regional, and local agencies during the development review process. These statutory referrals include:

Mandatory state referral agencies:

- The Colorado State Forest Service (CSFS) [Colorado State University] for issues related to forest stewardship, wildland fire prevention, mitigation, and preparedness.
- The Colorado State Engineer [Colorado Department of Natural Resources (DNR) – Division of Water Resources (DWR)] for an opinion regarding material injury likely to occur to decreed water rights by virtue of diversion of water necessary or proposed to be used to supply a proposed subdivision of land. The State Engineer also evaluates the adequacy of a proposed water supply to meet requirements of a proposed subdivision.

- The Colorado Geological Survey (CGS) [Colorado School of Mines] for an evaluation of those geologic factors that may have a significant impact on a proposed use of the land. The State Geologist works with the Colorado Avalanche Information Center (CAIC) to help make avalanche conditions known.

Mandatory local referral agencies:

- Appropriate school districts for an evaluation of potential impacts on local or regional education services.
- Each county or municipality within a two-mile radius of any portion of the proposed plan for the consideration of issues related to the proposed development.
- Any utility, local improvement and service district, or ditch company when applicable for critical infrastructure or service considerations.
- The local conservation district board within the county for explicit review and recommendations regarding soil suitability, floodwater problems, and watershed protection even if the plan does not fall into a conservation district. Local conservation districts are assisted in this work by the U.S. Department of Agriculture (USDA) – Natural Resource Conservation Service (NRCS). The Colorado Department of Agriculture (CDA) – Colorado State Conservation Board provides the local conservation district with guidance regarding this referral process.
- The county or district public health agency or the Colorado Department of Public Health and Environment (CDPHE) for review of the on-lot sewage disposal reports, review of the adequacy of existing or proposed sewage treatment works to handle the estimated effluent, and for a report on the water quality of the proposed water supply to serve the subdivision. In instances where a local land use authority does not have applicable water and wastewater review capacity, the CDPHE has both regulatory and technical assistance responsibilities.

Many local jurisdictions have referral and consultation processes that extend beyond the basic statutory requirements. Home and property owner associations, fire and law enforcement service providers, and historic preservation groups are often consulted as development proposals move through the land use review process.

## **EFFECTIVENESS OF THE REFERRAL PROCESS**

Colorado's local land use referral review process is partially effective in conveying local hazard information. State agency concerns with the referral process include limited review time periods, a lack of uniform funding for the review process, and the effectiveness of information transfer procedures for what are often technical and complex issues.

A secondary concern is that the statutory referral processes specified in state law have not kept pace with changes in state agency responsibilities. As an example, the Colorado Water Conservation Board (CWCB) is the principal planning and regulatory agency for flood planning and floodplain rulemaking. Local conservation districts have a duty to comment on flood related issues; their referral comments could be more effective if made in consultation with the CWCB and its community flood mitigation team.

It is also important to note that referral comments to local officials are advisory in nature. Land use approval bodies may, in many instances, choose to overlook referral recommendations. While they may request that mitigation measures be incorporated into a development approval, referral agencies typically are not required to review or approve those measures.

Colorado lawmakers amended the state's Disaster-Emergency Act (HB18-1394) in 2018 which now requires that all phases of emergency management include hazard mitigation consideration and be incorporated into local emergency operations plans. The bill updates the Colorado Disaster-Emergency Act to include provisions related specifically to recovery, mitigation, and resiliency and to establish the roles and responsibilities of state and local agencies at all stages of emergency management. This is a positive step forward for mitigation planning. The effectiveness of this approach should be evaluated as a State Hazard Mitigation Plan (SHMP) maintenance element.

# APPENDIX C: CURRENT BUILDING CODE CONDITIONS IN COLORADO

# SECTION 9. APPENDIX C: CURRENT BUILDING CODE CONDITIONS IN COLORADO

## CONTENTS

Section 9. Appendix C: Current Building Code Conditions in Colorado.....	2
Building Code Effectiveness Grading Schedule .....	3
Building Codes by County .....	4
Entities that are Resources for Building Codes .....	5
Exemplar Areas to Emulate.....	6
1. Losses Avoided in 2013.....	6
2. Planning for Hazards .....	7
3. Moody’s Analytics Credit Ratings for Jurisdictions .....	8
4. Natural Hazard Mitigation Saves .....	8
Resources for Action.....	10

## LIST OF FIGURES

Figure 9C-1 Counties without Building Codes.....	5
--	---

## LIST OF TABLES

Table 9C-1 Entities that Monitor Building Codes Statewide.....	5
Table 9C-2 Potential Resources for Action.....	10

Adoption and adherence to building codes create stronger and safer buildings, increases sustainability, improves environmental friendliness, decreases recovery efforts following a natural disaster, complies with guidelines for government assistance, and saves money over the life of a building. In 2000 the International Code Council (ICC) published its first set of codes, since then it has continued to update codes every three years, in order to provide guidance on best practices and standards for new construction and updates. The International Building Code (IBC), International Residential Code (IRC) and International Existing Building Code (IEBC) all provide guidance for development to create communities that are built to keep residents safer in the event of disaster.

Currently, many jurisdictions in Colorado have adopted either the most up to date or a recent review of the ICC codes. However, there is not a statewide code for either residential or commercial buildings in Colorado. At this time, there is not a centralized, updated database of Colorado jurisdictions with building codes available to perform analysis on the adoption or enforcement of local building codes, nor an entity tasked with maintaining any such information. While DOLA did compile this information, which was used as part of the 2013 SHMP, they do not have designated resources to keep such a database up to date.

## **BUILDING CODE EFFECTIVENESS GRADING SCHEDULE**

The Building Code Effectiveness Grading Schedule (BCEGS) assesses the building codes in effect in a community and how well the community enforces these codes. The grading system is focused on mitigating hazards and looks at the administration of building codes, including adoption and enforcement. This system also analyzes data on plan review, including processes in place to promote plan review accuracy, completeness, and consistency as well as adequate staffing for this work. The BCEGS finally considers field inspection and if a community enforces codes, and enforces them specifically for structure features designed to mitigate damages from natural disaster hazards common to an area.

BCEGS classifications range from 1, lowest scoring, to 10, the highest scoring. BCEGS most recently completed a review of Colorado communities in June 2015. As a state, Colorado received a 5 for both residential and commercial codes grading.

The scoring notes that:

- Forty-six (46) communities participate in the FEMA Community Rating System (CRS) Program, which encourages higher codes and standards to reduce the impacts of natural hazards.
- There is one building code official for every 4,055 people in the state of Colorado.
- From 2005 to 2015, more than 13,000 wildfires have burned 1,006,758 acres in Colorado.

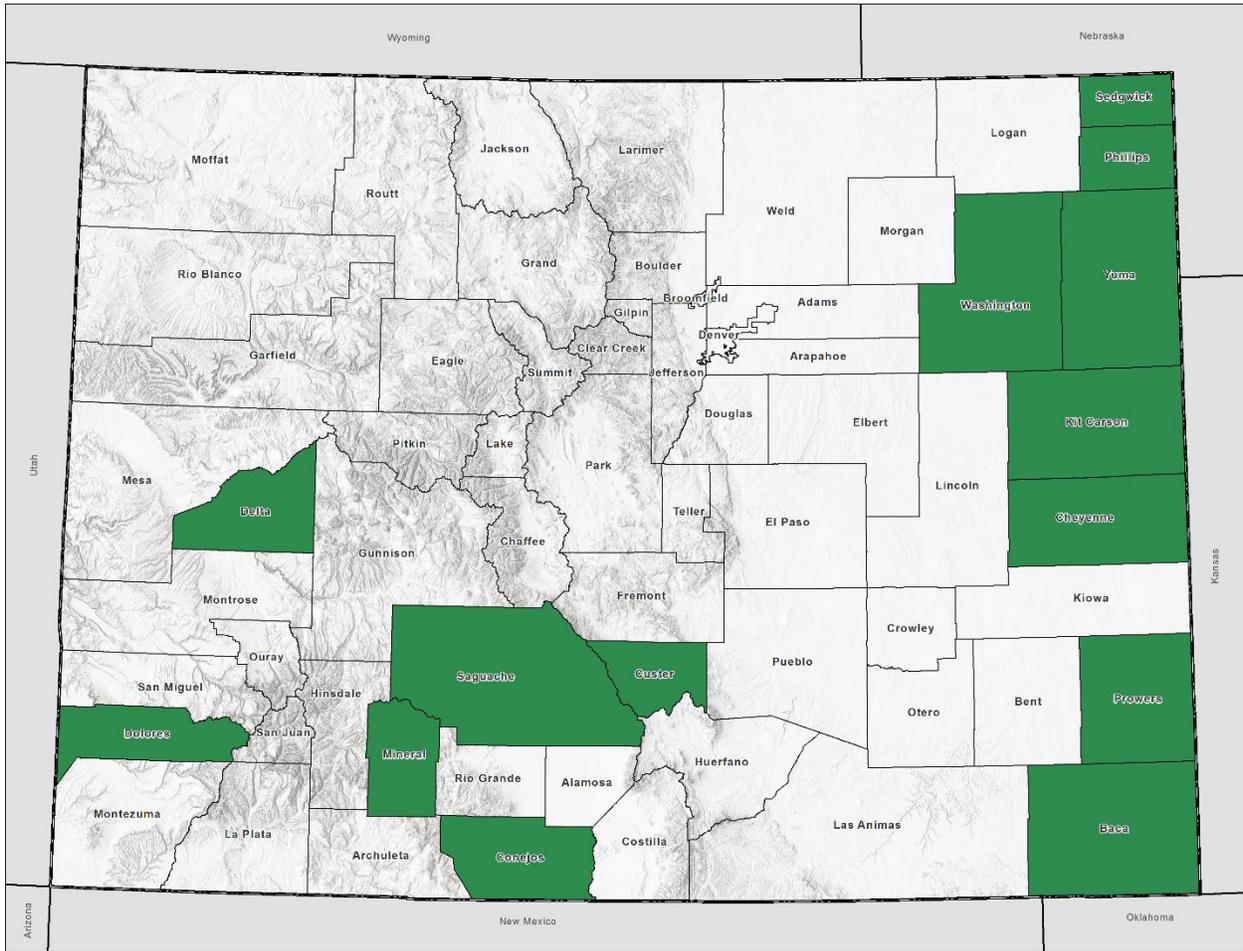
The full report can be accessed here: [https://www.isomitigation.com/siteassets/downloads/iso-bcegs-state-report\\_web.pdf](https://www.isomitigation.com/siteassets/downloads/iso-bcegs-state-report_web.pdf)

## **BUILDING CODES BY COUNTY**

Of the 64 counties in Colorado, 14 currently do not have building codes. These counties represent 1.78 percent of the population and 21.69 percent of the total land area of Colorado, and are listed below and shown in Figure 9C-1.

- Baca
- Prowers
- Cheyenne
- Kit Carson
- Yuma
- Phillips
- Sedgwick
- Washington
- Custer
- Saguache
- Conejos
- Mineral
- Dolores
- Delta

FIGURE 9C-1 COUNTIES WITHOUT BUILDING CODES



## ENTITIES THAT ARE RESOURCES FOR BUILDING CODES

There are several agencies, organizations, and entities that monitor buildings codes statewide for structures under their purview, or provide information and resources to jurisdictions on building codes, as described in Table 9C-1.

TABLE 9C-1 ENTITIES THAT MONITOR BUILDING CODES STATEWIDE

Entity	Description of building code connection	Where to find more information?
<b>State Facilities</b>	The Office of the State Architect is responsible for establishing minimum building codes for all construction by state agencies on state-owned or state lease-purchased properties or facilities.	<a href="https://www.colorado.gov/pacific/osa/bldgcodes">https://www.colorado.gov/pacific/osa/bldgcodes</a> <a href="https://www.colorado.gov/pacific/sites/default/files/approvedstatebldgcode.pdf">https://www.colorado.gov/pacific/sites/default/files/approvedstatebldgcode.pdf</a>

Entity	Description of building code connection	Where to find more information?
<b>Division of Fire Prevention and Control</b>	All public schools and junior colleges and licensed healthcare facilities.	<a href="https://www.colorado.gov/pacific/dfpc/permits1">https://www.colorado.gov/pacific/dfpc/permits1</a>
<b>Colorado Examining Board of Plumbers</b>	State Minimum Plumbing Code	<a href="https://www.colorado.gov/pacific/dora/Plumbing">https://www.colorado.gov/pacific/dora/Plumbing</a>
<b>Building Code Assistance Project</b>	Local Codes	<a href="http://bcapcodes.org/code-status/local-adoptions/#co">http://bcapcodes.org/code-status/local-adoptions/#co</a>
<b>Colorado Department of Local Affairs, Community Development Office, Division of Housing</b>	If a county or municipality does not have a building code, factory-built structures and buildings constructed on site intended for multiple occupancy are subject to building standards set forth by the state Division of Housing.	<a href="https://www.colorado.gov/pacific/dola/division-housing">https://www.colorado.gov/pacific/dola/division-housing</a>
<b>Colorado Municipal League</b>	Code Enforcement guidance is available via a 2015 publication titled, "Code Enforcement in Colorado."  An FAQ notes that code enforcement for buildings ensures that "land and buildings are safe and attractive."	<a href="https://www.cml.org/">https://www.cml.org/</a>

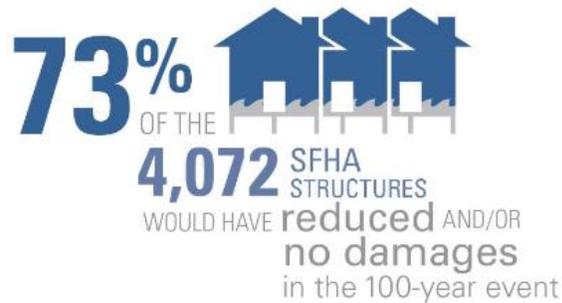
## EXEMPLAR AREAS TO EMULATE

Recently, there have been a number of state and federal efforts directed at encouraging the adoption of building codes and quantifying their benefit to communities. Four are highlighted below.

### 1. LOSSES AVOIDED IN 2013

Following the 2013 flood events in Colorado, FEMA Region VIII undertook a study to evaluate the losses avoided by building code regulations. The findings show that building codes can: dramatically reduce the impacts of hazards to communities, decrease hazard losses substantially, and allow a community to recover from events more quickly.

In Boulder County,  
if all post-regulatory structures had today's freeboard,



In Boulder County,  
if freeboard was never adopted,



This report can be accessed at: [https://www.fema.gov/media-library-data/1429759809776-2d0be16f764d0e704aff1f7664334ba0/FEMA\\_CO\\_BestPractices\\_Strategies.pdf](https://www.fema.gov/media-library-data/1429759809776-2d0be16f764d0e704aff1f7664334ba0/FEMA_CO_BestPractices_Strategies.pdf)

A summary can also be accessed at:

- [https://data.femadata.com/Region8/ColoradoFlooding\\_2013/Losses\\_Avoided\\_Study/Final\\_Report/Trifold\\_CO\\_RegulatoryLAS\\_Color.pdf](https://data.femadata.com/Region8/ColoradoFlooding_2013/Losses_Avoided_Study/Final_Report/Trifold_CO_RegulatoryLAS_Color.pdf)
- [http://www.casfm.org/wp-content/uploads/2017/08/R8\\_Loss\\_Avoidance\\_Study.pdf](http://www.casfm.org/wp-content/uploads/2017/08/R8_Loss_Avoidance_Study.pdf)

## 2. PLANNING FOR HAZARDS

The Planning for Hazards Implementation Project was initiated by the Department of Local Affairs' (DOLA) Division of Local Government to demonstrate how communities can use land use, building codes, and other strategies to reduce the risk of damage or destruction due to hazards such as floods and wildfires. In the spring of 2016, the DOLA's Division of Local Government launched the *Planning for Hazards: Land Use Solutions for Colorado* guide and website to help communities mitigate their risks to natural hazards.

Building Codes are one specific land use tool that is covered in this guide, providing an overview for communities regarding: how Building Codes work, how to implement, examples of where they have been successfully implemented, as well as advantages and challenges to

adopting. For more information, please visit the Planning for Hazards website:  
<https://www.planningforhazards.com/building-code>

### **3. MOODY'S ANALYTICS CREDIT RATINGS FOR JURISDICTIONS**

Moody's Analytics (Moody's) has been tracking and released reports on the increasing impacts of hazards to jurisdictions due to climate change. They identify a key need for jurisdictions to proactively adapt and prepare for increased exposure to hazards due to climate change in order to protect a high credit rating. They note displacement due to damaged structures and infrastructure vulnerability as two key aspects considered when analyzing impacts on hazards, and future projections of hazards, in a jurisdiction. Building codes that effectively protect structures from disaster may reduce a jurisdiction's exposure to a credit downgrade.

<https://www.eticanews.it/wp-content/uploads/2017/01/Moodys-climate-change-and-sovereigns-November-7.pdf>

### **4. NATURAL HAZARD MITIGATION SAVES**

The National Institute of Building Sciences (NIBS) recently released its 2017 Inter Report, titled *Natural Hazard Mitigation Saves*. As part of this study, Research focused on the benefits in designing new buildings to exceed IBC and IRC requirements. An excerpt from the report's *Summary of Findings* is included below:

## Multiple Stakeholders Benefit from Above-Code Design

Designing new buildings in some places to exceed select 2015 IBC and IRC requirements, and designing new buildings in parts of the WUI to better resist fire, affects various stakeholder groups differently. The project team considered how each of five stakeholder groups bears the costs and enjoys the benefits of mitigation for the four natural hazards under consideration. Stakeholders include:

**Developers:** Corporations that invest in and build new buildings, and usually sell the new buildings once they are completed, owning them only for months or a few years.

**Title holders:** People or corporations, who own existing buildings, generally buying them from developers or from prior owners.

**Lenders:** People or corporations that lend a title holder the money to buy a building. Loans are typically secured by the property, meaning that if the title holder defaults on loan payments, the lender can take ownership.

**Tenants:** People or corporations, who occupy the building, whether they own it or not. This study uses the term “tenant” loosely, and includes visitors.

**Community:** People, corporations, local government, emergency service providers, and everyone else associated with the building or who does business with the tenants.

When one subtracts the costs each group bears from the benefits it enjoys, the difference - called the net benefit - is positive in each category. Figure 8 reflects long-term averages to broad groups, so it only speaks to the group as a whole, on average, rather than to the experience of each individual member of the group.

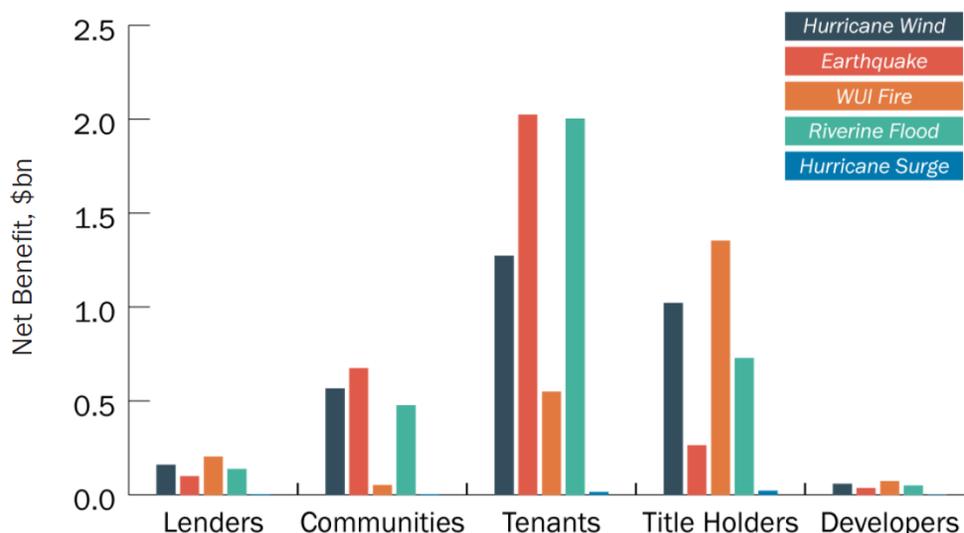


Figure 8. Stakeholder net benefits resulting from one year of constructing all new buildings

# RESOURCES FOR ACTION

The following Table 9C-2 highlights potential resources.

TABLE 9C-2 POTENTIAL RESOURCES FOR ACTION

Resource	Description of building code connection	Where to find more information?
<b>COMcheck</b>	Software to check commercial compliance with IECC and ASHRAE.	<a href="https://www.energycodes.gov/comcheck">https://www.energycodes.gov/comcheck</a>
<b>REScheck</b>	Software to check residential compliance with IECC and ASHRAE.	<a href="https://www.energycodes.gov/images/states-can-use-rescheck-show-compliance">https://www.energycodes.gov/images/states-can-use-rescheck-show-compliance</a>
<b>Governer’s Energy Office (GEO)</b>	Works with building departments to provide energy code training, information, and other resources to support local adoption and implementation.	<a href="https://www.colorado.gov/energyoffice">https://www.colorado.gov/energyoffice</a>
<b>DOLA Planning for Hazards</b>	Provides communities with information for local municipalities related to building codes and other land use tools to reduce disaster risk.	<a href="http://www.Planningforhazards.com">www.Planningforhazards.com</a>

# APPENDIX D: TOOLS

# SECTION 9. APPENDIX D: ENHANCED COMPLIANCE TOOLS

## CONTENTS

Enhanced Compliance Tools Overview.....	2
Meeting Agenda Template: Mitigation Strategy Review and Mitigation Action Review & Assessment.....	6
Meeting Minutes Template: Mitigation Strategy Review and Mitigation Action Review & Assessment .....	7
Meeting Agenda Template: HIRA Review & Update & Enhanced Compliance Evaluation.....	8
Meeting Minutes Template: HIRA Review & Update & Enhanced Compliance Evaluation.....	9
Meeting Agenda Template: SHMT Meeting .....	10
Meeting Minutes Template: SHMT Meeting .....	11
Record of Mitigation Coordination.....	13
Local Mitigation Capabilities Tracker .....	15
Mitigation Project Prioritization Tool.....	16
Mitigation Action Tracker.....	17
Post-Event Assessment of Mitigation Effectiveness Checklist .....	18
Eligible HMA Activities by Program.....	20
HMA Project Eligibility & Completeness Checklist.....	21
HMA HMP Eligibility & Completeness Checklist.....	26
HMA Sub-Recipient Closeout Checklist.....	28
HMA Sub-Recipient to State Closeout Letter .....	33
HMA Sub-Recipient to State De-Obligation Letter.....	34
Annual Mitigation Progress Report Template.....	35

# ENHANCED COMPLIANCE TOOLS OVERVIEW

The following tools have been developed to assist the Mitigation Team with a systemic approach to ongoing compliance with enhanced hazard mitigation plan requirements. These tools supplement existing grants procedures, such as the Hazard Mitigation Grant Program (HMGP) Administrative Plan.

## **Meeting Agenda Template: Mitigation Strategy Review and Mitigation Action Review & Assessment**

This meeting will be held annually in the Spring as per the Plan Maintenance Schedule (Table 7-2) in Chapter 7.

## **Meeting Minutes Template: Mitigation Strategy Review and Mitigation Action Review & Assessment**

This template may be used to capture the minutes of the above meeting.

## **Meeting Agenda Template: Hazard Identification & Risk Assessment (HIRA) Review & Update and Enhanced Compliance Evaluation**

This meeting will be held annually in the Fall as per the Plan Maintenance Schedule (Table 7-2) in Chapter 7.

## **Meeting Minutes Template: HIRA Review & Update and Enhanced Compliance Evaluation**

This template may be used to capture the minutes of the above meeting.

## **Meeting Agenda Template: State Hazard Mitigation Team (SHMT) Meeting**

This meeting will be held annually concurrent with one of the Colorado Resiliency Office (CRO) quarterly meetings, as described in Section 8.1.1

## **Meeting Minutes Template: State Hazard Mitigation Team (SHMT) Meeting**

This template may be used to capture the minutes of the above meeting.

## **Record of Mitigation Coordination**

This form can be used to guide and document formal or informal discussions with other departments and agencies regarding the statewide hazard mitigation program. To ensure the SHMP remains coordinated and integrated with other state and regional planning initiatives, the Mitigation Team should document engagement with each of the agencies listed in Chapter 8, Table 8-3. Agency participation in the annual plan implementation meetings (listed above) may preclude the need to document a separate engagement. This form can also be used by DHSEM

Regional Field Managers to document coordination and integration discussions with local mitigation programs, as necessary.

### **Local Mitigation Capabilities Tracker**

This form may be filled out by local and tribal emergency management programs to provide updated information to DHSEM on their mitigation capabilities. It may be used on its own or in conjunction with the Record of Mitigation Coordination.

### **Mitigation Project Prioritization Tool**

This example Microsoft Excel-based tool was developed as part of the E-SHMP to help prioritize proposed mitigation projects. SHMT members can use it to customize the scoring and ranking of their respective projects and/or actions. Users may choose to only utilize certain criteria, add custom criteria based upon agency or funding requirements or limitations, and uniquely weight the scoring of each criteria as necessary. The resiliency prioritization criteria enable SHMT members to score and rank projects and/or projects within each participating agency, according to each agencies' priorities and funding requirements. The resiliency prioritization criteria are intended to be flexible. A copy of this .xlsx database tool is available through DHSEM.

### **Mitigation Action Tracker**

A Mitigation Action Database was developed as part of the E-SHMP. This Microsoft Excel-based database allows DHSEM and SHMT members to track the status and implementation of the newly identified and on-going 2018 actions. In addition, it allows for the historical tracking of successfully implemented actions from current and past years. This database is intended to serve as a living tool to be leveraged as part of the Plan's maintenance and implementation. A copy of this .xlsx database is available through DHSEM.

### **Post-Event Assessment of Mitigation Effectiveness Checklist**

This checklist can be used to measure or estimate the effectiveness of mitigation actions following an actual hazard incident or disaster.

### **Eligible Hazard Mitigation Assistance (HMA) Activities by Program**

This Table, reprinted from FEMA's 2015 HMA Guidance manual, summarizes what types of projects, activities, and costs are eligible under the three HMA grant streams.

### **HMA Project Eligibility & Completeness Checklist**

This checklist, modified from FEMA's 2015 HMA Guidance, is used to ensure project sub-applications submitted to FEMA meet both state and FEMA requirements for eligibility.

### **HMA Hazard Mitigation Plan (HMP) Eligibility & Completeness Checklist**

This checklist, modified from FEMA's 2015 HMA Guidance, is used to ensure hazard mitigation planning sub-applications submitted to FEMA meet both state and FEMA requirements for eligibility.

### **HMA Sub-Recipient Closeout Checklist**

This checklist is used to ensure subaward closeout requests submitted to FEMA meet both state and FEMA requirements for eligibility.

### **HMA Sub-Recipient to State Closeout Letter**

This template is used by HMA subrecipients to close out projects.

### **HMA Sub-Recipient to State De-Obligation Letter**

This template is used by HMA subrecipients to de-obligate remaining funds.

### **Annual Mitigation Progress Report Template**

This report will be released annually, summarizing developments in the mitigation program. This report collates and summarizes the information in the above reports and meetings, and captures all information necessary to demonstrate enhanced plan compliance in one document.

### **Other Resources**

The State of Colorado Hazard Mitigation Grant Program (HMGP) Administrative Plan, dated March 10, 2017 (currently being updated), is the primary document used to ensure ongoing HMA compliance. It is described more fully in Section 8.1.3 and is incorporated here by reference.

Additional tools, checklists, and job aids can be downloaded from the following websites:

- FEMA Benefit-Cost Analysis (BCA) Program guidelines and BCA Tool Download  
<https://www.fema.gov/benefit-cost-analysis>
- Hazard Mitigation Assistance Tools and Resources:  
<https://www.fema.gov/media-library/assets/documents/34870>
- Hazard Mitigation Assistance Job Aids:  
<https://www.fema.gov/media-library/assets/documents/102051>
- Hazard Mitigation Products:  
<https://www.fema.gov/media-library/resources-documents/collections/479>
- Mitigation Fact Sheets:  
<https://www.fema.gov/media-library/resources-documents/collections/9>



# COLORADO

## Division of Homeland Security & Emergency Management

Department of Public Safety

### MEETING AGENDA

**Purpose:** Mitigation Strategy Review and Mitigation Action Review & Assessment  
**Date:** (Target: annually in May)  
**Time:**  
**Location:**

### Meeting Access Information:

**If Local Call** \_\_\_\_\_ **or** \_\_\_\_\_ **Passcode:** \_\_\_\_\_

### Agenda

- [time] **Welcome & Introductions**
- [time] **Status of Enhanced State Hazard Mitigation Plan and Planning Cycle**
- [time] **Review of Significant Hazard Incidents During Past Year**
  - Declared state/local/tribal disaster emergencies
  - Other hazard events of note
- [time] **Mitigation Strategy Review** *(note: may be skipped in the first year after SHMP approval)*
  - Review of current mitigation Goals and Objectives
  - New or updated information that might suggest changes to Goals and Objectives
  - Discussion of proposed changes to Goals and Objectives, if any
- [time] **Mitigation Action Review & Assessment**
  - Status update on all current mitigation actions
  - Changes to prioritization
  - Funding changes or concerns
  - New action items, if any
  - Pre-development of project proposals for possible later funding
- [time] **Assessments of Mitigation Effectiveness**
  - Losses avoided from actual events due to mitigation activities
  - Calculated/projected savings from mitigation activities
- [time] **Other Relevant Information**
- [time] **Action Items**
- [time] **Closing Remarks**

Next meeting:



# COLORADO

## Division of Homeland Security & Emergency Management

Department of Public Safety

---

### MEETING MINUTES

**Purpose:** Mitigation Strategy Review and Mitigation Action Review & Assessment

**Date:**

**Time:**

**Location:**

---

### Attendees

### Agenda

- Welcome & Introductions
- Status of Enhanced State Hazard Mitigation Plan and Planning Cycle
- Review of Significant Hazard Incidents During Past Year
- Mitigation Strategy Review (*note: may be skipped in the first year after SHMP approval*)
- Mitigation Action Review & Assessment
- Assessments of Mitigation Effectiveness
- Other Relevant Information
- Action Items
- Closing Remarks

### Action Items

- 1.
- 2.

### Next Meeting

### Meeting Summary

#### **Status of Enhanced State Hazard Mitigation Plan and Planning Cycle**

#### **Review of Significant Hazard Incidents During Past Year**

#### **Mitigation Strategy Review**

#### **Mitigation Action Review & Assessment**

#### **Assessments of Mitigation Effectiveness**

#### **Other Relevant Information**



# COLORADO

## Division of Homeland Security & Emergency Management

Department of Public Safety

---

### MEETING AGENDA

**Purpose:** HIRA Review & Update and Enhanced Compliance Evaluation  
**Date:** (Target: annually in November)  
**Time:**  
**Location:**

---

### Meeting Access Information:

**If Local Call** \_\_\_\_\_ **or** \_\_\_\_\_ **Passcode:** \_\_\_\_\_

### Agenda

- [time] **Welcome & Introductions**
  - [time] **Status of Enhanced State Hazard Mitigation Plan and Planning Cycle**
  - [time] **Review of Significant Hazard Incidents During Past Year**
    - Declared state/local/tribal disaster emergencies
    - Other hazard events of note
  - [time] **Hazard Identification and Risk Assessment (HIRA) Review & Update**
    - Review existing hazards and risk rankings
    - New/updated information that might suggest changes to existing risk rankings
    - New hazards worth adding to HIRA
    - Changes to risk assessment of state assets
  - [time] **Evaluation of Enhanced Plan Compliance**
    - Compliance with FEMA mitigation grant performance measure
    - Changes to agency responsibilities pertaining to mitigation
    - Changes to agency capabilities pertaining to mitigation
    - Changes to any relevant laws, regulations, codes, policies, or plans
    - Mitigation training, education, technical assistance, or outreach
    - Mitigation-related coordination or partnerships between agencies/initiatives
  - [time] **Other Relevant Information**
  - [time] **Action Items**
  - [time] **Closing Remarks**
- Next meeting:



# COLORADO

## Division of Homeland Security & Emergency Management

Department of Public Safety

---

### MEETING MINUTES

**Purpose:** HIRA Review & Update and Enhanced Compliance Evaluation

**Date:**

**Time:**

**Location:**

---

### Attendees

### Agenda

- Welcome & Introductions
- Status of Enhanced State Hazard Mitigation Plan and Planning Cycle
- Review of Significant Hazard Incidents During Past Year
- Hazard Identification and Risk Assessment (HIRA) Review & Update
- Evaluation of Enhanced Plan Compliance
- Other Relevant Information
- Action Items
- Closing Remarks

### Action Items

- 1.
- 2.

### Next Meeting

### Meeting Summary

#### **Status of Enhanced State Hazard Mitigation Plan and Planning Cycle**

#### **Review of Significant Hazard Incidents During Past Year**

#### **HIRA Review & Update**

#### **Evaluation of Enhanced Plan Compliance**

#### **Other Relevant Information**



# COLORADO

## Division of Homeland Security & Emergency Management

Department of Public Safety

### MEETING AGENDA

**Purpose:** State Hazard Mitigation Team (SHMT) Annual Meeting  
**Date:** (Target: annually)  
**Time:**  
**Location:**

### Meeting Access Information:

**If Local Call** \_\_\_\_\_ **or** \_\_\_\_\_ **Passcode:** \_\_\_\_\_

### Agenda

- [time] **Welcome & Introductions**
  - [time] **Status of Enhanced State Hazard Mitigation Plan and Planning Cycle**
  - [time] **Status of Integration with State and Regional Planning Initiatives**
    - Colorado Homeland Security and All-Hazards Senior Advisory Committee (HSAC)
    - Colorado Threat and Hazard Identification and Risk Assessment (THIRA)
    - Colorado Resiliency Framework
    - Technical Assistance Partnerships (TAPs)
    - Flood Hazard Plan for Colorado
    - Colorado Drought Mitigation and Response Plan
    - Colorado Water Plan
    - Colorado Emergency Planning Committee (CEPC)
    - Colorado Disaster Housing Task Force
    - Colorado Energy Assurance Emergency Plan (CEAEP)
    - Colorado Sustainable Main Streets Initiative
    - Climate Change and Related Planning Initiatives
    - Local Hazard Mitigation Plans
    - Additional Integration Initiatives (E-SHMP Table 8-3)
    - Other Initiatives to note?
  - [time] **Status of Integration with FEMA Mitigation Programs and Initiatives**
    - Hazard Mitigation Assistance (HMA) Program
    - National Flood Insurance Program (NFIP)
    - Risk MAP
    - Cooperating Technical Partner (CTP) Program
    - National Earthquake Hazards Reduction Program (NEHRP)
    - Chemical Stockpile Emergency Preparedness Program (CSEPP)
  - [time] **Status of Integration with other Federal / National Mitigation Programs and Initiatives**
    - U.S. Army Corps of Engineers (USACE)
    - U.S. Geological Survey (USGS)
    - National Weather Service (NWS) StormReady Program
    - U.S. Bureau of Reclamation (USBR) WaterSMART Program
    - National Fire Protection Association (NFPA) Firewise Program
    - Community Development Block Grant (CDBG) Program
    - Emergency Management Accreditation Program (EMAP)
  - [time] **Other Relevant Information**
  - [time] **Action Items**
  - [time] **Closing Remarks**
- Next meeting:



# COLORADO

## Division of Homeland Security & Emergency Management

Department of Public Safety

---

### MEETING MINUTES

**Purpose:** State Hazard Mitigation Team (SHMT) Annual Meeting

**Date:**

**Time:**

**Location:**

---

### Attendees

### Agenda

- Welcome & Introductions
- Status of Enhanced State Hazard Mitigation Plan and Planning Cycle
- Status of Integration with State and Regional Planning Initiatives Year
- Status of Integration with FEMA Mitigation Programs and Initiatives
- Status of Integration with other Federal / National Mitigation Programs and Initiatives
- Other Relevant Information
- Action Items
- Closing Remarks

### Action Items

- 1.
- 2.

### Next Meeting

### Meeting Summary

#### **Status of Enhanced State Hazard Mitigation Plan and Planning Cycle**

#### **Status of Integration with State and Regional Planning Initiatives**

Colorado Homeland Security and All-Hazards Senior Advisory Committee (HSAC)

Colorado Threat and Hazard Identification AND Risk Assessment (THIRA)

Colorado Resiliency Framework

Technical Assistance Partnerships (TAPs)

Flood Hazard Plan for Colorado

Colorado Drought Mitigation and Response Plan

Colorado Water Plan

Colorado Emergency Planning Committee

Colorado Disaster Housing Task Force

Colorado Energy Assurance Emergency Plan (CEAEP)

Colorado Sustainable Main Streets Initiative

Climate Change and Related Planning Initiatives

Local Hazard Mitigation Plans

Additional Integration Initiatives (E-SHMP Table 8-3)

Other Initiatives to note?

#### **Status of Integration with FEMA Mitigation Programs and Initiatives**

Hazard Mitigation Assistance (HMA) Program

National Flood Insurance Program (NFIP)

Risk MAP

Cooperating Technical Partner (CTP) Program

National Earthquake Hazards Reduction Program (NEHRP)

Chemical Stockpile Emergency Preparedness Program (CSEPP)

#### **Status of Integration with other Federal / National Mitigation Programs and Initiatives**

U.S. Army Corps of Engineers (USACE)

U.S. Geological Survey (USGS)

National Weather Service (NWS) StormReady Program

U.S. Bureau of Reclamation (USBR) WaterSMART Program

National Fire Protection Association (NFPA) Firewise Program

Community Development Block Grant (CDBG) Program

Emergency Management Accreditation Program (EMAP)

#### **Other Relevant Information**



# COLORADO

## Division of Homeland Security & Emergency Management

Department of Public Safety

### RECORD OF MITIGATION COORDINATION

Date of Meeting: \_\_\_\_\_

Name of Agency: \_\_\_\_\_

Name or Nature of Meeting: \_\_\_\_\_

#### Coordination Sectors Agency Is Involved In (See Table 8-1 in 2018 SHMP)

Emergency Management	Economic Development	Land Use Development	Housing	Health & Social Services	Infrastructure	Natural & Cultural Resources

Status of Current/Ongoing Mitigation Projects: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

New or Previously-Unidentified Mitigation Projects: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Funding Developments: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Changes in Agency Mitigation Capabilities: \_\_\_\_\_

---

---

---

Changes in Relevant Law, Regulations, Policies, or Plans: \_\_\_\_\_

---

---

---

Mitigation-Related Coordination with Other Agencies/Initiatives: \_\_\_\_\_

---

---

---

Changes to Agency's Mitigation Priorities: \_\_\_\_\_

---

---

---

Mitigation Training: \_\_\_\_\_

---

---

---

Assessments of Effectiveness of Mitigation Projects: \_\_\_\_\_

---

---

---

## Local Mitigation Capabilities Tracker for Local and State Plan Updates

**Jurisdiction:** \_\_\_\_\_

**Date:** \_\_\_\_\_

Planning and Regulatory	Yes/No
Building Codes	
Building Codes Year	
BCEGS Rating	
Capital Improvements Program (CIP) or Plan	
Community Rating System (CRS)	
Community Wildfire Protection Plan (CWPP)	
Comprehensive, Master, or General Plan	
Economic Development Plan	
Elevation Certificates	
Erosion/Sediment Control Program	
Floodplain Management Plan or Ordinance	
Flood Insurance Study	
Growth Management Ordinance	
Non-Flood Hazard-Specific Ordinance or Plan (e.g.- Steep Slope, Wildfire, Snow Load)	
NFIP	
Site Plan Review Requirements	
Stormwater Program, Plan, or Ordinance	
Zoning Ordinance	
Other	

Administrative and Technical	Yes/No
Emergency Manager	
Floodplain Administrator	
Community Planning:	
- Planner/Engineer (Land Development)	
- Planner/Engineer/Scientist (Natural Hazards)	
- Engineer/Professional (Construction)	
- Resiliency Planner	
- Transportation Planner	
Full-Time Building Official	
GIS Specialist and Capability	
Grant Manager, Writer, or Specialist	
Warning Systems/Services:	
- General	
- Flood	
- Wildfire	
- Tornado	
- Geological Hazards	
Other	

Financial	Yes/No
Has community used any of the following to fund mitigation activities:	
- Levy for Specific Purposes with Voter Approval	
- Utilities Fees	
- System Development / Impact Development Fee	
- General Obligation Bonds to Incur Debt	
- Special Tax Bonds to Incur Debt	
- Withheld Spending in Hazard-Prone Areas	
- Stormwater Service Fees	
- Capital Improvement Project Funding	
- Community Development Block Grants	
- Other	

Education & Outreach	Yes/No
Local Citizen Groups that Communicate Hazard Risks	
Firewise	
StormReady	
Other	

The mission of the Colorado Division of Homeland Security and Emergency Management is to lead and support Colorado's effort to prevent, protect, mitigate, respond to, and recover from all-hazards events.







# COLORADO

## Division of Homeland Security & Emergency Management

Department of Public Safety

### POST-EVENT ASSESSMENT OF MITIGATION EFFECTIVENESS - CHECKLIST

This checklist can be used to measure or estimate the effectiveness of mitigation actions following an actual hazard incident or disaster.

Disaster or Hazard Incident: \_\_\_\_\_

Mitigation Project Evaluated: \_\_\_\_\_

Date(s) of Incident: \_\_\_\_\_

Date of Assessment: \_\_\_\_\_

Assessment Completed By: \_\_\_\_\_

	<b>Phase 1: Project Identification &amp; Selection</b>	<b>Yes</b>	<b>No</b>	<b>NA</b>
1a	Review data from hazard event.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1b	Compare area affected by the incident/disaster to database of mitigation projects. Are there any completed or ongoing mitigation projects in the impacted area?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1c	[OR] Are there any mitigation projects in areas <u>not</u> impacted by the incident/disaster, which could be used to extrapolate losses that could have been reduced if the incident/disaster had happened in that area?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1d	Is the mitigation project of a type that could potentially reduce losses from the incident/disaster?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1e	Was a Benefit Cost Analysis (BCA) done for the project pre-event?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1f	Is there adequate data for the project to calculate effectiveness?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Note: See the State Capabilities section of the SHMP for state resources that may have relevant data and technical expertise to assist with this analysis.

<b>Phase 2: Hazard Event Analysis</b>		Yes	No	NA
2a	Review data from the mitigation project.	X	X	X
2b	Was the hazard event severe enough to have caused damage if the project had not been in place?			
2c	Has there been an estimation on the recurrence interval of the event? (ie – 100-year storm, 500-year flood, etc)			

Note: Wherever possible, effectiveness should be measured in terms of interconnected hazards rather than simply looking at one event. For example, fire mitigation efforts may also be effective at decreasing flood losses.

<b>Phase 3: Project Effectiveness/Loss Avoidance Analysis</b>		Yes	No	NA
3a	Is there enough information to make a quantitative evaluation?			
3b	Calculate the damage that actually occurred with the mitigation action in place (Mitigation Project Complete, MPc). MPc =	X	X	X
3c	Calculate or estimate the damage that would likely have occurred if the mitigation action had not been taken (Mitigation Project Absent, MPa). MPa =	X	X	X
3c	MPa – MPc = Return on Investment (ROI). ROI =	X	X	X
3d	[If 3a was NO] Is there enough information to make a <u>qualitative</u> analysis and discussion summarizing the benefits (What would have been damaged if the project had not been in place?) and effectiveness (did the project perform as intended?) of the mitigation action?			

Note: MPa is most often calculated based on past incidents that impacted this or similar areas.

<b>Phase 4: Documentation</b>		Yes	No	NA
4a	Document the results of this assessment in a memorandum or other report, to be provided to the State Hazard Mitigation Team (SHMT).	X	X	X

## Eligible HMA Activities by Program

<b>Eligible Activities</b>	<b>HMGP</b>	<b>PDM</b>	<b>FMA</b>
<b>Mitigation Projects</b>	√	√	√
Property Acquisition and Structure Demolition	√	√	√
Property Acquisition and Structure Relocation	√	√	√
Structure Elevation	√	√	√
Mitigation Reconstruction	√	√	√
Dry Floodproofing of Historic Residential Structures	√	√	√
Dry Floodproofing of Non-residential Structures	√	√	√
Generators	√	√	
Localized Flood Risk Reduction Projects	√	√	√
Non-Localized Flood Risk Reduction Projects	√	√	
Structural Retrofitting of Existing Buildings	√	√	√
Non-structural Retrofitting of Existing Buildings and Facilities	√	√	√
Safe Room Construction	√	√	
Wind Retrofit for One- and Two-Family Residences	√	√	
Infrastructure Retrofit	√	√	√
Soil Stabilization	√	√	√
Wildfire Mitigation	√	√	
Post-Disaster Code Enforcement	√		
Advance Assistance	√		
5% Initiative Projects*	√		
Aquifer and Storage Recovery**	√	√	√
Flood Diversion and Storage**	√	√	√
Floodplain and Stream Restoration**	√	√	√
Green Infrastructure**	√	√	√
Miscellaneous/Other**	√	√	√
<b>Hazard Mitigation Planning</b>	√	√	√
<b>Technical Assistance</b>			√
<b>Management Costs</b>	√	√	√

\*FEMA allows increasing the 5% Initiative amount up to 10% for a Presidential major disaster declaration under HMGP. The additional 5% Initiative funding can be used for activities that promote disaster-resistant codes for all hazards. As a condition of the award, either a disaster-resistant building code must be adopted, or an improved Building Code Effectiveness Grading Schedule (BCEGS) is required.

\*\*Indicates that any proposed action will be evaluated on its own merit against program requirements. Eligible projects will be approved provided funding is available.

Costs for eligible activities must be reasonable, allowable, allocable, and necessary as required by 2 CFR Part 200 Subpart E, applicable program regulations, and this guidance.

Table adapted from FEMA's Hazard Mitigation Assistance (HMA) Guidance, dated February 27, 2015. DHSEM will check for changes or updates during all HMA application opportunities.

## Criteria Checklist for Project Subapplications – HMGP, PDM, FMA

Subapplications submitted to FEMA that do not contain at least the basic components listed below may be immediately denied because there is no method to determine eligibility without these data. This information is required for all submittals, including potential substitutions, and further details may be requested by CO DHSEM to complete the subapplication. Please include a copy of this Checklist as a cover page with your application and upload it into your CO.EM.Grants application. Applications without the checklist will be considered incomplete and returned to the sub-applicant. Please note, additional information may be requested during FEMA review.

Subapplication Component	Yes	No	Comment
<b>Applicant and Subapplicant</b>			
Is the subapplicant eligible for FEMA funding? Please see <a href="#">FEMA HMA Guidance</a> , Part III. Section A and B			
<b>Plan Requirement</b>			
If applicable, does the project conform to the State and Local Mitigation Plan under 44 CFR Part 201?			
If applicable, does the project conform to the Tribal Mitigation Plan under 44 CFR Section 201.7?			
<b>FEMA E-Grants access for Mitigation Programs (PDM and FMA)</b>			
Has the point of contact or authorized agent for the subapplicant created an account via FEMA's E-Grants portal? (If no, please contact your State Mitigation Specialist for technical assistance).			
<b>CO EM-Grants Website Access</b>			
Has the authorized representative and primary point of contact for the sub-applicant registered for access through the State's grants management system: <a href="http://co.emgrants.com">co.emgrants.com</a> ? (If no, please contact your State Mitigation Specialist for technical assistance.)			
<b>Scope of Work</b>			
Is the scope of work complete, thorough and easily understood by a person who is not familiar with this project?			
Does the project address a problem that has been repetitive or a problem that poses a significant risk to public health and safety if left unsolved?			
Does the project consider long-term changes to the areas and entities it protects?			
Does the project have manageable future <b>maintenance</b> and modifications requirements?			
If the project has a maintenance requirement, has the subapplicant provided a Maintenance agreement or schedule with the project?			
Does the project contribute, to the extent practicable to a long term solution to the problem it is intended to address?			

Does the project include site location(s), maps, and GPS coordinates?			
Does the project solve a problem independently or constitute a functional portion of a solution and is there assurance that the project as a whole will be completed? (Projects that merely identify or analyze hazards or problems are not eligible.)			
Does the project consider and evaluate alternative solutions to the problem? Does the project include a narrative on the "No Action Alternative"?			
<b>Cost Review</b>			
Does the project include a detailed budget?			
Are costs adequately documented? How have quotes been obtained? Is a memo included explaining the cost estimate and how costs are determined?			
With the cost breakdown, are the units used appropriate for the costs? Please evaluate the types of units used and quantities for reasonableness.			
Does the project identify information on cost-share and match sources? Is a Match Commitment letter included as part of the application?			
With the project's cost estimate, are Pre-Award costs identified? If so, are they eligible? Please contact your State Mitigation Specialist and review FEMA's Hazard Mitigation Assistance Guidance (2015) to determine pre-award costs eligibility.			
<b>Schedule</b>			
Does the project include a work schedule for 3 years or less that conforms to period of performance requirements?			
Is the timeline identified for the project appropriate and reasonable for the scope of work to be completed?			
<b>Cost-Effectiveness</b>			
Does the project include a benefit-cost analysis, or alternate cost-effectiveness documentation, such as Substantial Damage verification, and located in a riverine floodplain; or a narrative supporting cost-effectiveness and request for consideration under 5 percent <b>HMGP</b> discretionary funding?			
Do the costs in the BCA match those outlined in the budget (less any annual future maintenance costs)?			
Does the project include substantiating documentation to support values in the BCA? Please upload documentation directly into the BCA module.			
Is the project cost effective and does it substantially reduce the risk of future damage, hardship, loss, or suffering?			
<b>Environmental and Historical Preservation</b>			
Project includes information to demonstrate conformance with 44 CFR Part 9 and Part 10 (or FEMA Directive Number: FD 108- 1, <i>Environmental and Historic Preservation Planning, Responsibilities and Program Requirements</i> )?			

Project includes information and documentation required by the EHP Checklist, including all available information relating to known historic, archaeological, or environmentally sensitive areas (e.g., Coastal Barrier Resources System Units or Otherwise Protected Areas)?			
Project includes EHP information for each property identified in the subapplication, including the construction date for each property?			
Project demonstrates and documents consideration of alternatives that avoid or minimize harm to the environment or historic resources?			
Project includes documentation of all coordination, correspondence, consultation, or previous EHP reviews with appropriate Federal, State, and local agencies? Please submit consultation letters with your application (see the attached EHP spreadsheet to determine which agencies should be contacted for your project type).			
Does the project include all known EHP compliance costs?			
<b>Acquisition / Demolition / Relocation Information (If applicable) N/A <input type="checkbox"/></b>			
Does the project confirm compliance with timelines and all other criteria set forth in 44 CFR Part 80 requirements?			
Does the application include a photograph that represents the appearance of each property site at the time of application? Photos are required for each structure included in the application. Photos of exterior front, sides, and back of structures.			
For the cost estimate, how were home values determined (i.e. assessor data or appraisal)?			
Does the project include Voluntary Interest documentation for each property? This must include language that the subapplicant has informed the property owner in writing that it will not use its eminent domain authority for the open space purpose.			
Does the project include Declaration and Release forms for each participating household?			
Does the project include Hazard Materials survey form for each property?			
Does the project prioritize the properties to be acquired? Is the prioritization based on a "highest risk properties first" methodology?			
Does the project provide a narrative on property prioritization methodology? Please provide an explanation on how properties were prioritized.			
Does the project provide a secondary property list?			
Has the subapplicant sent letters to the Colorado Department of Transportation (CDOT) and the US Army Corps of Engineers (USACE) to determine if future infrastructure projects are planned in the project area?			

Are any of the properties identified for acquisition renter occupied housing?			
If the project has identified eligible tenants (renters), does the project document costs associated with Uniform Relocation Act (URA) in the cost estimate?			
For relocated projects, will the structure be relocated outside of the Special Flood Hazard Area?			
Does the project include a copy of FEMA's Model Deed Restriction?			
<b>Elevation Information (if applicable) N/A <input type="checkbox"/></b>			
Does the project identify the Base Flood Elevation or Advisory Base Flood Elevation?			
Does the project include finished floor elevation (Elevation Certificate is preferred)?			
Does the project include proposed elevation height of the structure?			
Is the project consistent with the design and implementation of ASCE 24-14?			
Does the project provide a property prioritization ranking?			
Does the project provide a narrative on property prioritization methodology? Please provide an explanation on how properties were prioritized.			
Does the project include a backup list of properties identified for mitigation beyond the primary list?			
<b>Safe Room Information (if applicable) N/A <input type="checkbox"/></b>			
Does the project include the population size to be protected?			
Is the project consistent with the design and implementation criteria of FEMA P-320 or FEMA P-361?			
<b>Wind Retrofit Information (if applicable) N/A <input type="checkbox"/></b>			
Does the project include the proposed level of protection as per FEMA P-804?			
Is the project consistent with the design and implementation criteria of FEMA P-804?			
<b>Drainage Information (if applicable) N/A <input type="checkbox"/></b>			
Does the project include initial technical information to support size, costs, and local permitting requirements?			
<b>Required Forms</b>			
If applying for PDM or FMA programs, does the project include <a href="#">Standard Form (SF) 424: Application for Federal Assistance SF-424?</a>			
Budget information: if a Non-construction Project, does the project include <a href="#">Budget Information for Non-construction Programs (SF-424a)</a>			

Budget information: if a Construction Project, does the project include <a href="#">Budget Information for Construction Programs (SF-424c)</a>			
Does the project include <a href="#">Certifications Regarding Lobbying, Debarment, Suspension and Other Responsibility Matters; and Drug-Free Workplace Requirements (FF 20-16C)</a> ?			
Does this project include <a href="#">Disclosure of Lobbying Activities (SF-LLL)</a> ? (if the Applicant has engaged in or intends to engage in lobbying activities).			
If a non-construction project, does the project include <a href="#">Assurances for Non Construction Programs (SF-424B)</a> ?			
If a construction project, does the project include <a href="#">Assurances for Construction Programs (SF-424D)</a> ?			

The SF-424 family of forms are available on the Grants.gov website: <http://www.grants.gov/web/grants/forms/sf-424-family.html>

The FEMA Form FF 20-16c, Certifications Regarding Lobbying, Debarment, Suspension and Other Responsibility Matters; and Drug-Free Workplace Requirements is available from the FEMA library online at <https://www.fema.gov/media-library/assets/documents/9754>.

**Certification**

The undersigned assures fulfillment of all requirements of the Hazard Mitigation Assistance (HMA) grant program as contained in the program guidelines and that all information contained herein is true and correct to the best of my knowledge.

\_\_\_\_\_  
Signature of Authorized Representative/Applicant Agent

\_\_\_\_\_  
Title

# DHSEM Eligibility and Completeness Review Checklist for Hazard Mitigation Planning Sub-applications

**Sub-Applicant:** \_\_\_\_\_

**Plan Title:** \_\_\_\_\_

Sub-applications submitted to DHSEM and FEMA that do not contain at least the basic components listed below may be immediately denied because there is no method to determine eligibility without these data. Additional information may be requested during FEMA review prior to award if selected. **Bold items are minimum FEMA requirements.**

Sub-Application Component	Yes	No	Comment
<b>FEMA eGrants access for Mitigation Programs (PDM and FMA)</b>			
Has the point of contact or authorized agent for the sub-applicant created an account via FEMA's Mitigation eGrants portal: <a href="https://portal.fema.gov">https://portal.fema.gov</a> ? (If no, please contact your State Mitigation Specialist for technical assistance.)			
<b>CO EM-Grants Website Access</b>			
Has the authorized representative and primary point of contact for the sub-applicant registered for access through the State's grants management system: <a href="http://co.emgrants.com">co.emgrants.com</a> ? (If no, please contact your State Mitigation Specialist for technical assistance.)			
<b>Scope of Work (SoW)</b>			
<b>Is the proposed mitigation planning activity, as described in the SoW, eligible for the program?</b>			
<b>Is the proposed planning activity described, including whether it will result in a new or updated hazard mitigation plan or enhance an existing mitigation plan, in accordance with the FEMA Mitigation Planning regulation at 44 CFR Part 201 and current HMA Guidance?</b>			
<b>Are participating jurisdiction(s) and private nonprofits, if applicable, identified and described?</b>			
<b>Does the narrative describe procedures to engage stakeholders and participating jurisdictions?</b>			
<b>Does the SoW discuss approaches, outcomes, and level of effort, including key milestones and schedule, and the relationship of each activity to the cost estimate?</b>			
Is an updated Scope of Work (SoW) included in DHSEM Required Document "3. HMP Project Description (SOW, Schedule, Budget)?"			
Does the proposed planning activity described include public involvement, identification of hazards, development of a comprehensive risk/vulnerability assessment, identification of mitigation goals and strategies, and plan implementation & maintenance?			
<b>Mitigation Plan Updates</b>			
<b>Does the SoW describe the process that each jurisdiction will complete to review each section of the previous plan and address gaps, as needed; utilize best available new information (including hazard, land use, and development trends); how the previous plan was implemented; and what process will be used?</b>			

# DHSEM Eligibility and Completeness Review Checklist for Hazard Mitigation Planning Sub-applications

Schedule			
Does the application include a DHSEM-approved work schedule that conforms to POP requirements and allows sufficient time for State or Tribal and FEMA reviews, preparation of required revisions, if needed, formal adoption by all participating jurisdiction(s), and final FEMA approval?			
Is an updated proposed work schedule included in DHSEM Required Document "3. HMP Project Description (SoW, Schedule, Budget)?"			
Cost Review			
Does the application include a detailed cost estimate that supports the SoW and is reasonable for the jurisdiction(s) participating? <i>Lump-sum cost estimates are not eligible and will be NOT be accepted.</i>			
Does the application or sub-application identify information on the required non-Federal cost share and contribution sources?			
Are a completed Cost Estimate and Narrative included in DHSEM Required Document "3. HMP Project Description (SoW, Schedule, Budget)?"			
Is a completed Funding Match Commitment Letter attached for each participating jurisdiction, to include the sub-applicant?			
Attachments/Other Documents to Complete Application			
Is a completed Designated Agent's Delegation of Project Management Duties document attached?			
Are the following completed Federal Forms attached: <ul style="list-style-type: none"> <li>- Standard Form (SF) 424</li> <li>- SF 424A</li> <li>- SF 424B</li> <li>- FEMA Form 20-16C</li> <li>- FEMA Certification Regarding Lobbying</li> </ul>			
Are completed Letter(s) of Intent to Participate for each participating jurisdiction, excluding the sub-applicant, attached?			
Grant Requirements			
Does the sub-applicant acknowledge the Procurement, Request for Reimbursement, and Closeout documentation requirements included in DHSEM Supporting Document "E. Grant Management Documents Required PDM 2018?"			

\_\_\_\_\_  
Signature of Chief Elected Official or Authorized Agent

\_\_\_\_\_  
Date

\_\_\_\_\_  
Title of Chief Elected Official or Authorized Agent

## Closeout Toolkit: Checklist for Hazard Mitigation Assistance Programs Subawards (HMGP, PDM, & FMA)

The State (“Recipient”) must submit closeout requests to FEMA within 90 days of completion of each subaward. At a minimum, the Recipient’s requests for subaward closeouts must include the supporting documentation outlined in this checklist to verify compliance with the award. Additional documentation may be requested prior to FEMA’s approval of the closeout request. A subaward is officially closed when FEMA approves the request and sends a closeout letter to the Recipient confirming the final Federal expenditures for the subaward.

Enclosed: Subrecipient-to-State closeout letter; Subrecipient deobligation request letter

Minimum Requirements	Verified for Compliance?		
	Yes	No	Comments
Required Documentation or Action			
Provide a letter requesting Closeout (Signed by authorized representative, on letterhead, addressed to Director of Office of Emergency Management, DHSEM)			
Provide letter requesting de-obligation of funds, if applicable.			
Certify that the project was completed in compliance with all environmental and/or historic preservation conditions identified in the Record of Environmental Considerations (REC). Provide signed copy of Environmental Declaration form.			
Provide photographs of the completed project to compare with the pre-mitigation photos? ( <i>Photos must be clearly labeled with the FEMA project number, sub-grantee name and address, and latitude/longitude coordinates</i> ).			
Perform a site inspection visit with DHSEM Mitigation Specialist of the completed project and provide a copy of the site inspection report with the closeout request (excluding non-construction sub-awards)?			
Were special environmental/historic preservation compliance conditions identified as part of the approved scope of work (SOW)?			
Was the project completed within the established Period of Performance (POP)?			
Were there approved requests for POP extensions?			
Certify that the entire project was completed in accordance with all required permits and building codes (if applicable)? Provide copies if applicable.			
Certification that the project meets NFIP insurance requirements (if applicable)			
Are there insurable structure(s) remaining in the Special Flood Hazard Area after project completion? <i>If yes, provide proof of insurance for structure(s)</i> .			
Certify that the AW-501 forms (the NFIP Repetitive Loss Update Worksheet) were submitted for BureauNet update, if applicable.			
Was a Duplication of Benefits (DOB) review completed to ensure the sub-grantee did not receive Federal assistance for the same purpose from another source (e.g., Increased Cost of Compliance [ICC], Individual Assistance)?			
Was a Duplication of Programs (DOP) review completed to ensure the sub-grantee did not receive Federal assistance for the same purpose from another source (e.g., Public Assistance, Individual Assistance)?			
Complete quarterly reports in EMGrants until FEMA closes the project.			

DHSEM task: Did the Governor's Authorized Representative or equivalent certify that reported costs were incurred in the performance of eligible work, that the approved work was completed, and that the mitigation measure is in compliance with the provisions of the FEMA-State Agreement? (Certification provided in letter form from DHSEM to FEMA)			DHSEM Action Item
DHSEM task: Has the project been updated in the National Emergency Management Information System (NEMIS)?			DHSEM Action Item
<b>Cost Review</b>	<b>Yes</b>	<b>No</b>	<b>Comments</b>
Were costs incurred after the POP expired?			
Were the final expenditures reported consistent with the approved costs?			
Did the actual reimbursements match the reported sum of expenditures?			
Were the local cost share requirements met?			
Were in-kind third-party contributions identified under the sub-award? <i>If yes, did the sub-grantee obtain prior approval?</i>			
If additional costs were incurred, was prior approval obtained?			
Was expendable and nonexpendable equipment purchased or federally owned equipment furnished? <i>If yes, FEMA Form 20-18, Report on Government Property must be provided.</i>			
Was program income generated under the project? <i>If yes, did the sub-grantee deduct program income from the total project costs?</i>			
Was interest earned on Federal advance payments? <i>If yes, was interest returned to the Treasury according to the applicable regulation for the disaster?</i>			
<b>Planning Requirements</b>	<b>Yes</b>	<b>No</b>	<b>Comments</b>
Has the Recipient verified the activity and approved SOW are consistent with 44 CFR Part 201?			DHSEM Action Item
For new or updated hazard mitigation plans, has a final FEMA-approved mitigation plan been adopted by the community?			
For multi-jurisdictional plans, does the closeout request indicate which jurisdictions adopted the FEMA-approved plan?			
<b>Wind Retrofit Requirements</b>	<b>Yes</b>	<b>No</b>	<b>Comments</b>
For residential buildings, has the project been designed and implemented in conformance with FEMA P-804?			
Does the completed project provide the level of protection approved in the SOW?			
<b>Community Safe Room Requirements</b>	<b>Yes</b>	<b>No</b>	<b>Comments</b>
Submit the final, signed Operations & Maintenance (O&M) Plan, including affirmation that the O&M Plan is consistent with FEMA P-361 criteria.			
Is the completed safe room design consistent with FEMA P-361 criteria and engineer certified?			

<b>Residential Safe Room Requirements</b>	<b>Yes</b>	<b>No</b>	<b>Comments</b>
Is the completed safe room design consistent with FEMA P-320 criteria and engineer certified?			
<b>Flood Risk Reduction Requirements</b>	<b>Yes</b>	<b>No</b>	<b>Comments</b>
If a map revision was required, did the sub-grantee submit documentation to FEMA for a Letter of Map Revision?			
Provide a copy of the as-built drawings. <i>If yes, did the as-built drawings verify the SOW was completed as approved? If no, how was it verified the flood risk reduction project was constructed as designed and compliant with the approved SOW?</i>			
<b>Elevation Requirements</b>	<b>Yes</b>	<b>No</b>	<b>Comments</b>
Provide a Certificate of Occupancy for each structure in the project to certify that the structure is code-compliant.			
Provide a copy of the recorded deed amendment for each property.			
Provide certification by an engineer, floodplain manager, or senior local official that the completed structure is in compliance with the approved SOW, local ordinances, NFIP regulations, and technical bulletins.			
Provide a Final Elevation Certificate (FEMA Form 81-31) for each structure to ensure the structure has been elevated to the approved SOW elevation.			
Provide a front, rear, and side photographs of the final elevated structure.			
Verification of flood insurance for each structure.			
<b>Acquisition Requirements</b>	<b>Yes</b>	<b>No</b>	<b>Comments</b>
Provide photographs of each property site after project implementation that includes the latitude and longitude coordinates of the property.			
Provide a copy of the deed recorded for each mitigated property approved in the SOW.			
Is the deed restrictions recorded consistent with the FEMA Model Deed Restriction language?			
Provide voluntary participation agreements 1 & 2 from each property owner identified in the approved SOW.			
If pre-event market value was used, was Duplication of Benefits (DOB) considered in the purchase price?			
Were the structure(s) removed by demolition within 90 days of settlement of the property transaction?			
For each property identified in the FEMA Repetitive Loss database, a completed FEMA Form AW-501 documenting the completion of mitigation on the repetitive loss property is required. The form is available on the FEMA website at <a href="https://www.fema.gov/media-library/assets/documents/13146">https://www.fema.gov/media-library/assets/documents/13146</a> .			

<b>Reconstruction Requirements</b>	<b>Yes</b>	<b>No</b>	<b>Comments</b>
Provide a Certificate of Occupancy and Final Elevation Certificate for each structure in the project to certify that the structure is code-compliant.			
Provide a copy of a recorded deed for each property, including mitigation reconstruction project deed requirements.			
Provide certification from a building official or licensed design professional verifying that the structure was designed and constructed to the most recent International Building Codes.			
Provide verification of insurance for each structure.			
Certify that final square footage is within 10% of the original structure square footage.			
Provide a final elevation certificate to certify each structure is code-compliant.			
<b>Wildfire Requirement</b>	<b>Yes</b>	<b>No</b>	<b>Comments</b>
Submit final signed Operations and Maintenance (O&M) Plan.			
<b>Generator Requirements</b>	<b>Yes</b>	<b>No</b>	<b>Comments</b>
Provide documentation that the installed generator size and specifications are compliant with those approved in the SOW?			
Provide Air Pollutant Emission Notice (APEN) Permit, if applicable. <a href="https://www.colorado.gov/pacific/cdphe/apen-and-">https://www.colorado.gov/pacific/cdphe/apen-and-</a>			

**Certification**

The undersigned assures fulfillment of all requirements of the Hazard Mitigation Assistance (HMA) grant program as contained in the program guidelines and that all information contained herein is true and correct to the best of my knowledge.

\_\_\_\_\_  
Signature of Authorized Representative/Applicant Agent

\_\_\_\_\_  
Title

PLEASE INCLUDE YOUR LOCAL GOVERNMENT LETTERHEAD

DATE

Michael J. Willis, Director  
Office of Emergency Management  
Colorado Division of Homeland Security & Emergency Management  
9195 East Mineral Ave. #200  
Centennial, CO 80112

RE: Project closeout for FEMA DR-4145-CO, HMGP Project XX

Dear Mr. Willis,

The project referenced above, FEMA DR-4067-CO, HMGP Project XX, has been completed. Financial audit and reimbursements have been finalized. The total cost for the project was XXXXX, accomplished with the following federal, state, and local share cost breakdown:

Federal share: \$XXXXXX  
State share: \$XXXXXX (if applicable)  
Local share: \$XXXXXX

Copies of required documents for closeout for this project are enclosed.

I hereby request closeout of this project and certify that:

The project was completed in accordance with FEMA's approved scope of work;  
All required and allowable costs are accounted for;  
All reported costs were incurred in the performance of eligible work;  
Work was completed in compliance with the provisions of the FEMA-State Agreement;  
Payments were made and final disbursements are accounted for and were made in accordance with the existing requirements of Federal and State laws and regulations;  
No further requests for funding on this project will be made; and  
There are no pending bills or invoices that have not been accounted for.

Further, we attest that all financial records covered by this closeout request (checks, warrants, invoices, in-kind expense reports, etc.) will be retained and made available for Inspection and Audit per 44CFR (Part 14.2) 10/1/00 Edition and OMB Circular A-133.

After the information included with this letter has been reviewed, should you require further information concerning this project closeout, please contact [POINT OF CONTACT for project].

Sincerely,

INDIVIDUAL WHO SIGNED THE APPLICATION or GRANT AGREEMENT

**PLEASE INSERT YOUR LOCAL GOVERNMENT LETTER HEAD**

**DATE**

Michael J. Willis, Director  
Office of Emergency Management  
Colorado Division of Homeland Security and Emergency Management  
9195 East Mineral Ave. #200  
Centennial, CO 80112

Re: De-obligation of funds for **GRANT AND PROJECT NUMBER**

Dear Mr. Willis:

I hereby request de-obligation of **\$XXX** of the remaining funds for this project. The **INSERT SUB-RECIPIENT NAME** has expended all necessary funds to complete their **PROJECT TYPE** project and will not be requesting any further reimbursements from the Colorado Division of Homeland Security and Emergency Management (DHSEM) for this project.

The federal award amount was **\$XXX** and final federal share of the project cost was **\$XXX**. We hereby request that the balance amount of **\$XXX** be de-obligated from the project funding.

<b>PROJECT NUMBER</b>		
<b>Total Budget</b>	<b>Federal 75%</b>	<b>Local 25%</b>
<b>\$XXX</b>	<b>\$XXX</b>	<b>\$XXX</b>
<b>Final project cost</b>	<b>Federal 75%</b>	<b>Local 25%</b>
<b>\$XXX</b>	<b>\$XXX</b>	<b>\$XXX</b>
<b>De-obligation amount</b>	<b>\$XXX</b>	<b>\$XXX</b>

We understand that we will be receiving a letter of de-obligation confirmation from DHSEM, along with any outstanding project documents jointly identified by DHSEM staff and the sub-recipient. It is understood that DHSEM may request further project and financial supporting documentation if still required after the project closeout date.

Should you require further information concerning this project, please contact **XXX** at **XXX-XXX-XXXX**.

Sincerely,

**INDIVIDUAL WHO SIGNED THE APPLICATION**  
**TITLE**



# COLORADO

## Division of Homeland Security & Emergency Management

Department of Public Safety

---

### ANNUAL MITIGATION PROGRESS REPORT

#### **Ongoing Mitigation Programs Update**

Program: Mitigation Planning (including state, local, & tribal)

Lead State Agency: DHSEM

Lead State Agency POC:

Guidance document: [name & year] [link]

Program Update:

Program: FEMA Hazard Mitigation Grant Program (HMGP)

Lead State Agency: DHSEM

Lead State Agency POC:

Guidance document: [name & year] [link]

Program Update:

Program: FEMA Pre-Disaster Mitigation (PDM) Program

Lead State Agency: DHSEM

Lead State Agency POC:

Guidance document: [name & year] [link]

Program Update:

Program: FEMA Flood Mitigation Assistance (FMA) Program

Lead State Agency: DHSEM

Lead State Agency POC:

Guidance document: [name & year] [link]

Program Update:

Program: FEMA Public Assistance (PA) Program

Lead State Agency: DHSEM

Lead State Agency POC:

Guidance document: [name & year] [link]

Program Update:

Program: FEMA National Flood Insurance program (NFIP) and Community Rating System (CRS)

Lead State Agency: CWCB

Lead State Agency POC:

Guidance document: [name & year] [link]

Program Update:

Program: DHSEM Strategic Plan

Lead State Agency: DHSEM

Lead State Agency POC:

Guidance document: [name & year] [link]

Program Update:

Program: State Homeland Security Strategy

Lead State Agency: DHSEM

Lead State Agency POC:

Guidance document: [name & year] [link]

Program Update:

Program: State EOP & Recovery Plan

Lead State Agency: DHSEM

Lead State Agency POC:

Guidance document: [name & year] [link]

Program Update:

Program: Chemical Stockpile Emergency Preparedness Program (CSEPP)

Lead State Agency: DHSEM

Lead State Agency POC:

Guidance document: [name & year] [link]

Program Update:

Program: Risk MAP

Lead State Agency: CWCB

Lead State Agency POC:

Guidance document: [name & year] [link]

Program Update:

Program: National Dam Safety Program (NDSP)

Lead State Agency: DWR Dam Safety

Lead State Agency POC:

Guidance document: [name & year] [link]

Program Update:

Program: National Earthquake Hazards Reduction Program (NEHRP)

Lead State Agency: DNR

Lead State Agency POC:

Guidance document: [name & year] [link]

Program Update:

Program: Cooperating Technical Partners (CTP) Program

Lead State Agency: CWCB / UDFCD

Lead State Agency POC:

Guidance document: [name & year] [link]

Program Update:

Program: Community Assistance Program – State Support Services Element (CAP-SSSE)

Lead State Agency: CWCB

Lead State Agency POC:

Guidance document: [name & year] [link]

Program Update:

Program: Critical Infrastructure Protection Program (CIPP)

Lead State Agency: DPS-DHSEM

Lead State Agency POC:

Guidance document: [name & year] [link]

Program Update:

*Program:*

*Lead State Agency:*

*Lead State Agency POC:*

*Guidance document: [name & year] [link]*

*Program Update:*

### **New Mitigation Programs**

*Program:*

*Lead State Agency:*

*Lead State Agency POC:*

*Guidance document: [name & year] [link]*

*Program Update:*

### **Mitigation Planning**

State HMP Implementation, Maintenance, & Update Cycle:

Other State Plans

Local & Regional Plans

**Other Changes to State Mitigation Capabilities**

[including staffing, funding, laws/policies/procedures, training]

Coordination Sectors:

- Emergency Management
- Economic Development
- Land Use Development
- Housing
- Health & Social Services
- Infrastructure
- Natural & Cultural Resources

**Demonstrated/Assessed Effectiveness of Mitigation Projects**

**Mitigation Trainings and Workshops**

Past Year:

Coming Year:

**Public Outreach & Education**

Past Year:

Coming Year:



# APPENDIX E: E1.1 FULL PLANNING PROCESS SCHEDULE



## Colorado State Enhanced Mitigation Plan (E-SHMP)

### E1.1 – Planning Schedule (Version 1.0)

This document is intended to provide a detailed planning schedule and plan for all elements of the E-SHMP project. Included on the following pages is a comprehensive combination of all content identified in the Request for Proposal and the resulting Project Proposal. Additional details have been refined during initial project meetings with the DHSEM planning leads, in addition to coordination with the State Hazard Mitigation Team (SHMT), individual SHMT members, and other subject matter experts. It is anticipated that this document will be refined over the course of the initial few weeks of the project, with potential modifications throughout the planning process.

A detailed Gantt chart can be found in Appendix A at the end of this document which details timelines for all project elements and sub-elements, including DHSEM planning leads and SHMT reviews, and SHMT meetings.

The remaining portions of this plan step through each of the twenty-two (22) project sub-elements. Details included focus on a combination of items, when applicable, including: timelines, deliverables, DHSEM planning leads coordination / expectations, and SHMT coordination / expectations.

#### Element 1 – Planning Process

##### *E1.1 Planning Schedule*

- Deliverable due date: 11/14/17
- Deliverables:
  - A final version of this planning schedule document
- DHSEM Planning Leads Coordination:
  - Kick-off Meeting – 10/12/17
  - Weekly Webinars – Tuesdays @ 2:30 (began 10/24/17)
  - Emails, phone calls, and other communications as needed
  - An additional three (3) in-person meetings can be scheduled as needed
- DHSEM Planning Leads Expectations:
  - Review and comment on this planning schedule document. A draft version of this document will be made available by 11/7/17, to allow 1 week for review.
  - Approval of the final planning schedule document.
- SHMT Coordination - The following tools will be utilized throughout the project to coordinate with the SHMT:
  - Webinars
  - Emails
  - Online surveys
  - SHMT meetings
  - Individual coordination
  - Project website
  - Additional tools identified in E1.2



- SHMT Expectations:
  - None

## *E1.2 Develop Communication Strategy & Medium*

- Deliverable due date: 12/4/17
- Deliverables:
  - A final plan identifying the preferred communication strategy and medium
  - Begin utilization of communication medium
  - Provide training to SHMT (I/A)
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
  - An additional five (5) in-person meetings can be scheduled as needed
- DHSEM Planning Leads Expectations:
  - Internally determine the preferred communication medium and requirements.
  - Assist in potential coordination with State IT resources
- SHMT Coordination:
  - Potential webinar(s) to inform/educate relating to communication medium
  - Other potential IT-related interactions, depending on the communication medium that is being utilized
- SHMT Expectations:
  - Agreement to utilize the selected communication medium

## *E1.3 Coordination and Integration*

- Deliverable due date: 6/18/18
- Deliverables:
  - A final plan section detailing areas of increased coordination, consistency, and integration across State agencies and mitigation initiatives as identified in the Phase 1 Roadmap
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Review and comment on this plan section, prior to SHMT review. An initial draft version of this document will be made available by 5/3/18, to allow 2 weeks for review.
  - Approval of the final plan section.
- SHMT Coordination:
  - Mitigation Workshop #2 and related pre-workshop and follow-up communications
- SHMT Expectations:
  - Availability to discuss potential coordination and integration ideas and solutions, and the resulting integration activities
  - Review and comment on this plan section. A draft version of this document will be made available by 5/17/18, to allow 2 weeks for review.



## *E1.4 Document Planning Process*

- Deliverable due date: 6/29/18
- Deliverables:
  - A final plan section detailing a narrative of the planning process
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Review and comment on this plan section. An initial draft version of this document will be made available by 5/17/18, to allow 2 weeks for review.
  - Approval of the final plan section
- SHMT Coordination:
  - None
- SHMT Expectations:
  - Participation in the planning process

## *E1.5 Plan Implementation and Maintenance*

- Deliverable due date: 6/18/18
- Deliverables:
  - A final plan section detailing specific actions and timelines DHSEM must follow to successfully complete all implementation and maintenance requirements to maintain Enhanced plan status
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Review and comment on this plan section, prior to SHMT review. An initial draft version of this document will be made available by 5/3/18, to allow 2 weeks for review.
  - Approval of the final plan section
- SHMT Coordination:
  - Mitigation Workshop #2 and related pre-workshop and follow-up communications
- SHMT Expectations:
  - Availability to discuss potential implementation and maintenance ideas and solutions.
  - Review and comment on this plan section. A draft version of this document will be made available by 5/17/18, to allow 2 weeks for review.

## **Element 2 – HIRA**

### *E2.1 Profile Hazards*

- Deliverable due date: 12/19/17
- Deliverables:
  - A draft plan section profiling all natural hazards which meets all FEMA requirements
  - A final plan section by 2/20/18



- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Review and comment on this plan section, prior to SHMT review. An initial draft version of this document will be made available by 12/19/17, to allow 3 weeks for review. When possible, individual hazard sections will be delivered as they are produced, to help streamline this process.
  - Approval of the final plan section
- SHMT Coordination:
  - Mitigation Workshop #1 and related pre-workshop and follow-up communications
- SHMT Expectations:
  - Review and comment on this plan section. A draft version of this document will be made available by 1/22/18, to allow 3 weeks for review.

## *E2.2 Climate Change Requirements*

- Deliverable due date: 12/19/17
- Deliverables:
  - A draft plan section profiling climate change's impacts to all natural hazard profiles which meets all FEMA requirements
  - A final plan section by 2/20/18
  - If applicable, plan sections that relate to technological and human-caused hazards will mirror the schedule for element E2.3
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Review and comment on this plan section, prior to SHMT review. An initial draft version of this document will be made available by 12/19/17, to allow 3 weeks for review. When possible, individual hazard sections will be delivered as they are produced, to help streamline this process.
  - Approval of the final plan section
- SHMT Coordination:
  - Mitigation Workshop #1 and related pre-workshop and follow-up communications
- SHMT Expectations:
  - Review and comment on this plan section. A draft version of this document will be made available by 1/22/18, to allow 3 weeks for review.

## *E2.3 Technological & Human-Caused Hazards*

- Deliverable due date: 1/18/18
- Deliverables:
  - A draft plan section profiling all technological and human-caused hazards
  - A final plan section by 3/29/18



- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Review and comment on this plan section, prior to SHMT review. An initial draft version of this document will be made available by 1/18/18, to allow 3 weeks for review. When possible, individual hazard sections will be delivered as they are produced, to help streamline this process.
  - Approval of the final plan section
- SHMT Coordination:
  - Mitigation Workshop #1 and related pre-workshop and follow-up communications
- SHMT Expectations:
  - Review and comment on this plan section. A draft version of this document will be made available by 2/22/18, to allow 3 weeks for review.

## *E2.4 Jurisdictional Risk Analysis*

- Deliverable due date: 12/19/17
- Deliverables:
  - A draft plan section profiling jurisdictional risk analysis for natural hazards which meets all FEMA requirements
  - A final plan section for natural hazards by 2/20/18
  - Plan sections that relate to technological and human-caused hazards will mirror the schedule for element E2.3
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Assist in determinations as to what local HMP content will be rolled-up into the Plan.
  - Review and comment on this plan section, prior to SHMT review. An initial draft version of this document will be made available by 12/19/17, to allow 3 weeks for review. When possible, individual hazard sections will be delivered as they are produced, to help streamline this process.
  - Approval of the final plan section
- SHMT Coordination:
  - Mitigation Workshop #1 and related pre-workshop and follow-up communications
- SHMT Expectations:
  - Review and comment on this plan section. A draft version of this document will be made available by 1/22/18, to allow 3 weeks for review.

## *E2.5 State Asset Risk*

- Deliverable due date: 12/19/17
- Deliverables:



- A draft plan section profiling state asset risk analysis for natural hazards which meets all FEMA requirements
- A final plan section for natural hazards by 2/20/18
- Plan sections that relate to technological and human-caused hazards will mirror the schedule for element E2.3
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Assist in coordinating the acquisition of state asset data
  - Review and comment on this plan section, prior to SHMT review. An initial draft version of this document will be made available by 12/19/17, to allow 3 weeks for review. When possible, individual hazard sections will be delivered as they are produced, to help streamline this process.
  - Approval of the final plan section
- SHMT Coordination:
  - Mitigation Workshop #1 and related pre-workshop and follow-up communications
- SHMT Expectations:
  - Review and comment on this plan section. A draft version of this document will be made available by 1/23/18, to allow 3 weeks for review.

## *E2.6 Population At-Risk*

- Deliverable due date: 12/19/17
- Deliverables:
  - A draft plan section profiling state asset risk analysis for natural hazards which meets all FEMA requirements
  - A final plan section for natural hazards by 2/20/18
  - Plan sections that relate to technological and human-caused hazards will mirror the schedule for element E2.3
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Assist in coordinating the acquisition of applicable State data
  - Review and comment on this plan section, prior to SHMT review. An initial draft version of this document will be made available by 12/19/17, to allow 3 weeks for review. When possible, individual hazard sections will be delivered as they are produced, to help streamline this process.
  - Approval of the final plan section
- SHMT Coordination:
  - Mitigation Workshop #1 and related pre-workshop and follow-up communications
- SHMT Expectations:



- Review and comment on this plan section. A draft version of this document will be made available by 1/22/18, to allow 3 weeks for review.

## E2.7 Changes in Development

- Deliverable due date: 12/19/17
- Deliverables:
  - A draft plan section profiling risk analysis relating to changes in development, for natural hazards, which meets all FEMA requirements
  - A final plan section for natural hazards by 2/20/18
  - Plan sections that relate to technological and human-caused hazards will mirror the schedule for element E2.3
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Assist in coordinating the acquisition of applicable State data
  - Review and comment on this plan section, prior to SHMT review. An initial draft version of this document will be made available by 12/19/17, to allow 3 weeks for review. When possible, individual hazard sections will be delivered as they are produced, to help streamline this process.
  - Approval of the final plan section
- SHMT Coordination:
  - Mitigation Workshop #1 and related pre-workshop and follow-up communications
- SHMT Expectations:
  - Review and comment on this plan section. A draft version of this document will be made available by 1/22/18, to allow 3 weeks for review.

## E2.8 Loss Methodology Tool

- Deliverable due date: 11/23/17
- Deliverables:
  - A draft plan section documenting the risk assessment methodology for all profiled hazards
  - A final plan section by 3/15/18, to align with the end of the SHMT's final HIRA section review and comment period
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Assist in coordinating the acquisition of applicable State data
  - Review and comment on this plan section, prior to SHMT review. An initial draft version of this document was made available on 10/16/17.
  - Approval of the final plan section
- SHMT Coordination:



- Mitigation Workshop #1 and related pre-workshop and follow-up communications
- SHMT Expectations:
  - Review and comment on this plan section. A draft version of this document was made available on 10/23/17, which allowed 2 weeks for review.

## **Element 3 – Mitigation Strategies**

### *E3.1 Review Goals and Mitigation Actions*

- Deliverable due date: 4/18/18
- Deliverables:
  - A plan section documenting the status of 2013 SHMP mitigation actions and any changes to the State's mitigation goals and objectives
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Assist in coordinating action reporting updates
  - Review and comment on this plan section. An initial draft version of this document will be made available by 4/4/18, to allow 2 weeks for review.
  - Approval of the final plan section
- SHMT Coordination:
  - Mitigation Workshop #1 and related pre-workshop and follow-up communications
- SHMT Expectations:
  - Assistance in reporting on past mitigation actions and participation in a dialog pertaining to necessary updates to the Plan's goals and objectives

### *E3.2 Research Support*

- Deliverable due date: support through 6/18/18
- Deliverables:
  - The results arising from any requested research support pertaining to mitigation strategies and goals
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Assist in helping to identify potential research activities
  - Approval of any resulting final products stemming from this research
- SHMT Coordination:
  - Mitigation Workshops #1, #2, and #3 and related pre-workshop and follow-up communications
- SHMT Expectations:
  - Assistance in contributing any subject matter expertise that may relate to these potential mitigation strategies and goals



- Evaluation of potential mitigation strategies

### *E3.3 3rd Party Facilitator*

- Deliverable due date: support through 6/3/18
- Deliverables:
  - All necessary content and materials for the three (3) SHMT workshops
    - Workshop 1: Late January / Early February
    - Workshop 2: Early-mid April
    - Workshop 3: Mid-late May
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Review and comment on all workshop content and materials
  - Approval of any resulting final products
- SHMT Coordination:
  - Mitigation Workshops #1, #2, and #3 and related pre-workshop and follow-up communications
- SHMT Expectations:
  - Any requested preparation and follow-up workshop activities or content
  - Attendance and participation at the workshops

### *E3.4 Funding Prioritization Process*

- Deliverable due date: 4/18/18
- Deliverables:
  - A final plan section detailing a funding prioritization process to allocate mitigation funding for all identified high and medium risk hazards
  - Facilitation of SHMT discussions relating to funding prioritization
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Review and comment on this plan section, prior to SHMT review. An initial draft version of this document will be made available by 3/28/18, to allow 2 weeks for review.
  - Approval of the final plan section.
  - Review and comment on all workshop content and materials
  - Approval of any resulting final products
- SHMT Coordination:
  - Mitigation Workshop #2 and related pre-workshop and follow-up communications
- SHMT Expectations:
  - Availability to discuss potential funding prioritization ideas and solutions



- Review and comment on this plan section. A draft version of this document will be made available by 4/11/18, to allow 1 week for review.

## *E3.5 Mitigation Actions or Initiatives Spreadsheet*

- Deliverable due date: 6/18/18
- Deliverables:
  - A final spreadsheet detailing newly identified mitigation actions that can be analyzed and monitored over the next 5-year plan cycle.
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Assist in helping to identify necessary spreadsheet components
  - Review and comment on this spreadsheet
  - Approval of any resulting final products
- SHMT Coordination:
  - None
- SHMT Expectations:
  - None

## *E3.6 State and Local Government Mitigation Responsibility Analysis*

- Deliverable due date: 3/22/18
- Deliverables:
  - A final plan section detailing State and local government responsibilities for the implementation of mitigation strategies and actions in Colorado.
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Assist in coordinating the acquisition of applicable State data and contacts
  - Review and comment on this plan section, prior to SHMT review. An initial draft version of this document will be made available by 3/8/18, to allow 1 weeks for review.
  - Approval of the final plan section.
- SHMT Coordination:
  - Mitigation Workshop #1 and related pre-workshop and follow-up communications
- SHMT Expectations:
  - Availability to discuss governmental mitigation responsibilities
  - Review and comment on this plan section. A draft version of this document will be made available by 3/15/18, to allow 1 week for review.

## *E3.7 Analysis of Existing State Referral Process*

- Deliverable due date: 4/13/18
- Deliverables:



- A final plan section detailing the State’s existing land use review and referral process to local communities
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Assist in coordinating the acquisition of applicable State data and contacts
  - Review and comment on this plan section, prior to SHMT review. An initial draft version of this document will be made available by 3/30/18, to allow 1 weeks for review.
  - Approval of the final plan section.
- SHMT Coordination:
  - Mitigation Workshop #1 and related pre-workshop and follow-up communications
- SHMT Expectations:
  - Availability to discuss existing State referral processes
  - Review and comment on this plan section. A draft version of this document will be made available by 4/6/18, to allow 1 week for review.

## Element 4 – Enhanced Plan

### *E4.1 Qualitative and Quantitative Methodology*

- Deliverable due date: 6/18/18
- Deliverables:
  - A final plan section detailing a qualitative and/or quantitative methodology for assessing effectiveness of completed mitigation actions or projects. This analysis on a few select projects will provide a resulting tool to be used to refine mitigation strategies, determine mitigation priorities, and allocate project funding.
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Assist in input and previous best practices for incorporation into the methodology and tool.
  - Review and comment on this plan section, prior to SHMT review. An initial draft version of this document will be made available by 5/3/18, to allow 2 weeks for review.
  - Approval of the final plan section.
- SHMT Coordination:
  - Mitigation Workshop #3 and related pre-workshop and follow-up communications
- SHMT Expectations:
  - Availability to discuss existing State referral processes
  - Review and comment on this plan section. A draft version of this document will be made available by 5/17/18, to allow 2 weeks for review.

### *E4.2 Services and Technical Assistance*



- Deliverable due date: support through 6/18/18
- Deliverables:
  - Recommendations for Statewide mitigation actions and support in developing the updated mitigation strategy
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Assist in input and previous best practices for incorporation into the methodology and tool.
  - Approval of any resulting recommended outputs stemming from this support
- SHMT Coordination:
  - Mitigation Workshops #1, #2, and #3 and related pre-workshop and follow-up communications
- SHMT Expectations:
  - Assistance in contributing any subject matter expertise that may relate to these potential mitigation strategies and goals
  - Evaluation of potential mitigation strategies

#### *E4.3 Funding Sources*

- Deliverable due date: 3/8/18
- Deliverables:
  - A final plan section detailing existing State mitigation resources and potential strategies to explore to increase available funding to achieve mitigation goals
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Assist in coordinating the acquisition of applicable State data and contacts
  - Review and comment on this plan section, prior to SHMT review. An initial draft version of this document will be made available by 2/22/18, to allow 1 week for review.
  - Approval of the final plan section.
- SHMT Coordination:
  - Mitigation Workshop #1 and related pre-workshop and follow-up communications
- SHMT Expectations:
  - Availability to discuss existing mitigation resources
  - Review and comment on this plan section. A draft version of this document will be made available by 3/1/18, to allow 1 week for review.

#### *E4.4 Analyze Building Code Requirements*

- Deliverable due date: 6/18/18
- Deliverables:



- A final plan section detailing local building codes, local and State practices, and recommendations to promote stronger building code requirements.
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Assist in coordinating the acquisition of applicable State data and contacts
  - Review and comment on this plan section, prior to SHMT review. An initial draft version of this document will be made available by 5/3/18, to allow 2 weeks for review.
  - Approval of the final plan section.
- SHMT Coordination:
  - Mitigation Workshop #2 and related pre-workshop and follow-up communications
- SHMT Expectations:
  - Availability to discuss building codes and related topics
  - Review and comment on this plan section. A draft version of this document will be made available by 5/17/18, to allow 2 weeks for review.

#### *E4.5 Tool or Measurable System*

- Deliverable due date: 6/18/18
- Deliverables:
  - A final plan section detailing a measurable system to ensure and evaluate ongoing State compliance with Enhanced Plan requirements.
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Assist in input and previous best practices for incorporation into the system
  - Review and comment on this plan section, prior to SHMT review. An initial draft version of this document will be made available by 5/3/18, to allow 2 weeks for review.
  - Approval of the final plan section.
- SHMT Coordination:
  - Mitigation Workshop #2 and related pre-workshop and follow-up communications
- SHMT Expectations:
  - Review and comment on this plan section. A draft version of this document will be made available by 5/17/18, to allow 2 weeks for review.

#### *E4.6 HMA Certification Process*

- Deliverable due date: 4/18/18
- Deliverables:
  - A final plan section detailing a HMA certification process and monitoring system
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed



- DHSEM Planning Leads Expectations:
  - Assist in input and previous best practices for incorporation into the system
  - Review and comment on this plan section, prior to SHMT review. An initial draft version of this document will be made available by 4/4/18, to allow 1 week for review.
  - Approval of the final plan section.
- SHMT Coordination:
  - Mitigation Workshop #1 and related pre-workshop and follow-up communications
- SHMT Expectations:
  - Review and comment on this plan section. A draft version of this document will be made available by 4/11/18, to allow 1 week for review.

## *E4.7 Public Assistance 406*

- Deliverable due date: 5/24/18/18
- Deliverables:
  - A final plan section detailing a plan to maximize available Public Assistance 406 mitigation funding.
- DHSEM Planning Leads Coordination:
  - Weekly Webinars
  - Emails, phone calls, and other communications as needed
- DHSEM Planning Leads Expectations:
  - Assist in input and previous best practices for incorporation into the system
  - Review and comment on this plan section, prior to SHMT review. An initial draft version of this document will be made available by 5/3/18, to allow 2 weeks for review.
  - Approval of the final plan section.
- SHMT Coordination:
  - Mitigation Workshop #2 and related pre-workshop and follow-up communications
- SHMT Expectations:
  - Review and comment on this plan section. A draft version of this document will be made available by 5/17/18, to allow 1 week for review.

## *Final Plan*

- Submission of Final Draft to DHSEM (6/14/18)
- DHSEM review period: 6/14/18-6/29/18
- Submission of Final Plan to FEMA (6/29/18)



**Appendix A – Gantt Chart**

ID	Task Name	Start	Finish	October			November			December			January			February			March			April			May			June			July			August			September
				E	B	M	E	B	M	E	B	M	E	B	M	E	B	M	E	B	M	E	B	M	E	B	M	E	B	M	E	B	M	E	B		
1	<b>Element E1 Planning Process</b>	<b>Tue 10/10/17</b>	<b>Fri 6/29/18</b>	[Gantt bar from Oct 10 to Jun 29]																																	
2	<b>E1.1 Planning Schedule</b>	<b>Tue 10/10/17</b>	<b>Tue 11/14/17</b>	[Gantt bar from Oct 10 to Nov 14]																																	
3	DHSEM Review	Tue 11/7/17	Mon 11/13/17	[Gantt bar from Nov 7 to Nov 13]																																	
4	E1.2- Develop Communication Strategy & Medium	Tue 10/10/17	Mon 12/4/17	[Gantt bar from Oct 10 to Dec 4]																																	
5	<b>E.1.3-Coordination and Integration</b>	<b>Wed 12/20/17</b>	<b>Mon 6/18/18</b>	[Gantt bar from Dec 20 to Jun 18]																																	
6	DHSEM Review	Thu 5/3/18	Wed 5/16/18	[Gantt bar from May 3 to May 16]																																	
7	SHMT Review	Thu 5/17/18	Wed 5/30/18	[Gantt bar from May 17 to May 30]																																	
8	<b>E1.4-Document Planning Process</b>	<b>Tue 10/10/17</b>	<b>Fri 6/29/18</b>	[Gantt bar from Oct 10 to Jun 29]																																	
9	DHSEM Review	Thu 5/17/18	Wed 5/30/18	[Gantt bar from May 17 to May 30]																																	
10	<b>E1.5-Plan Implementation and Maintenance</b>	<b>Wed 12/20/17</b>	<b>Mon 6/18/18</b>	[Gantt bar from Dec 20 to Jun 18]																																	
11	DHSEM Review	Thu 5/3/18	Wed 5/16/18	[Gantt bar from May 3 to May 16]																																	
12	SHMT Review	Thu 5/17/18	Wed 5/30/18	[Gantt bar from May 17 to May 30]																																	
13	<b>Element 2 HIRA</b>	<b>Mon 10/16/17</b>	<b>Thu 3/29/18</b>	[Gantt bar from Oct 16 to Mar 29]																																	
14	<b>E2.1-Profile Hazards</b>	<b>Tue 10/24/17</b>	<b>Tue 12/19/17</b>	[Gantt bar from Oct 24 to Dec 19]																																	
15	DHSEM Review	Tue 12/19/17	Mon 1/8/18	[Gantt bar from Dec 19 to Jan 8]																																	
16	SMHT Review	Mon 1/22/18	Fri 2/9/18	[Gantt bar from Jan 22 to Feb 9]																																	
17	Final Plan Section	Tue 2/20/18	Tue 2/20/18	[Gantt bar at Feb 20]																																	
18	<b>E2.2-Climate Change Requirements</b>	<b>Tue 10/24/17</b>	<b>Tue 12/19/17</b>	[Gantt bar from Oct 24 to Dec 19]																																	
19	DHSEM Review	Tue 12/19/17	Mon 1/8/18	[Gantt bar from Dec 19 to Jan 8]																																	
20	SHMT Review	Mon 1/22/18	Fri 2/9/18	[Gantt bar from Jan 22 to Feb 9]																																	
21	Final Plan Section	Tue 2/20/18	Tue 2/20/18	[Gantt bar at Feb 20]																																	
22	<b>E2.3-Technological and Human-Caused Hazards</b>	<b>Tue 10/24/17</b>	<b>Thu 1/18/18</b>	[Gantt bar from Oct 24 to Jan 18]																																	
23	DHSEM Review	Thu 1/18/18	Wed 2/7/18	[Gantt bar from Jan 18 to Feb 7]																																	





# APPENDIX F: FEMA REVIEW TOOL



**FEMA**

R8-MT

December 19, 2018

Mike Willis, Director  
Colorado Office of Emergency Management  
Division of Homeland Security and Emergency Management  
9195 E. Mineral Avenue, Suite 200  
Centennial, Colorado 80112

Dear Mr. Willis:

FEMA Region VIII is pleased to announce the approval of the Colorado State Hazard Mitigation Plan. FEMA found the plan to be in compliance with Title 44 of the Code of Federal Regulations (C.F.R.) Section 201.4, Standard State Mitigation Plans. The plan is approved through December 18, 2023.

This plan approval confirms the continued eligibility of the State of Colorado to receive non-emergency Stafford Act funding including Public Assistance (Categories C-G), Fire Management Assistance (FMAG), and Hazard Mitigation Assistance (HMA) grant programs. All requests for funding will be individually evaluated according to the specific eligibility and other requirements of the particular program. The Colorado Hazard Mitigation Plan must be reviewed, revised as appropriate, and resubmitted to FEMA every five years to maintain eligibility to apply for funding through the programs referenced above.

We commend the State of Colorado for its time and effort developing this plan and the State's continued commitment to reducing future disaster losses. Please contact Nicole Aimone, Senior Community Planner at (303) 235-4814 or Jeanine Petterson, Mitigation Division Director at (303) 235-4610 with any questions.

Sincerely,

A handwritten signature in black ink, appearing to read "Lee K. dePalo".

Lee K. dePalo  
Regional Administrator

Enclosure

cc: Steve Board, State Hazard Mitigation Officer, Colorado Office of Emergency Management

# Colorado State Hazard Mitigation Plan 2018

## STATE MITIGATION PLAN REVIEW TOOL

This section is organized as follows:

- B.1 Plan Review Tool Summary
- B.2 Standard State Mitigation Plan Regulation Checklist
- B.3 Enhanced State Mitigation Plan Regulation Checklist
- B.4 Strengths and Opportunities for Improvement

FEMA uses the State Mitigation Plan Review Tool (“**Plan Review Tool**”) to document how the state mitigation plan meets the regulation. If plan requirements are not met, FEMA informs the state of the changes it needs to make in each of the Required Revisions sections.

The “**Strengths and Opportunities for Improvement**” summary offers FEMA an opportunity to provide more comprehensive feedback to the state.

**INSTRUCTIONS:** The Regulation Checklist must be completed by FEMA. The FEMA Plan Approver must reference the *State Mitigation Plan Review Guide* when completing the *Plan Review Tool*. The purpose of the Checklist is to identify the location of relevant or applicable content in the Plan by Element/sub-element and to determine if each requirement has been ‘Met’ or ‘Not Met.’

The “**Required Revisions**” summary at the bottom of each Element must be completed by FEMA to provide a clear explanation of the revisions that are required for plan approval. Required revisions must be explained for each plan sub-element that is ‘Not Met.’ Sub-elements should be referenced in each summary by using the appropriate number, where applicable. Requirements for each Element and sub-element are described in detail in the *State Mitigation Plan Review Guide*.

FEMA will provide a narrative summary of the review findings that includes a discussion of “**Strengths and Opportunities for Improvement**” as a means to offer more comprehensive feedback to the state to acknowledge where the plan exceeds minimum requirements as well as provide suggestions for improvements. FEMA will describe the strengths that are demonstrated and highlight examples of best practices.

FEMA may provide suggestions for improvement as part of the *Plan Review Tool* or in a separate document. FEMA’s suggestions for improvement are not required to be made for plan approval.

Required revisions from the Regulation Checklist are not documented in the “**Strengths and Opportunities for Improvement**” section.

# State Mitigation Plan Review Guide 2015

## **B.1 Plan Review Tool Summary**

<b>State:</b> Colorado	<b>Title and Date of Plan:</b> Colorado State Hazard Mitigation Plan (SHMP), August 2018	<b>Date of Submission:</b> 8/17/2018 <i>11/13/2018 - resubmit</i>
<b>State Point of Contact (Name / Title):</b> Patricia Gavelda, State & Local Hazard Mitigation Planning Program Manager Steve Board, Colorado State Hazard Mitigation Officer (SHMO)		
<b>Agency:</b> Colorado Division of Homeland Security & Emergency Management (DHSEM)		<b>Address:</b> DHSEM Fort Lewis College, 1000 Rim Drive, Durango, CO 81301
<b>Phone Number:</b> (970) 247- 6560 / (970)749-8280 (720) 852-6713		<b>E-Mail:</b> patricia.gavelda@state.co.us steven.boand@state.co.us

<b>Date Received in FEMA Region:</b> 8/17/2018, 11/14/18	
<b>FEMA Reviewer (Planning– Name / Title):</b> Madi Pluss, Community Planner/Risk Map	<b>Date:</b> 10/1/18
<b>FEMA Reviewer (Name / Title):</b> Margaret Doherty, Risk MAP Program Manager	<b>Date:</b> 10/1/18
<b>FEMA Reviewer (Name / Title):</b> Sean McGowan, Regional Earthquake Program Manager, Building Science Lead	<b>Date:</b> 10/2/18
<b>FEMA Reviewer HMA – Name / Title):</b> Rich Hansen, HMA Specialist	<b>Date:</b> 10/2/18
<b>FEMA Reviewer (Name / Title):</b> Matt Buddie, Floodplain Management Specialist	<b>Date:</b> 9/25/18
<b>FEMA Approver (Name / Title):</b> Nicole Aimone, Senior Community Planner	<b>Date:</b> 10/2/18, 12/6/18
<b>Plan Status (Not Approved, Approvable Pending Adoption, Approved):</b> Not Approved Approvable Pending Adoption Approved	<b>Date:</b> 10/2/18 11/15/18 12/19/18

<b>SUMMARY</b>	<b>YES</b>	<b>NO</b>
<b>STANDARD STATE MITIGATION PLAN</b>		
Does the plan meet the standard state mitigation plan requirements?	X	
<b>REPETITIVE LOSS STRATEGY</b>		
Does the plan include a Repetitive Loss Strategy? [see S6 / RL1; S8 / RL2; S9 / RL3; S10 / RL4; S13 / RL5; and S15 / RL6]	N/A	N/A
<b>ENHANCED STATE MITIGATION PLAN</b>		
Does the plan meet the enhanced state mitigation plan requirements?	N/A	N/A

**B.2 Standard State Mitigation Plan Regulation Checklist**

<b>REGULATION CHECKLIST – STANDARD PLAN</b>		<b>Location in Plan</b>	<b>M / NM*</b>
<b>*M=Met; NM=Not Met</b>			
<b>STANDARD (S) STATE MITIGATION PLAN</b>			
<b>Planning Process</b>			
S1. Does the plan describe the planning process used to develop the plan? [44 CFR §§201.4(b) and (c)(1)]	Section 1 pgs. 3-32; Appendix E		M
S2. Does the plan describe how the state coordinated with other agencies and stakeholders? [44 CFR §§201.4(b) and (c)(1)]	Section 1 pgs. 3-30; Appendix E		M
<b>Required Revisions:</b>			
<b>Hazard Identification and Risk Assessment</b>			
S3. Does the risk assessment include an overview of the type and location of all natural hazards that can affect the state? [44 CFR §201.4(c)(2)(i)]	Section 3		M
S4. Does the risk assessment provide an overview of the probabilities of future hazard events? [44 CFR §201.4(c)(2)(i)]	Section 3; hazards subsection 9		M
S5. Does the risk assessment address the vulnerability of state assets located in hazard areas and estimate the potential dollar losses to these assets? [44 CFR §§201.4(c)(2)(ii) and 201.4(c)(2)(iii)]	Section 3; hazards subsection 10		M
S6. Does the risk assessment include an overview and analysis of the vulnerability of jurisdictions to the identified hazards and the potential losses to vulnerable structures? [44 CFR §§201.4(c)(2)(ii) and 201.4(c)(2)(iii)]	Section 3; hazards subsection 7		M
S7. Was the risk assessment revised to reflect changes in development? [44 CFR §201.4(d)]	Section 3; hazards subsection 8		M
<b>Required Revisions:</b>			
<b>Mitigation Strategy and Priorities</b>			
S8. Does the mitigation strategy include goals to reduce / avoid long-term vulnerabilities from the identified hazards? [44 CFR §201.4(c)(3)(i)]	Section 5; 5-3		M
S9. Does the plan prioritize mitigation actions to reduce vulnerabilities identified in the risk assessment? [44 CFR §§201.4(c)(3)(iii) and (iv)] a. The plan must identify actions based on the current risk assessment to reduce the vulnerability of jurisdictions within the state as well as the vulnerability of state-owned or operated buildings, infrastructure, and critical facilities. b. The plan must describe the process used by the state to evaluate and prioritize actions that are cost effective, environmentally sound, and technically feasible. c. The plan must describe how each action contributes to the hazard mitigation goals. d. The plan must describe how the local and tribal, as applicable, mitigation strategies are linked with the state mitigation strategy.	Section 5; (Section 8: 8-30) a. – Sect 5 pg. 11-34 b. – Sect 5 pg. 11-15 c. – Sect 5 pg. 16-34 d. – Sect 5 pg. 14		M
S10. Does the plan identify current and potential sources of funding to implement mitigation actions and activities? [44 CFR §201.4(c)(3)(iv)]	Section 4; 4-52		M
S11. Was the plan updated to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities? [44 CFR §201.4(d)]	Section 4; 4-49, Section 8; 8-4 & 8-43, Section 5; 5-9		M
<b>Required Revisions:</b>			

<b>State Mitigation Capabilities</b>		
<p>S12. Does the plan discuss the evaluation of the state’s hazard management policies, programs, capabilities, and funding sources to mitigate the hazards identified in the risk assessment? [44 CFR §201.4(c)(3)(ii)]</p> <p>The plan must describe existing state pre- and post-disaster hazard management policies, programs, and capabilities to mitigate the hazards in the state, including:</p> <ul style="list-style-type: none"> <li>a. An evaluation of state laws, regulations, policies, and programs related to hazard mitigation, as well as to development in hazard-prone areas, to include the state’s administration of the:               <ul style="list-style-type: none"> <li>1. National Flood Insurance Program (NFIP) and Community Rating System (CRS);and</li> <li>2. Risk Mapping, Assessment, and Planning (Risk MAP) program.</li> </ul> </li> <li>b. A discussion of state funding capabilities for hazard mitigation projects, including:               <ul style="list-style-type: none"> <li>1. A general description of how the state has used its own funds for hazard mitigation projects; and</li> <li>2. A general discussion of how the state has used FEMA mitigation programs and funding sources, including but not limited to:                   <ul style="list-style-type: none"> <li>a. HMGP, PDM, and FMA; and</li> <li>b. PA C-G.</li> </ul> </li> </ul> </li> <li>c. A general summary of:               <ul style="list-style-type: none"> <li>1. Obstacles and challenges; and</li> <li>2. Changes since the previous plan approval.</li> </ul> </li> </ul>	<p>Section 4; 4-3; Appendices A-C</p>	<p>M</p>
<p><b>Required Revisions:</b></p>		

# State Mitigation Plan Review Guide 2015

<b>REGULATION CHECKLIST – STANDARD PLAN</b>		<b>Location in Plan</b>	<b>M / NM*</b>
<b>*M=Met; NM=Not Met</b>			
<b>Local Coordination and Mitigation Capabilities</b>			
S13. Does the plan generally describe and analyze the effectiveness of local and tribal, as applicable, mitigation policies, programs, and capabilities? [44 CFR §201.4(c)(3)(ii)]	Section 4; 4-68	M	
S14. Does the plan describe the process to support the development of approvable local and tribal, as applicable, mitigation plans? [44 CFR §§201.3(c)(5) and 201.4(c)(4)(i)]	Section 6; 6-5	M	
S15. Does the plan describe the criteria for prioritizing funding? [44 CFR §201.4(c)(4)(iii)]	Section 6; 6-10	M	
S16. Does the plan describe the process and timeframe to review, coordinate and link local and tribal, as applicable, mitigation plans with the state mitigation plan? [44 CFR §§201.3(c)(6), 201.4(c)(2)(ii), 201.4(c)(3)(iii), and 201.4(c)(4)(ii)]	Section 6; 6-9	M	
<b>Required Revisions:</b>			
<b>Plan Review, Evaluation, and Implementation</b>			
S17. Is there a description of the method and schedule for keeping the plan current? [44 CFR §§201.4(c)(5)(i) and 201.4(d)]	Section 7; 7-4	M	
S18. Does the plan describe the systems for monitoring implementation and reviewing progress? [44 CFR §§201.4(c)(5)(ii) and 201.4(c)(5)(iii)]	Section 7; 7-4, Section 8; 8-4	M	
<b>Required Revisions:</b>			
<b>Adoption and Assurances</b>			
S19. Did the state provide documentation that the plan has been formally adopted? [44 CFR §201.4(c)(6)]		M	
S20. Did the state provide assurances? [44 CFR §201.4(c)(7)]	Preface	M	
<b>Required Revisions:</b>			
<b>Repetitive Loss (RL) Strategy</b>			
RL1. Did Element S6 (risk assessment) address RL and SRL properties? [44 CFR §§201.4(c)(2)(ii), 201.4(c)(2)(iii), and 201.4(c)(3)(v)]	N/A	N/A	
RL2. Did Element S8 (mitigation goals) address RL and SRL properties? [44 CFR §§201.4(c)(3)(i) and 201.4(c)(3)(v)]	N/A	N/A	
RL3. Did Element S9 (mitigation actions) address RL and SRL properties? [44 CFR §§201.4(c)(3)(iii) and 201.4(c)(3)(v)]	N/A	N/A	
RL4. Did Element S10 (funding sources) address RL and SRL properties? [44 CFR §§201.4(c)(3)(iv) and 201.4(c)(3)(v)]	N/A	N/A	
RL5. Did Element S13 (local and tribal, as applicable, capabilities) address RL and SRL properties? [44 CFR §§201.4(c)(3)(ii) and 201.4(c)(3)(v)]	N/A	N/A	
RL6. Did Element S15 (prioritizing funding) address RL and SRL properties? [44 CFR §§201.4(c)(4)(iii) and 201.4(c)(3)(v)]	N/A	N/A	
<b>Required Revisions:</b>			

### B.3 *Strengths and Opportunities for Improvement*

#### **STRENGTHS AND OPPORTUNITIES FOR IMPROVEMENT**

**INSTRUCTIONS:** The purpose of the “**Strengths and Opportunities for Improvement**” section is for FEMA to provide more comprehensive feedback on the state mitigation plan to help the state advance mitigation planning. The intended audience is the state staff responsible for the mitigation plan update. FEMA will address the following topics:

1. Plan strengths, including specific sections in the plan that are above and beyond the minimum requirements; and
2. Suggestions for future improvements.

FEMA will provide feedback and include examples of best practices, when possible, as part of the *Plan Review Tool*, or, if necessary, as a separate document. The state mitigation plan elements are included below in italics for reference but should be deleted as the narrative summary is completed. FEMA is not required to provide feedback for each element.

Required revisions from the **Regulation Checklist** are not documented in the **Strengths and Opportunities for Improvement** section.

Results from the **Strengths and Opportunities for Improvement** section are not required for Plan Approval, but may inform discussions during the Program Consultation.

**Describe the mitigation plan strengths, including areas that may exceed minimum requirements.**

#### *Hazard identification and risk assessment*

- Assessing 31 unique hazards is quite the undertaking, however, this plan successfully provides a sufficient amount of detail and pertinent information for each hazard. This all-encompassing approach reflects the geographic diversity of Colorado. Previous occurrences are comprehensive and cover the most significant events that have transpired in recent years. The hazard descriptions are informative and replete with scientific facts that are easy to understand for a range of different readers. Table 3-7 is very useful as it organizes the breadth of information and identifies the variety of hazards that impact Colorado’s communities.
- It is very effective to identify individual county’s vulnerabilities in each hazard section. The individual assessment in this plan is paired well with the assessment of how current local plans have ranked the hazard. This section be a useful reference tool for local hazard mitigation plan updates. During the 2014 update of the plan, recommendations were made to address the unique risk and capabilities of the communities beyond the Front Range. This comprehensive assessment now acknowledges the diversity of risk throughout the entire state.
- Great consideration of social vulnerability throughout the risk assessment. Integration of community characteristics and how hazard risk can disproportionately impact different populations is a relatively new practice, and this plan provides a solid foundation for subsequent planning efforts.
- Including the EMAP standards helps integrate this document with other Emergency Management initiatives. We strongly encourage increased cooperation with other state and federal agencies, and the EMAP tables offer a shared language to help reduce redundancy in other plans and to provide a useful resource that may be valuable for THIRA planning or EOPs or other preparedness efforts.
- Lots of references to other plans and recent studies. Conducting this assessment at the same time as the Colorado Flood and Drought Mitigation Plans is a great way to keep the data in all plans

- current and to integrate action items specified in both planning processes.
- Graphs and maps are all clear, concise, relevant and effectively emphasize what is communicated in supporting text.
- Incorporation of growth and future development in the exposure projections is great. The methodology for determining combined risk is clear and easy to follow. Looking forward helps make this plan a more living document and will strengthen mitigation actions, so that we are reducing risk in the present, while also providing additional support to the areas where growth will most significantly impact resources, infrastructure, and land use patterns.

## *Mitigation strategy*

- The Key Takeaway summary section added to the HIRA was an excellent addition to begin showing the connection between the risk assessment and mitigation actions. In the next Update, the Plan should go farther, offering more detail of how the key takeaway summary informs the state's mitigation priorities and prioritizing mitigation actions and policies.
- Including partnering agencies and working groups for the new mitigation actions was helpful and shows a deliberate collaborative mitigation strategy effort.

## **Describe areas for future improvements to the mitigation plan.**

### *Planning process*

- The revised version provides additional and useful context of the planning process, but it would be helpful if the Plan provided more detail describing the simultaneously occurring State Drought and Flood Plans' update processes, explaining who led those planning processes and how they were also active participants to the State Mitigation plan.
- Unfortunately, the Core Planning Team is made up only of DHSEM and their contract support. In future Plan Updates, it may be helpful to have additional key plan contributors as part of the Core Planning Team, especially if Colorado is interested in becoming Enhanced. Also, a bit more clarity around how the Silver Jackets/US Army Corp of Engineers were involved in the plan process is also recommended. It is important for the Plan to address in detail how the, providing examples of how specific sectors were engaged and given the chance to provide input to affect the plan's content.

### *Hazard identification and risk assessment*

- The multiple methodologies to assess risks is comprehensive and the local mitigation plans were heavily utilized; the plan provides a risk assessment summary but the Plan ideally should even go further, offering an explanation of how the conclusions of the risk assessment inform the state's mitigation priorities. How does the State's understanding of vulnerabilities assist in prioritizing mitigation actions and policies that reduce risk from future events?
- The Social Capital Index analysis was an interesting exercise; however, the results do not seem to reflect reality. For instance, the results conclude that Baca County's Social Capital Index level is High whereas Pitkin County is Low, which would imply that Baca would be better able to bounce back from a major disaster, as opposed to Pitkin, which does not ring true if you're familiar with the communities in these counties. The metric is a good attempt at including an additional social component to risk, but in the future, the Plan might want to either to adjust some of the index variables or create a new metric methodology that better reflects the actual capabilities of Colorado's counties.

# State Mitigation Plan Review Guide 2015

## *Mitigation strategy*

- Including an “Implementation Notes” row in the Mitigation Action table is very helpful but there are still some actions that are very broad and general in nature. It would be useful if some of the actions were able to provide more specificity, especially geographically speaking.

## *Plan review, evaluation, and implementation*

- The plan discusses the annual May SHMT meeting to discuss and update the Mitigation Action Database. The state may want to consider having these two required meetings occur at or around the same time.