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EXECUTIVE SUMMARY

Hazard mitigation planning for Douglas County and participating jurisdictions identifies ways to reduce risk from foreseeable natural and non-natural hazards that may impact the planning area. Douglas County prepared a hazard mitigation plan update in 2015, with five municipalities and one special purpose district in the County, participating as partners in the plan. The 2015 plan update was an update to the Denver Regional Natural Hazards Mitigation Plan, of which both the Town of Castle Rock and Douglas County participated. Since the completion of the 2015 plan update, the County has continued to experience major growth in residential, commercial and infrastructure development.

Between 2015 and 2019, the County's population grew from 306,974 people to 336,041 people. During that time, the County and its jurisdictions have added thousands of housing units and millions of square feet of new commercial and institutional structures. Current and future development in hazard prone areas may increase risks, impacts and vulnerabilities of people and property in the county.

To address these changes, and to meet federal requirements for keeping hazard mitigation plans current, Douglas County has completed the *2021 Douglas County Local Hazard Mitigation Plan Update* (HMP, Plan or Update). In preparing the 2021 Plan, Douglas County partnered with the City of Castle Pines, Town of Castle Rock, Town of Larkspur, City of Lone Tree, and Town of Parker, as well as Centennial Water and Sanitation, Denver Water, and Parker Water and Sanitation. Such multi-jurisdictional planning allows these planning partners to pool resources and eliminate redundant activities within a planning area that can have uniform risk exposure and vulnerabilities.

The 2021 Plan reduces risk for those who live, work, and visit within the Douglas County planning area. The resources and background information in the 2021 Plan are applicable across the County, and the Plan's goals and recommendations lay groundwork for local mitigation activities and partnerships.

Community involvement in the Hazard Mitigation Plan Update

This planning effort was led by a Core Planning Team (CPT) of staff from various Douglas County departments including the Office of Emergency Management (DCOEM) and consultant Tetra Tech, Inc. The broader Douglas County community participated in the development of the update through the following activities:

Defining Stakeholders—The CPT identified stakeholders to engage during the update. "Stakeholder" was defined as any person or entity that owns or operates facilities that would benefit from the mitigation actions of this plan or has a capability to support hazard mitigation actions.

Establishing the Planning Partnership—The team identified various local governments to engage through this Plan update process. Ultimately, eight joined the County and participated in the planning process (see Table ES-1).

Forming the Local Planning Committee (LPC)—Douglas County established a thirty-eight member Local Planning Committee that represents the entire planning partnership to oversee the planning process.

Reviewing Previous Hazard Mitigation Plan and Existing Programs—The CPT and LPC reviewed the 2015 hazard mitigation plan, as well as all laws, ordinances and programs in effect within the County that can affect hazard mitigation.

Public Outreach—The update effort included a webpage describing update activities, public polling distributed throughout the County to gather public input, the use of social media and informational bulletins to report on update activities, and public meetings to explain the update process and gather feedback. More than 100 people completed surveys.

Table ES-1. Hazard Mitigation Planning Partners Covered Under This Plan

Planning Partners	
Unincorporated Douglas County	
City of Castle Pines	Town of Parker
Town of Castle Rock	Centennial Water and Sanitation District
Town of Larkspur	Denver Water District
City of Lone Tree	Parker Water and Sanitation District

Planning Area, Hazards of Concern, and Risk Assessment

The planning area for the 2021 Plan consists of the jurisdictional boundaries for the unincorporated county, and planning partners. The Local Planning Committee considered the full range of natural hazards that could affect the planning area and then identified those that present the greatest concern.

Risk assessment is the process of estimating the potential loss of life, personal injury, economic injury, and property damage resulting from identified hazards. The risk assessments in the 2021 Plan describes the risks associated with each identified hazard of concern. The following steps were used to assess the risk of each hazard:

- Identification and profile hazards of concern
- Determine the planning areas "exposure" to each hazard—Exposure was assessed by overlaying hazard maps with an inventory of structures, facilities, and systems to decide which of them would be exposed to each hazard.
- Assess the "vulnerability" of exposed facilities—Vulnerability of exposed structures and infrastructure was evaluated by interpreting the probability of occurrence of each event and assessing potential damage to structures, facilities, and systems that are exposed to each hazard.

Table ES-2 summarizes the findings of the risk assessment.

Table ES-2. Key Findings from Risk Assessment of Hazard of Concern

Hazard of Concern	Exposure	Vulnerability
Animal Disease	Entire planning area exposed	No quantitative loss estimates
Dam and Levee Failure	• Areas and structures downstream of dams are exposed • Dam inundation areas unknown at time of 2021 update	No quantitative loss estimates
Drought	Entire planning area exposed	No quantitative loss estimates
Earthquake	Entire planning area exposed	• 1 household displaced in 500-year earthquake, 31 households displaced in 250—year event

Hazard of Concern	Exposure	Vulnerability
		• $77.5 million in estimated total damage from 500-year event • $1.087 billion in estimated total damage from 2500-year event
Extreme Temperatures	Entire planning area exposed	No quantitative loss estimates
Flood	Entire planning area exposed, with special concern to the FEMA-designated areas of special and moderate flood hazards (comprising more than 28,000 acres, or 5.2% of County) 595 residents are in the Special Flood Hazard Area, and 4,775 are in the Moderate Flood Hazard Area (most of which are in Parker)	• 458 buildings are exposed to the 100-year flood zone and 2,143 buildings are exposed to the 500-year flood zone (representing $3.4 billion in total value) • 158 lifelines are exposed to the areas of moderate or special flood hazard
Hazardous Materials	Entire planning area exposed, with highest risk on major roadways and along transportation corridors	No quantitative loss estimates
Pandemic/Disease Outbreak	Entire planning area exposed	No quantitative loss estimates
Severe Weather: Hail and Lightning	Entire planning area exposed	No quantitative loss estimates
Severe Weather: Thunderstorms	Entire planning area exposed	No quantitative loss estimates
Severe Weather: Tornadoes	Entire planning area exposed	No quantitative loss estimates
Severe Winter Storm	Entire planning area exposed	No quantitative loss estimates
Soil Hazards: Erosion	• Areas along Douglas County waterways are exposed (including the Special Flood Hazard Area and Area of Moderate Flood Hazard) • Approximately 852 residents are in the erosion hazard area, the vast majority of which are in Unincorporated Douglas County • Approximately one-half of Larkspur’s buildings are in the erosion hazard area	No quantitative loss estimates
Soil Hazards: Expansive Soils	• Areas in the foothills of Douglas County, between Roxborough State Park and Perry Park • Approximately 7,800 residents are in a dipping bedrock hazards area, the vast majority of which are in Unincorporated Douglas County (7,175) • Total RCV exposed totals $2.8 billion	No quantitative loss estimates
Soil Hazards: Land Subsidence	• Scattered and isolated areas of land subsidence are found throughout Douglas County • Approximately 33,779 residents are in subsidence areas	No quantitative loss estimates
Soil Hazards: Slope Failure	• Slope failure areas are found throughout Douglas County • Slope failure is more likely to occur in areas with high topographic relief • Approximately 0.26% of residents are in slope failure areas, exposing more than $333 million in structures	No quantitative loss estimates
Wildfire	Entire planning area exposed	• More than one-third of residents (35.5%) live in wildfire risk areas • Approximately 30.6% of Building RV ($55.7 billion) is in wildfire risk areas • 421 of the County’s 971 lifelines are in wildfire risk areas (the majority of

Hazard of Concern	Exposure	Vulnerability
		which are food, water, and shelter lifelines

Risk Ranking

The 2021 Plan includes a risk ranking protocol for each planning partner, in which "risk" was calculated by multiplying probability by impact on people, property and the economy. The risk estimates were generated using methodologies promoted by FEMA. The Local Planning Committee reviewed, discussed and approved the methodology and results. The County-wide ranking results are listed in Table ES-3. All planning partners ranked risk for their own jurisdictions following the same methodology.

Table ES-3. Hazard Risk Ranking

Rank	Hazard Type	Risk Rating Score (Probability x Impact)	Category*
1	Wildfire	48	High
2	Drought	30	Medium
2	Pandemic	30	Medium
3	Hail	24	Medium
4	Animal Disease	18	Medium
4	Lightning	18	Medium
4	Severe Thunderstorms	18	Medium
4	Severe Winter Storm	18	Medium
4	Transportation Accidents	18	Medium
5	Earthquake	16	Medium
5	Tornadoes	16	Medium
6	Erosion	12	Low
6	Expansive Soils	12	Low
6	Extreme Temperatures	12	Low
6	Flood	12	Low
6	Land Subsidence	12	Low
6	Landslide	12	Low
6	Slope Failure	12	Low
7	Dam and Levee Failure	6	Low

**Scores of 31 or greater are rated as "high," scores of 15 to 30 are "medium," and scores of less than 14 are "low"*

Guiding Principle, Goals and Objectives

The Local Planning Committee updated the 2021 HMP guiding Principle as follows:

The purpose of this plan update is to guide hazard mitigation planning, implement projects, and prioritize resources to better protect the people and property of the County from the effects of hazards. This plan demonstrates the community's commitment to reducing risks from hazards and serves as a tool to help decision makers direct mitigation activities and resources. This plan was also developed to ensure Douglas County and participating jurisdictions' continued eligibility for federal, state, and local disaster assistance including but not limited to the FEMA Hazard Mitigation Grant Program (HMGP), Building Resilient Infrastructure and Communities (BRIC), and the Flood Mitigation Assistance Program (FMA); and HUD Community Development Block Group-Mitigation (CDBG-MIT).

Completion also earns credits for the National Flood Insurance Program's Community Rating System (CRS) which provides for lower flood insurance premiums in CRS communities.

Table ES-4 lists goals and objectives for this hazard mitigation plan update, as established by the Local Planning Committee.

Table ES-4. Mission Statement, Goals and Objectives

Goals	Objectives
Goal 1 – Warning - Enhance predictive measures including the expansion and protection of warning systems and supporting technologies. Goal 2 – Data Collection - Enhance the quality of assessments, analysis and planning through the development and collection of data. Goal 3 – Outreach and Education - Increase public awareness of hazards and their mitigation. Goal 4 - Mitigate Structures and Protect Lives - Reduce impacts, costs, and damages from hazard events to people, property, local government and private assets, economy, and natural and cultural resources. Goal 5 - Planning - Coordinate and integrate hazard mitigation activities with local land development planning activities and emergency operations planning to consider resiliency. Goal 6 - Codes & Standards - Review, update, adopt and enforce local, state and federal plans, codes and regulations to reduce the impacts of natural hazards. Goal 7 - Entity Coordination - Strengthen communication and coordination among public entities, non-governmental organizations (NGOs), businesses and private citizens. Goal 8 - Continuity of Operations - Support continuity of operations pre-, during, and post- hazard events including the support of community lifelines.	• Objective 1: Improve systems that provide warning and emergency communications. • Objective 2: Increase public awareness of risk. • Objective 3: Research, develop, and promote adoption of cost-effective building and development laws, regulations, and ordinances. • Objective 4: Improve hazard information databases and maps and increase accessibility to those resources. • Objective 5: Develop and provide updated information about threats, hazards, vulnerabilities, and mitigation strategies to state, regional, and local agencies, as well as private sector groups. • Objective 6: Manage development in geologically hazardous areas and floodplains to protect life and property. • Objective 7: Incorporate risk reduction considerations in new and updated infrastructure and development plans to reduce the impacts of natural hazards. • Objective 8: Establish and maintain partnerships among all levels of government, private sector, community groups, and institutions of higher learning that improve and implement methods to protect life and property. • Objective 9: Improve understanding of the locations, potential impacts, and linkages among threats, hazards, vulnerability, and measures needed to protect life safety and health. • Objective 10: Consider risk reduction in long-term planning. • Objective 11: Minimize impacts of hazard events to key employers. • Objective 12: Identify projects that simultaneously reduce risk while increasing operational area resilience and sustainability. • Objective 13: Establish a partnership among all levels of government and the business community to improve and implement methods to protect property. • Objective 14: Reduce risks that may impact critical business operations. • Objective 15: Promote and enhance outreach and education efforts by state, regional and local agencies with hazard mitigation plans and programs to actively encourage engagement of stakeholder groups such as homeowners, private sector businesses, and nonprofit community organizations. • Objective 16: Inform the public on the risk exposure to natural hazards and ways to increase the public's capability to prepare, respond, recover and mitigate the impacts of these events. • Objective 17: Modify structures, as necessary, to meet life safety standards. • Objective 18: Encourage the incorporation of mitigation measures into repairs, major alterations, new development, and redevelopment practices, especially in areas subject to substantial hazard risk. • Objective 19: Retrofit, purchase, or relocate structures in high hazard areas, especially those known to be repetitively damaged. • Objective 20: Encourage hazard mitigation measures that promote and enhance natural processes and minimize adverse impacts on the ecosystem. • Objective 21: Promote enforcement of relevant state regulations and local ordinances that significantly reduce life loss and injuries. • Objective 22: Strengthen local building code enforcement. • Objective 23: Ensure continuity of operations of essential county government services. • Objective 24: Protect rare, endangered, unusual, or educationally important natural resources.

Goals	Objectives
	• Objective 25: Provide incentives for development and land use techniques that reduce risks.

Mitigation Action Plans

Catalogs of hazard mitigation best practices were developed that present a broad range of action alternatives to be considered for use by the planning partners. One catalog was developed for each hazard of concern. The alternatives include actions that will mitigate current risk from hazards and actions that will help reduce risk from changes in the impacts of these hazards resulting from climate change.

Hazard mitigation actions recommended in this plan were selected from an analysis of the alternatives presented in the catalogs. Each planning partner selected appropriate mitigation actions to establish an individual mitigation action plan for its jurisdiction. Actions were selected based on an analysis of the planning partner's ability to implement the action and general feasibility.

The combined action plans of the nine planning partners include dozens of actions for mitigating hazard risks in Douglas County. The planning partners have prioritized the actions in their action plans and can begin to implement the highest-priority actions over the next five years.

Plan Implementation and Maintenance

The effectiveness of the 2021 Plan depends on its effective implementation and incorporation of the outlined action items as needed into each partner's existing plans, policies, and programs. Douglas County will have lead responsibility for overseeing the plan implementation and maintenance strategy. Plan implementation will be a shared responsibility among all planning partnership members and agencies identified as lead agencies in the jurisdiction-specific action plans.

A formal implementation and maintenance process will ensure that the hazard mitigation plan remains an active and relevant document and that the planning partners maintain their eligibility for applicable funding sources. The plan maintenance process includes a schedule for monitoring and evaluating the plan annually and producing an updated plan every five years. The plan maintenance matrix shown in Table ES-5 provides a synopsis of responsibilities for the overall plan maintenance strategy.

Table ES-5. Plan Maintenance Matrix

Task	Approach	Timeline	Lead Responsibility	Support Responsibility
Monitoring-Progress Reporting	Preparation of status updates and action implementation tracking as part of submission for annual progress report.	April to April of each calendar year or upon full update to comprehensive plan or major disaster	Jurisdictional points of contact	Jurisdictional implementation lead
Evaluation	Annual progress reports will be evaluated by an oversight steering committee annually	Finalized progress report completed by April 1 of each year	Douglas County OEM	Jurisdictional points of contacts
Update	Reconvene the planning partners, at a minimum, every 5 years to guide a full review and revision of the plan.	Every 5 years or upon full update to comprehensive plan or major disaster	Douglas County OEM and Local Planning Committee	Jurisdictional points of contacts

Task	Approach	Timeline	Lead Responsibility	Support Responsibility
Grant Monitoring and Coordination	Monitor grant funding opportunities via agency notifications, state associations and post-disaster response	Ongoing	Douglas County OEM	Jurisdictional points of contacts
Plan Integration	Create a linkage between the hazard mitigation plan and individual jurisdictions' comprehensive plans or similar plans	Ongoing as opportunities for integration become available, or according to timelines identified in individual actions plans	Jurisdictional points of contact	Jurisdictional implementation lead
Continuing Public Involvement	Keep the website maintained and receive comments through it over the course of the plan. Planning partners will maintain links to the website. County-wide progress report will be posted to the website.	Ongoing. Progress reports to be posted annually.	Douglas County OEM will maintain the overall website and post the progress report annually. Each planning partner will provide a link to the website and may post individual progress reports.	Douglas County OEM and jurisdictional implementation lead

SECTION 1 INTRODUCTION

1.1 BACKGROUND

A Hazard Mitigation Plan (HMP) is a living document that communities use to reduce their vulnerability to hazards. It forms the foundation for a community's long-term strategy to reduce disaster losses and creates a framework for decision making to reduce damages to lives, property, and the economy from future disasters. Hazard Mitigation involves long- and short-term actions implemented before, during and after hazard events. Hazard mitigation activities include planning efforts, policy changes, programs, studies, improvement projects, and other steps to reduce the impacts of hazards. Ultimately, these actions reduce vulnerability, and communities are able to recover more quickly from damaging hazard events.

In response to the requirements of the Disaster Mitigation Act of 2000 (DMA 2000), Douglas County developed this HMP, which represents a regulatory update to the 2015 "Douglas County Local Hazard Mitigation Plan" The DMA 2000 amends the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) and is designed to improve planning for, response to, and recovery from disasters by requiring state and local entities to implement pre-disaster mitigation planning and develop HMPs. The Federal Emergency Management Agency (FEMA) has issued guidelines for HMPs. Colorado Division of Homeland Security and Emergency Management (DHSEM) also supports plan development for jurisdictions in the State of Colorado.

Hazard Mitigation is any sustained action taken to reduce or eliminate the long-term risk and effects that can result from specific hazards.

FEMA defines a ***Hazard Mitigation Plan*** as the documentation of a state or local government evaluation of natural hazards and the strategies to mitigate such hazards.

Specifically, the DMA 2000 requires that states, with support from local governmental agencies, develop and update HMPs on a five-year basis to prepare for and reduce the potential impacts of natural hazards. The DMA 2000 is intended to facilitate cooperation between state and local authorities, prompting them to work together. This enhanced planning better enables local and State governments to articulate accurate needs for mitigation, resulting in faster allocation of funding and more effective risk reduction projects.

1.1.1 DMA 2000 Origins - The Stafford Act

In the early 1990s, a new federal policy regarding disasters began to evolve. Rather than reacting whenever disasters strike communities, the federal government began encouraging communities to first assess their vulnerability to various disasters and proceed to take actions to reduce or eliminate potential risks. The logic is that a disaster-resistant community can rebound from a natural disaster with less loss of property or human injury, at much lower cost, and, consequently, more quickly. Moreover, these communities minimize other costs associated with disasters, such as the time lost from productive activity by business and industries.

The DMA 2000 provides an opportunity for states, tribes, and local governments to take a new and revitalized approach to mitigation planning. The DMA 2000 amended the Stafford Act by repealing the previous mitigation planning provisions (Section 409) and replacing them with a new set of requirements (Section 322). Section 322 sets forth the requirements that communities evaluate natural hazards within their respective jurisdictions and develop an appropriate plan of action to mitigate those hazards, while emphasizing the need for State, tribal and local governments to closely coordinate mitigation planning and implementation efforts.

The amended Stafford Act requires that each local jurisdiction identify potential natural hazards to the health, safety, and well-being of its residents and identify and prioritize actions that the community can take to mitigate those hazards—before disaster strikes. To remain eligible for hazard mitigation assistance from the federal government, communities must first prepare and then maintain and update an HMP (this plan).

Responsibility for fulfilling the requirements of Section 322 of the Stafford Act and administering the FEMA Hazard Mitigation Program has been delegated to the State of Colorado, specifically to the Colorado Division of Homeland Security and Emergency Management (DHSEM). FEMA also provides support through guidance, resources, and plan reviews.

1.1.2 Benefits of Mitigation Planning

The planning process helps prepare citizens and government agencies to better respond when damaging hazard events occur. Also, mitigation planning allows Douglas County and participating jurisdictions to remain eligible for mitigation grant funding for mitigation projects that will reduce the impact of future disaster events. Eligible projects include property acquisition and structure demolition, structure elevation, localized flood risk reduction projects, infrastructure retrofit, soil stabilization, wildfire mitigation, post-disaster code enforcement, wind retrofit for one- and two-family residences, and planning related activities. The long-term benefits of mitigation planning include the following:

National Benefit-Cost Ratio (BCR) Per Peril *BCR numbers in this study have been rounded	Beyond Code Requirements	Federally Funded
Overall Hazard Benefit-Cost Ratio	$4:1	$6:1
Riverine Flood	$5:1	$7:1
Hurricane Surge	$7:1	Too few grants
Wind	$5:1	$5:1
Earthquake	$4:1	$3:1
Wildland-Urban Interface Fire	$4:1	$3:1

Source: *FEMA 2018; Federal Insurance Mitigation Administration 2018*
Note: *Natural hazard mitigation saves $6 on average for every $1 spent on federal mitigation grants.*

- Building a more sustainable and disaster-resistant County.
- Reduced long-term impacts and damages to human health and structures.
- Increasing education and awareness of hazards and their threats, as well as their risks.
- An increased understanding of hazards faced by Douglas County
- Developing implementable and achievable actions for risk reduction in the County.
- Financial savings through partnerships that support planning and mitigation efforts.
- Focused use of limited resources on hazards that have the biggest impact on the community.
- Reduced repair costs.

1.1.3 Organizations Involved in the Mitigation Planning Effort

Douglas County intends to implement this HMP with full coordination and participation of local departments, organizations and groups, and relevant state and federal entities. Coordination helps to ensure that stakeholders have established communication channels and relationships necessary to support mitigation planning and mitigation actions included in Section 6 (Mitigation Strategy).

Multiple Agency Support for Hazard Mitigation

Primary responsibility for the development and implementation of mitigation strategies and policies lies with local governments. However, local governments are not alone; various partners and resources at the regional, state, and federal levels are available to assist communities in the development and implementation of mitigation strategies. Within the State of Colorado, the Division of Homeland Security and Emergency Management (DHSEM) is the lead agency providing hazard mitigation planning assistance to local jurisdictions. DHSEM provides guidance to support mitigation planning. In addition, FEMA provides grants, tools, guidance, and training to support mitigation planning.

Additional input and support for this planning effort was obtained from a range of agencies and through public involvement (as discussed in Section 2). The Local Planning Committee for the County's HMP update provided project management and oversight of the planning process. A list of Local Planning Committee, municipal, and special district POCs is provided in Section 2 (Planning Process), while Appendix B (Participation Matrix) provides further documentation of the broader level of jurisdictional involvement.

This HMP was prepared in accordance with the following regulations and guidance:

- FEMA *Local Mitigation Planning Handbook*, March 2013.
- FEMA *Integrating Hazard Mitigation into Local Planning*, March 1, 2013.
- FEMA *Plan Integration: Linking Local Planning Efforts,* July 2015.
- *Local Mitigation Plan Review Guide*, October 1, 2011.
- DMA 2000 (Public Law 106-390, October 30, 2000).
- 44 Code of Federal Regulations (CFR) Parts 201 and 206 (including: Feb. 26, 2002, Oct. 1, 2002, Oct. 28, 2003, and Sept. 13, 2004 Interim Final Rules).
- FEMA *How-To Guide for Using HAZUS for Risk Assessment* FEMA Document No. 433, February 2004.
- FEMA *Mitigation Planning How-to Series* (FEMA 386-1 through 4, 2002), available at: http://www.fema.gov/fima/planhowto.shtm.
- FEMA *Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards*, January 2013.
- 2018-2023 Colorado Hazard Mitigation Plan

Table 1-1 summarizes the requirements outlined in the DMA 2000 Interim Final Rule and provides the section where each is addressed in this HMP.

Table 1-1. FEMA Local Mitigation Plan Review Crosswalk

Plan Criteria	Primary Location in Plan
Prerequisites	
Adoption by the Local Governing Body: §201.6(c)(5)	Section 6; Appendix A
Planning Process	
Documentation of the Planning Process: §201.6(b) and §201.6(c)(1)	Section 2
Risk Assessment	
Identifying Hazards: §201.6(c)(2)(i)	Sections 4.2
Profiling Hazards: §201.6(c)(2)(i)	Section 5.4

Plan Criteria	Primary Location in Plan
Assessing Vulnerability: Overview: §201.6(c)(2)(ii)	Section 5.4
Assessing Vulnerability: Identifying Structures: §201.6(c)(2)(ii)(A)	Section 4 Section 5.4
Assessing Vulnerability: Estimating Potential Losses: §201.6(c)(2)(ii)(B)	Section 5.4
Assessing Vulnerability: Analyzing Development Trends: §201.6(c)(2)(ii)(C)	Section 4 and Section 8
Mitigation Strategy	
Local Hazard Mitigation Goals: §201.6(c)(3)(i)	Section 6
Identification and Analysis of Mitigation Actions: §201.6(c)(3)(ii)	Section 6
Implementation of Mitigation Actions: §201.6(c)(3)(iii)	Section 6
Jurisdictional Mitigation Actions: §201.6(c)(3)(iv)	Section 6
Plan Maintenance Process	
Monitoring, Evaluating, and Updating the Plan: §201.6(c)(4)(i)	Section 7
Incorporation into Existing Planning Mechanisms: §201.6(c)(4)(ii)	Section 7
Continued Public Involvement: §201.6(c)(4)(iii)	Section 7

1.1.4 Organization

The Douglas County Local Hazard Mitigation Plan Update (HMP) is organized in accordance with FEMA and DHSEM guidance. The HMP is organized in two volumes containing nine sections and associated appendices.

<u>**Volume I**</u>

Section 1: Introduction: Overview of participants and planning process.

Section 2: Plan Adoption: Information regarding adoption of the HMP by Douglas County and each participating jurisdiction.

Section 3: Planning Process: A description of the HMP methodology and development process; Local Planning Committee, Core Planning Team and stakeholder involvement efforts; and a description of how this HMP will be incorporated into existing programs.

Section 4: County Profile: An overview of Douglas County, including: general information, economy, land use trends, population and demographics, general building stock inventory, and critical facilities and lifelines.

Section 5: Risk Assessment: Documentation of the hazard identification and hazard risk ranking process, hazard profiles, and findings of the vulnerability assessment (estimates of the impact of hazard events on life, safety and health; general building stock; critical facilities and the economy); description of the status of local data; and planned steps to improve local data to support mitigation planning.

Section 6: Mitigation Strategy: Information regarding the mitigation goals and objectives identified by the Local Planning Committee in response to priority hazards of concern and the process by which local mitigation strategies have been developed or updated.

Section 7: Plan Maintenance Procedures: System established by the Local Planning Committee to continue to monitor, evaluate, maintain, and update the HMP.

Volume II

Section 8: Planning Partnership: Description of the participation requirements established by the Local Planning Committee, as well as instructions and templates that the partners used to complete their annexes.

Section 9: Jurisdiction Specific Annexes: Federally required jurisdiction-specific elements for each participating jurisdiction including general information, economy, land use trends, population and demographics, general building stock inventory, and critical facilities and lifelines; capability assessment; risk ranking; integration opportunities; and mitigation strategy.

Appendices

Appendix A: Resolution of Plan Adoption: Resolutions from the County and participating jurisdictions will be included as they formally adopt the HMP update.

Appendix B: Participation Matrix: A matrix is presented to give a broad overview of who attended meetings and when input was provided to the HMP update. Letters of Intent to Participate as described in Section 2 are also included in this appendix.

Appendix C: Meeting Documentation: Agendas, attendance sheets, minutes, and other documentation (as available and applicable) of planning meetings convened during the development of the plan.

Appendix D: Public and Stakeholder Outreach Documentation: Documentation of the public and stakeholder outreach effort including webpages, informational materials, public and stakeholder meetings and presentations, surveys, and other methods used to receive and incorporate public and stakeholder comment and input to the plan process. Survey results for both citizens and stakeholders are summarized as well.

Appendix E: Risk Assessment Supplementary Data: Supplemental information for the hazard profiles, including data from the 2015 Plan Update.

Appendix F: Mitigation Strategy Supplement: Supplemental information used to inform the mitigation strategy development.

Appendix G: Plan Maintenance Tools: Information that can be used by jurisdictions to maintain their plans through the next planned update.

Appendix H: Linkage Procedures: Provides instructions for non-participating jurisdictions to link to the current plan update.

Appendix I: Critical Facilities: Provides a list of critical facilities identified in the plan (not included in the public review document).

Goals and Objectives

The planning process included a review and update of the prior mitigation goals and objectives as a basis for the planning process and to guide the selection of appropriate mitigation actions addressing all hazards of concern. Further, the goal development process considered the mitigation goals expressed in the State of Colorado HMP, as well as other relevant county and local planning documents, as discussed in Section 6 (Mitigation Strategy).

The eight goals of the Douglas County HMP.

Goal 1 – Warning: Enhance predictive measures including the expansion and protection of warning systems and supporting technologies.

Goal 2 - Data Collection: Enhance the quality of assessments, analysis and planning through the development and collection of data.

Goal 3 - Outreach and Education: Increase public awareness of hazards and their mitigation.

Goal 4 - Mitigate Structures and Protect Lives: Reduce impacts, costs, and damages from hazard events to people, property, local government and private assets, economy, and natural and cultural resources.

Goal 5 – Planning: Coordinate and integrate hazard mitigation activities with local land development planning activities and emergency operations planning to consider resiliency.

Goal 6 - Codes & Standards: Review, update, adopt and enforce local, state and federal plans, codes and regulations to reduce the impacts of natural hazards.

Goal 7 - Entity Coordination: Strengthen communication and coordination among public entities, non-governmental organizations (NGOs), businesses and private citizens.

Goal 8 - Continuity of Operations: Support continuity of operations pre-, during, and post- hazard events including the support of community lifelines.

Hazards of Concern

Douglas County and planning participants reviewed natural and non-natural hazards that caused measurable impacts based on events, losses, and information available since the development of the 2015 Douglas County Local Hazard Mitigation Plan Update and the 2018 Colorado Hazard Mitigation Plan. The County evaluated the risk and vulnerability due to each of the hazards of concern on the assets of the County and participating jurisdictions. While the overall hazard rankings were calculated for the County, the overall hazard rankings displayed reflect planning partner input. The hazard risk rankings were used to focus and prioritize the County and participating jurisdiction's mitigation strategies.

Plan Integration into Other Planning Mechanisms

Effective mitigation is achieved when hazard awareness and risk management approaches and strategies become an integral part of public activities and decision-making. Within the County there are many existing plans and programs that support hazard risk management, and thus it is critical that this HMP integrates, coordinates with, and complements those mechanisms. Comprehensive plans, codes and ordinances are among the sources of information to update the County's capabilities, to identify mitigation strategies, and to identify potential areas of future integration.

Section 5 (Capability Assessment) provides a summary and description of the existing plans, programs and regulatory mechanisms at all levels of government (federal state, county, and local) that support hazard mitigation within the County. Also in this section, the County identified how they have integrated hazard risk management into their existing planning, regulatory, and operational/administrative framework (*existing integration*), and how they intend to promote this integration (*opportunities for future integration*).

1.1.5 Implementation of Prior and Existing Local Hazard Mitigation Plans

Section 6 (Mitigation Strategy) of the plan presents the status of the mitigation projects identified in the 2015 Douglas County HMP. Numerous projects and programs have been implemented that have reduced hazard vulnerability to assets in the planning area. Plan maintenance procedures in Section 7 (Plan Maintenance) were developed to include specific, implementable activities. Future actions include integrating hazard mitigation goals into comprehensive plan updates; reviewing the HMP during updates of codes, ordinances, zoning, and development; and ensuring a more thorough integration of hazard mitigation, with its related benefits, will be completed within the upcoming five-year planning period.

1.1.6 Implementation of the Planning Process

The planning process and findings are required to be documented in local HMPs. To support the planning process in developing this HMP, Douglas County and the participating jurisdictions have accomplished the following:

- Developed a Local Planning Committee and Core Planning Team.
- Reviewed the 2015 *Douglas County Local Hazard Mitigation Plan*
- Identified and reviewed those natural and non-natural hazards that are of greatest concern to the community (hazards of concern) to be included in the plan.
- Profiled the relevant hazards.
- Estimated the inventory at risk and potential losses associated with the relevant hazards.
- Reviewed and updated the hazard mitigation goals and objectives.
- Reviewed mitigation strategies identified in the 2015 Douglas County Local HMP.
- Developed new mitigation actions to address reduction of vulnerability of hazards of concern.
- Involved a wide range of stakeholders and the public in the plan process.
- Developed mitigation plan maintenance procedures to be executed after obtaining approval of the plan from DHSEM and FEMA.

As required by the DMA 2000, Douglas County has informed the public and provided opportunities for public comment and input. Numerous agencies and stakeholders have participated as core or support members by providing input and expertise throughout the planning process. Refer to Appendix D (Public and Stakeholder Outreach) for copies of public service announcements, newspaper articles, and social media posts.

This HMP update documents the process and outcomes of Douglas County and the planning partner's efforts. Section 6 (Mitigation Strategy) includes documentation that the prerequisites for plan approval have been met. Section 3 (Planning Process) includes additional information on the process to develop this plan.

1.2 The Plan Update – What is Different?

Douglas County's initial HMP was approved by FEMA and adopted by the County in 2015. The 2020 update builds on the 2015 plan and specifically includes the following changes or enhancements. This plan differed from its predecessor for a variety of reasons:

Updated data and tools provided for a more detailed and accurate risk assessment. ArcGIS Survey123 was utilized to update critical facility and critical lifeline data. Additional hazards of concern were added including animal and disease infestation and impacts of the COVID-19 pandemic. An exposure analysis was utilized to determine risk for all soil hazards. The risk assessment was prepared to better support future grant applications by providing risk and vulnerability information that would directly support the measurement of "cost-effectiveness" required under FEMA mitigation grant programs.

The plan identified implementable actions with enough information to serve as the basis for policy and funding decisions and represent measurable impacts on resiliency and mitigation progress.

Table 1-2. Plan Changes Crosswalk

44 CFR Requirement	2015 Plan	2021 Updated Plan
Requirement §201.6(b): In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process shall include: *(1) An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval;* *(2) An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia and other private and non-profit interests to be involved in the planning process; and* *(3) Review and incorporation, if appropriate, of existing plans, studies, reports and technical information.*	The 2015 plan followed an outreach strategy utilizing multiple media developed and approved by the Steering Committee. This strategy involved the following: • Public participation on an oversight Steering Committee. • Public meetings between County employees and citizens. • Distribution of information at the Public Safety Advisory Committee meeting. • E-mails • Press releases. Stakeholders were identified and coordinated with throughout the process. A comprehensive review of relevant plans and programs was performed by the planning team.	Building upon the success of the 2015 plan, the 2021 planning effort deployed a similar public engagement methodology. The plan included the following enhancements: • Using social media. • Distribution of newsletters • Web-deployed survey and questionnaires As with the 2015 plan, the 2021 planning process identified key stakeholders and coordinated with them throughout the process. A comprehensive review of relevant plans and programs was performed by the planning team.
§201.6(c)(2): The plan shall include a risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.	The 2015 plan included a risk assessment of hazards of concern. It looked at assets exposed to the hazard, vulnerability, frequency of occurrence, warning time, geographic extent, potential impact, land use and development trends, and hazard summary.	Similar methodology, using new, updated data, was deployed for the 2021 plan update. This included new American Community Survey data and data sources that enabled a GIS-based analysis of exposure to several hazards.
§201.6(c)(2)(i): [The risk assessment] shall include a] description of the … location and extent of all-natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.	The 2015 plan presented a risk assessment of each hazard of concern. Each section included the following: • Hazard/Problem Description • Past Occurrences • Likelihood of Future Occurrences • Vulnerability Assessment	A new format, using new and updated data, was used for the 2021 plan update. Each section of the risk assessment includes the following: • Hazard profile, including maps of extent and location, previous occurrences, and probability of future events. • Climate change impacts on future probability.

44 CFR Requirement	2015 Plan	2021 Updated Plan
		• Vulnerability assessment including: impact on life, safety, and health, general building stock, critical facilities, and the economy, as well as future changes that could impact vulnerability. • The vulnerability assessment also includes changes in vulnerability since the 2015 plan. • Identified issues have been documented in each hazard profile.
§201.6(c)(2)(ii): [The risk assessment] shall include a] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i). This description shall include an overall summary of each hazard and its impact on the community.	Vulnerability was assessed for all hazards of concern. Each hazard of concern included a summary of assets exposed to the hazard (property risk/vulnerability, people risk/vulnerability, and environment risk/vulnerability).	A similar methodology was deployed for the 2021 plan update, using new and updated data. The 2021 plan update included the use of HAZUS computer model was used for the earthquake, flood, and hurricane hazards. These were Level 2 analyses using County data. Site-specific data on County-identified critical facilities were entered into the HAZUS model. HAZUS outputs were generated for other hazards by applying an estimated damage function to an asset inventory extracted from HAZUS-MH.
§201.6(c)(2)(ii): [The risk assessment] must also address National Flood Insurance Program insured structures that have been repetitively damaged floods.	A summary of NFIP insured properties including an analysis of repetitive loss property locations was included in the plan.	New NFIP data and participation stratus was included in the 2021 plan.
Requirement §201.6(c)(2)(ii)(A): The plan should describe vulnerability in terms of the types and numbers of existing and future buildings, infrastructure and critical facilities located in the identified hazard area.	A complete inventory of the numbers and types of buildings exposed was generated for each hazard of concern. The Steering Committee defined "critical facilities" for the planning area, and these were inventoried by exposure. Each hazard profile provides a discussion on future development trends.	The Local Planning Committee and Tera Tech staff comprehensively identified critical facilities and 2021 plan update using new and updated data.
Requirement §201.6(c)(2)(ii)(B): [The plan should describe vulnerability in terms of an] estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(i)(A) and a description of the methodology used to prepare the estimate.	Loss estimates were generated for all hazards of concern by using readily available information.	Quantitative loss estimates were generated for hazards of concern for which exposure data was available. These were generated by HAZUS for the earthquake, flood, wildfire, and soil hazards. For the other hazards, loss estimates were generated by

44 CFR Requirement	2015 Plan	2021 Updated Plan
		applying a regionally relevant damage function to the exposed inventory or through qualitative analysis. The asset inventory was the same for all hazards and was generated in HAZUS.
Requirement §201.6(c)(2)(ii)(C): [The plan should describe vulnerability in terms of] providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.	There is a summary of anticipated development in the Community profile.	A similar methodology was deployed for the 2021 plan update using new and updated data.
§201.6(c)(3):[The plan shall include a mitigation strategy that provides the jurisdiction's blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs and resources, and its ability to expand on and improve these existing tools.]	The 2015 plan contained goals, objectives, and actions. The identified actions covered multiple hazards, goals, and objectives.	A similar methodology for setting goals, objectives, and actions was applied to the 2021 plan update. The Local Planning Committee reviewed and reconfirmed the goals and objectives for the plan. The County used the progress reporting from the plan maintenance and evaluated the status of actions identified in the 2015 plan. Actions that were completed or no longer considered to be feasible were removed. The balance of the actions was carried over to the 2021 plan, and in some cases, new actions were added to the action plan.
Requirement §201.6(c)(3)(i): [The hazard mitigation strategy shall include a] description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.	The Local Planning Committee identified goals and objectives targeted specifically for this hazard mitigation plan. These planning components supported the actions identified in the plan.	A similar methodology for setting goals, objectives, and actions was applied to the 2021 plan update. The Local Planning Committee reviewed and updated the mission statement, goals, and objectives for the plan to include a focus on increased resiliency. This resulted in the finalization of eight goals and 25 objectives to frame the plan.
Requirement §201.6(c)(3)(ii): [The mitigation strategy shall include a] section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure.	For each identified hazard, goals and objectives were provided as part of the mitigation strategy for the County. The strategies were compiled into categories depending on the hazard they are related to. The strategies were then ranked.	The actions identified during the 2015 planning process were reviewed by the Core Planning Team and updated as necessary. This table was used to identified additional actions to include in the 2021 planning process.

44 CFR Requirement	2015 Plan	2021 Updated Plan
Requirement: §201.6(c)(3)(ii): [The mitigation strategy] must also address the jurisdiction's participation in the National Flood Insurance Program, and continued compliance with the program's requirements, as appropriate.	The County identified an action stating their commitment to maintain compliance and good standing under the program.	Ongoing participation in the NFIP for the County was included in ongoing capabilities.
Requirement: §201.6(c)(3)(iii): [The mitigation strategy shall describe] how the actions identified in section (c)(3)(ii) will be prioritized, implemented and administered by the local jurisdiction. Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.	Each recommended action was prioritized using a qualitative methodology based on the objectives the project will meet, the timeline for completion, how the project will be funded, the impact of the project, the benefits of the project, and the costs of the project.	A revised methodology based on the STAPLEE criteria, incorporating new and updated data, was used for the 2021 plan update.
Requirement §201.6(c)(4)(i): [The plan maintenance process shall include a] section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.	The 2015 plan details a plan maintenance strategy stating that the plan will be revised and maintained as required and formally adopted by the County after each revision.	The 2021 plan details a plan maintenance strategy similar to that of the initial plan.
Requirement §201.6(c)(4)(ii): [The plan shall include a] process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvement plans, when appropriate.	The 2015 plan details recommendations for incorporating the plan into other planning mechanisms.	The 2021 plan details recommendations for incorporating the plan into other planning mechanisms as identified by the jurisdictions.
Requirement §201.6(c)(4)(iii): [The plan maintenance process shall include a] discussion on how the community will continue public participation in the plan maintenance process.	The 2015 plan details a strategy for continuing public involvement.	A new plan maintenance strategy was developed for the 2021 plan.
Requirement §201.6(c)(5): [The local hazard mitigation plan shall include] documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting approval of the plan (e.g., City Council, County Commissioner, Tribal Council).	The County adopted the 2015 HMP.	The 2020 plan achieves DMA compliance for Douglas County and participating jurisdictions.

SECTION 2 PLAN ADOPTION

2.1 Overview

This section contains information regarding adoption of the plan by Douglas County and each participating jurisdiction.

> In addition to being required by DMA 2000, adoption of the plan is necessary because:
>
> - It lends authority to the plan to serve as a guiding document for all local and state government officials.
> - It gives legal status to the plan in the event it is challenged in court.
> - It certifies the program and grant administrators that the plan's recommendations have been properly considered and approved by the governing authority and jurisdictions' citizens.
> - It helps to ensure the continuity of mitigation programs and policies over time because elected officials, staff, and other community decision-makers can refer to the official document when making decisions about the community's future.
>
> Source: FEMA. 2003. H*ow to Series: Bringing the Plan to Life* (FEMA 386-4).

2.1.1 Plan Adoption by Local Governing Bodies

Adoption by the local governing bodies such as the County Commissioners, City Council or Town Board demonstrates the commitment of Douglas County and each participating jurisdiction to fulfill the mitigation goals and strategies outlined in the plan. Adoption of the plan via a municipal resolution legitimizes the HMP and authorizes responsible agencies to execute their responsibilities.

The County and all participating jurisdictions will proceed with formal adoption proceedings when FEMA has completed review of the plan and provides conditional approval of this HMP update, known as Approval Pending Adoption (APA)

Following adoption or formal action on the plan, the jurisdiction must submit a copy of the resolution or other legal instrument showing formal adoption (acceptance) of the plan to the Douglas County Hazard Mitigation Coordinator in the Douglas County Office of Emergency Management. Douglas County will forward the executed resolutions to Colorado DHSEM after which they will be forwarded to FEMA for record. The jurisdictions understand that FEMA will transmit acknowledgement of verification of formal plan adoption and the official approval of the plan to Douglas County.

The resolutions issued by each jurisdiction to support adoption of the plan will be included in Appendix A.

SECTION 3 PLANNING PROCESS

3.1 Introduction

This section includes a description of the planning process used to update the 2015 *Douglas County Local Natural Hazard Mitigation Plan* (HMP, also referred herein as the *Hazard Mitigation Plan* or *the plan*), including how it was prepared, who was involved in the process, and how the public was involved.

To ensure that the plan meets requirements of the DMA 2000 and that the planning process would have the broad and effective support of the participating jurisdictions, regional and local stakeholders, and the public, an approach to the planning process and plan documentation was developed to achieve the following:

- Douglas County invited multiple jurisdictions to join with them in the planning process. To date, five local municipal governments and three special districts in the County participated in the 2021 planning process. Jurisdictions that have not met participation requirements during the process will not be able to seek FEMA approval at the time of plan submittal nor will they be eligible to obtain FEMA mitigation grant funding Any non-participating local government within the Douglas County planning area can "link" to this plan in the future following the linkage procedures defined in Appendix H (Linkage Procedures).
- The plan will consider natural and non-natural hazards of concern facing the area, thereby satisfying the natural hazards mitigation planning requirements specified in DMA 2000.
- The plan will be developed following the process outlined by the DMA 2000 and FEMA regulations. Following this process ensures that all the requirements are met and support HMP review.

The Douglas County HMP update was written using the best available information obtained from a wide variety of sources. Throughout the HMP update process, a concerted effort was made to gather information from jurisdictional and regional agencies and staff, as well as stakeholders, federal and state agencies, and the residents of the County. The HMP Local Planning Committee solicited information from local agencies and individuals with specific knowledge of certain natural hazards and past historical events. In addition, the Local Planning Committee and Planning Partnership took into consideration planning and zoning codes, ordinances, and recent land use planning decisions. The hazard mitigation strategies identified in this HMP update were developed through an extensive planning process involving local, county and regional agencies, residents, and stakeholders.

This section of the plan describes the mitigation planning process, including (1) Organization of the Planning Process; (2) Stakeholder Outreach and Involvement; (3) Integration of Existing Data, Plans, and Technical Information; (4) Integration with Existing Planning Mechanisms and Programs; and (5) Continued Public Involvement.

3.2 Organization of the Planning Process

This section of the plan identifies how the planning process was organized with the many planning partners involved and outlines the major activities that were conducted in the development of this HMP update.

3.2.1 Organization of the Local Planning Committee

A contract planning consultant (Tetra Tech, Inc. referred herein as *Tetra Tech*) was selected to guide Douglas County and the participating jurisdictions through the HMP update process. A contract between Tetra Tech and Douglas County was executed May 26, 2020. Specifically, Tetra Tech, the *contract consultant*, was tasked with the following:

- Assisting with the organization of the Core Planning Team and Local Planning Committee.
- Assisting with the development and implementation of a public and stakeholder outreach program.
- Data collection.
- Facilitation and attendance at meetings (Core Planning Team, Local Planning Committee, stakeholder, public and other).
- Review and update of the hazards of concern, hazard profiling and risk assessment.
- Assistance with the review and update of mitigation planning goals and objectives.
- Assistance with the review of past mitigation strategies progress.
- Assistance with the screening of mitigation actions and the identification of appropriate actions.
- Assistance with the prioritization of mitigation actions.
- Authoring of the draft and final plan documents.

To facilitate plan development, Douglas County established a Local Planning Committee to provide guidance and direction to the HMP update effort and to ensure the resulting document will be embraced both politically and by the constituency within the planning area (refer to Table 3-1). Specifically, the Local Planning Committee was charged with the following:

- Attending and participating in Local Planning Committee meetings.
- Assisting with the development and completion of certain planning elements, including:
    - Reviewing and updating the hazards of concern.
    - Developing and promoting a public and stakeholder outreach program.
    - Assuring that the data and information used in the plan update process are the best available.
    - Reviewing and updating the hazard mitigation mission statement, goals and objectives.
    - Identifying and screening of appropriate mitigation strategies and activities.
- Reviewing and commenting on plan documents prior to submission to DHSEM and FEMA.

Table 3-1. Steering Committee Members

Name	Title	Organization	LPC Member	Core Planning Team Member
Lisa Goudy	Safety and Security Coordinator	Douglas County	Yes	Yes
Tim Johnson	Director Office of Emergency Management	Douglas County	Yes	Yes
Tim Hallmark	Director of Facilities, Fleet, and Emergency Support Services	Douglas County	Yes	Yes
Joel Hanson	GIS Services and Land Solutions	Douglas County	Yes	Yes
Zachary Humbles	Special Projects Engineer	Douglas County	Yes	Yes
Steve Koster	Assistant Director of Planning Services	Douglas County	Yes	
Keith Mathena	Sergeant, Sherriff's Office	Douglas County	Yes	

Name	Title	Organization	LPC Member	Core Planning Team Member
Carrie Groce	Senior Communications Specialist	Douglas County	Yes	
Sean Owens	Special Projects Manager, Public Works	Douglas County	Yes	
Wendy Manitta Holmes	Director, Communications and Public Affairs	Douglas County	Yes	
Jeff Case	Director of Public Works	Centennial Water and Sanitation District	Yes	
Emmalyn White		Centennial Water and Sanitation District	Yes	
Larry Nimmo	Director of Public Works	City of Castle Pines	Yes	
Sam Bishop	Director of Community Development	City of Castle Pines	Yes	
Bill Medina	Administrative Services Director	City of Lone Tree	Yes	
Ron Pinson	Commander	City of Lone Tree	Yes	
Rebecca Franco	Emergency Management Manager	Denver Water	Yes	
Holly Piza	Engineering Services Manager	Mile High Flood District	Yes	
Angelo Carrieri	Maintenance Superintendent	Parker Water & Sanitation District	Yes	
Ron Redd	District Manager	Parker Water & Sanitation District	Yes	
Norris Croom	Fire Chief	Town of Castle Rock	Yes	
Craig Rollins	Assistant Fire Chief	Town of Castle Rock	Yes	
Randal Johnson	Fire Marshal	Town of Larkspur	Yes	
Sean Hogan	Town Clerk	Town of Larkspur	Yes	
Gregg Epp	Sergeant, Parker Police Department	Town of Parker	Yes	
Andrew Coleman	Commander, Parker Police Department	Town of Parker	Yes	
Steve Brueske	Vice Chairman	Douglas County Public Safety Advisory Committee	Yes	
Christine Duffy	Appointed Public Trustee	Douglas County		
Tom Cribley	Volunteer	Douglas County Search and Rescue	Yes	
John Zettler	Public Citizen		Yes	
Matt Fierro	Public Citizen		Yes	
Dan Qualmann	Public Citizen		Yes	
John Hoskinson	Public Citizen		Yes	
Bill Denning	Public Citizen		Yes	
Vicky Starkey	Public Citizen		Yes	
Janice Michael	Public Citizen		Yes	
Deb Watts	Emergency Management Liaison	Xcel Energy	Yes	
Tom Henley	Community and Local Government Affairs	Xcel Energy	Yes	

Appendix B (Participation Matrix), identifies those individuals who represented the municipalities during this planning effort and indicates how they contributed to the planning process.

3.2.2 Planning Activities

The Local Planning Committee, as well as key stakeholders, convened and/or communicated regularly to share information and participate in workshops to identify hazards; assess risks; review existing inventories of and identify new critical facilities; assist in updating and developing new mitigation goals and strategies; and provide continuity through the process to ensure that natural hazards vulnerability information and appropriate mitigation strategies were incorporated. All members of the Local Planning Committee had the opportunity to review the draft plan and supported interaction with other stakeholders and assisted with public involvement efforts.

A summary of the Local Planning Committee meetings held, and key milestones met during the development of the HMP update is included in Table 3-2 that also identifies which DMA 2000 requirements the activities satisfy. Documentation of meetings (agendas, sign-in sheets, minutes, etc.) are in Appendix C (Meeting Documentation). Table 3-2 identifies only the formal meetings held during plan development and does not reflect the planning activities conducted by individuals and groups throughout the planning process. In addition to these meetings, there was a great deal of communication between the County, Planning Partners, Local Planning Committee members, and the contract consultant through individual virtual meetings, electronic mail (email), and by phone.

After completion of the HMP update, implementation and ongoing maintenance will become a function of the Steering Committee as described in Section 7. The Steering Committee is responsible for reviewing the HMP and soliciting and considering public comment as part of the five-year mitigation plan update.

This table summarizes a list of mitigation planning activities and meetings and their respective participants. A more detailed list of participants for each meeting is provided in Appendix C. Refer to DMA 2000 (Public Law 106-390) for details on each of the planning requirements (https://www.fema.gov/media-library-data/20130726-1524-20490-1790/dma2000.pdf).

Table 3-2. Summary of Mitigation Planning Activities / Efforts

Date	DMA 2000 Requirement	Description of Activity	Participants
July 8, 2020	2	Planning Partnership Kick-off Meeting	Douglas County, City of Castle Rock, City of Lone Tree, Town of Castle Rock, Town of Larkspur, Town of Parke, Centennial Water & Sanitation District, Denver Water, Mile High Water & Sanitation, Parker Water & Sanitation District
July 22, 2020	2	Local Planning Committee Meeting #1: Established Committee Role/Ground rules and schedule; reviewed hazard mitigation planning and update process; defined the Planning Area for the update; defined and identified critical facilities/infrastructure; and confirmed hazards of	Representatives Douglas County and Planning Participants departments: OEM, Public Works, Communications, Planning, Vehicle and Fleet Services, Engineering, Facilities, Fleet, and Emergency Support Services, Safety and Security, Search and Rescue, Fire, Police, Administration, Xcel Energy, Tetra Tech; and the General Public

Date	DMA 2000 Requirement	Description of Activity	Participants
		concern, reviewed data collection status/ confirmed public involvement strategy and tracking of efforts.	
August 19, 2020	2, 4a	Steering Committee Meeting #2: Confirmed mission statement, Plan goals, and identified potential objectives for the Plan	Representatives Douglas County and Planning Participants departments: OEM, Public Works, Communications, Planning, Vehicle and Fleet Services, Engineering, Facilities, Fleet, and Emergency Support Services, Safety and Security, Search and Rescue, Fire, Police, Administration, Xcel Energy, Tetra Tech; and the General Public
September 16, 2020	2, 4b	Steering Committee Meeting #3: Established public outreach strategy, conducted a capability exercise to determine strengths, weaknesses, obstacles and opportunities; and confirmed Plan objectives.	Representatives Douglas County and Planning Participants departments: OEM, Public Works, Communications, Planning, Vehicle and Fleet Services, Engineering, Facilities, Fleet, and Emergency Support Services, Safety and Security, Search and Rescue, Fire, Police, Administration, Xcel Energy, Tetra Tech; and the General Public
October 28, 2020	2	Steering Committee Meeting #4: Reviewed draft risk assessment results, presented risk ranking methodology, and conducted risk ranking exercise.	Representatives Douglas County and Planning Participants departments: OEM, Public Works, Communications, Planning, Vehicle and Fleet Services, Engineering, Facilities, Fleet, and Emergency Support Services, Safety and Security, Search and Rescue, Fire, Police, Administration, Xcel Energy, Tetra Tech; and the General Public
November 18, 2020	1b, 2, 3a, 3b, 3c, 3d, 3e	Risk Assessment - Public Workshop	OEM, General Public, Tetra Tech
January 6, 2021	2, 4a, 4b, 4c	Planning Participants Mitigation Strategy Workshop: confirmed Risk Ranking of hazards and developed mitigation actions for the Plan.	Douglas County, City of Castle Rock, City of Lone Tree, Town of Castle Rock, Town of Larkspur, Town of Parke, Centennial Water & Sanitation District, Denver Water, Parker Water & Sanitation District
January 27, 2021	2, 5a, 5b, 5c	Steering Committee Meeting #5: Presentation of Draft Plan to Committee and provided instructions on how to submit edits and comments.	Representatives Douglas County and Planning Participants departments: OEM, Public Works, Communications, Planning, Vehicle and Fleet Services, Engineering, Facilities, Fleet, and Emergency Support Services, Safety and Security, Search and Rescue, Fire, Police, Administration, Xcel Energy, Tetra Tech; and the General Public
February 10, 2021	1b, 2	Solicit Public Comment on Draft Plan – Public Workshop	OEM, General Public, Tetra Tech
February 26, 2021	NA	Public Comment Period Closed	Representatives Douglas County and Planning Participants departments: OEM, Public Works, Communications, Planning, Vehicle and Fleet Services, Engineering, Facilities, Fleet, and Emergency Support Services, Safety and Security, Search and Rescue, Fire, Police, Administration, Xcel Energy, Tetra Tech; and the General Public

Date	DMA 2000 Requirement	Description of Activity	Participants
March 2021	NA	Final draft revised with public input to DHSEM for review	DHSEM
May 2021	NA	Plan submittal revised to address DHSEM comments provided to DHSEM for submittal to FEMA Region VIII for review	FEMA Region VIII
July 21, 2021	NA	Approval Pending Adoption received from FEMA Region VIII	FEMA Region VIII
July 2021	NA	Adoption window of final plan opens	Participating Jurisdictions
December 10, 2021	NA	Final plan approved by FEMA	FEMA Region VIII

Note: All activities/efforts were conducted during the National Emergency response to the COVID-19 pandemic.
TBD = to be determined.
Each number in column 2 identifies specific DMA 2000 requirements, as follows:
1a – Prerequisite – Adoption by the Local Governing Body
1b – Public Participation
2 – Planning Process – Documentation of the Planning Process
3a – Risk Assessment – Identifying Hazards
3b – Risk Assessment – Profiling Hazard Events
3c – Risk Assessment – Assessing Vulnerability: Identifying Assets
3d – Risk Assessment – Assessing Vulnerability: Estimating Potential Losses
3e – Risk Assessment – Assessing Vulnerability: Analyzing Development Trends
4a – Mitigation Strategy – Local Hazard Mitigation Goals
4b – Mitigation Strategy – Identification and Analysis of Mitigation Measures
4c – Mitigation Strategy – Implementation of Mitigation Measures
5a – Plan Maintenance Procedures – Monitoring, Evaluating, and Updating the Plan
5b – Plan Maintenance Procedures – Implementation through Existing Programs
5c – Plan Maintenance Procedures – Continued Public Involvement

3.3 Stakeholder Outreach and Involvement

This section details the outreach to and involvement of the many agencies, departments, organizations, non-profits, districts, authorities, and other entities that have a stake in managing hazard risk and mitigation, commonly referred to as *stakeholders*. Involving stakeholders in the planning process helps to develop support for the plan.

Diligent efforts were made to assure broad regional, county, and local representation in this planning process. To that end, a comprehensive list of stakeholders was developed with the support of the Steering and Planning Partnerships. Stakeholder outreach was performed early and throughout the planning process. This HMP update includes information and input provided by these stakeholders where appropriate, as identified in the references.

The following is a list of the various stakeholders that were invited to participate in the development of this plan, along with a summary of how these stakeholders participated and contributed. This summary discusses the various stakeholders that were invited to participate in the development of this HMP update and how they participated and contributed to the HMP. It should be noted that this summary listing cannot represent the sum total of stakeholders that were aware of and contributed to this HMP update, as outreach efforts were being made, both formally and informally, throughout the process by the many planning partners involved in the effort, and documentation of all such efforts is impossible. Instead, this summary is intended to demonstrate the scope and breadth of the stakeholder outreach efforts made during the plan update process.

3.3.1 Federal, State, and County Departments

The following describes the various departments and agencies that were involved during the planning process.

Federal Agencies

FEMA Region VIII: Provided updated planning guidance, summarized and detailed NFIP data for planning area, and conducted plan review.

Other Agencies: Information regarding hazard identification and the risk assessment for this HMP update was requested and received or incorporated by reference from the following agencies and organizations:

- Bureau of Land Management
- National Centers for Environmental Information (NCEI)
- National Oceanic and Atmospheric Administration (NOAA)
- National Weather Service (NWS)
- Storm Prediction Center (SPC)
- U.S. Census Bureau
- United States Forest Service

State Agencies

Relevant state agencies were invited to participate in the plan development process and were kept apprised of plan development process through area meetings, data requests, inter-agency communication, and data sharing. Relevant agencies include:

- Colorado Division of Fire Protection and Control
- Colorado Division of Homeland Security and Emergency Management
- Colorado Division of Water Resources (Dam Safety Branch)
- Colorado State Forest Service
-

Douglas County and Participating Jurisdictional Departments

Several Douglas County and participating jurisdictional departments were represented on the Local Planning Committee and involved in the HMP update planning process. Appendix B (Participation Matrix) provides further details regarding regional and local stakeholder agencies. All responses to the stakeholder surveys are in Appendix D (Public and Stakeholder Outreach).

Douglas County Office of Emergency Management: The Director of Emergency Management is identified as the ongoing Douglas County HMP Coordinator and served in this role throughout the planning process. In addition, the Office provided critical data, assisted with the update of events and losses in the County, updated the previous mitigation strategy, facilitated outreach to stakeholders, contributed to the County's capability assessment, updated the mitigation strategy, and reviewed draft sections of the HMP.

Additionally, representatives from facilities, fleet, and emergency support services, safety and security, GIS services and land solutions, engineering, and flood plain management participated as part of the Core

Planning Team. Representatives emergency management, public works, communications, planning, engineering, planning, search and rescue, fire, police, community development, and administration participated as members of the Local Planning Committee.

3.3.2 Regional and Local Stakeholders

The stakeholders listed below were directly contacted by Douglas County to take a stakeholder survey, which included the identification of hazard risk, mitigation projects and/or review of the draft HMP. Appendix B (Participation Matrix) identifies the stakeholders that attended meetings. Appendix D (Public and Stakeholder Outreach) provides stakeholder survey results.

Adjacent Counties

Douglas County made an effort to keep surrounding counties and municipalities appraised of the project and allowed the opportunity to provide input to the planning process. Specifically, the following adjoining and nearby county representatives were contacted to inform them about the availability of the project website, draft plan documents, and surveys, and to invite them to provide input to the planning process. The neighboring county survey was provided to the neighboring counties on October 2, 2020.

- Arapahoe County*
- El Paso County*
- Elbert County*
- Jefferson County*
- Teller County*
- Park County

County indicated by an asterisk (*) provided input to the planning process via the County online stakeholder survey.

3.3.3 Stakeholder Survey Summary

The following provides a summary of the results and feedback received by stakeholders who completed the survey. Feedback was reviewed by the Local Planning Committee and integrated where appropriate in the plan.

Neighboring County Survey

The neighbor survey was sent to the surrounding counties of Douglas County due to their proximity to the County and due to the fact that effects of hazard events that impact Douglas County would be similar to that of their neighbors. As of February 2, 2021, five counties completed the survey.

Respondents were asked to answer 38 questions to help Douglas County get an understanding of their involvement with the County. A summary of each county response is provided below.

Arapahoe County

Arapahoe County stated that they collaborate with Douglas County's comprehensive emergency operations planning and nearly all aspects of emergency management and public safety. Douglas County is also involved in Arapahoe County's comprehensive emergency operations planning. However, neither county is involved in each other's continuity of operations planning.

Information sharing is achieved through email, phone, text, radios, and in-person training and exercises. Additionally, the counties share risk and vulnerability assessments through GIS, Teams, and WebEOC.

Through participation in North Central Region (NCR), both counties collaborate on establishing evacuation routes and alternate evacuation routes. When making decisions about evacuation routes, coordination is conducted through various methods of communication and GIS. With regards to sheltering, the counties consult with each other for sheltering locations near their borders.

While the counties do not have a method of sharing information about mitigation projects, they do share information regarding mitigation during the planning and implementation phases of projects through participation in NCR.

Arapahoe County indicated that they are aware of projects that would require collaboration between the counties like floodplain projects or planning. This type of collaboration typically occurs through shared special districts.

El Paso County

El Paso County indicated that Douglas County is involved in their comprehensive emergency operations planning and they are involved in Douglas County's planning. El Paso County said that Douglas County has been a very strong partner and has included them in many events that have the potential to impact both counties. While Douglas County is not involved in El Paso County's continuity of operations planning, El Paso County is involved in Douglas County's through collaboration.

During an emergency event, the counties communication through direct contact from OEM leadership either prior to or during an event. The counties also both share risk and vulnerability assessments if needed. With regards to evacuation and sheltering, the El Paso and Douglas Counties collaborate on establishing evacuation routes and sheltering. Also, El Paso County has access to contacting the Douglas County emergency operations center. The counties have cross-collaborated on projects, including the I-25 gap roadway improvements.

Elbert County

Elbert County collaborates with Douglas County on multiple planning efforts and both participate in NCR coordination initiatives. Through NCR coordination, both counties are involved in their continuity of operations planning and share risk and vulnerability assessment data. Through collaboration and direct communication during an incident, Elbert and Douglas Counties consult one another before making evacuation decisions that could impact either county and collaborate on establishing and making sheltering decisions. In the event of an emergency, Elbert County has access to contact information for Douglas County's emergency operations center.

Each county offers information sharing between each other, including the planning and implementation phases of mitigation projects. The counties have OEM personnel involved in animal evacuation/sheltering outreach projects. Lastly, Elbert County has shared service agreements with Douglas County for IPAWS and dispatch.

Jefferson County

Jefferson County regularly communicates with Douglas County to share resources and best practices. The two counites participate in numerous regional planning committees. Jefferson and Douglas Counties communicate through phone calls, emails, WebEOC, regional training and exercises, and regional committee participation. Jefferson County also has contact information for Douglas County OEM in the event of an emergency. Jefferson County indicated that they are not currently involved in Douglas County's continuity of operations planning; however, Jefferson County would welcome and assist Douglas County with any COOP needs that they are able to assist with.

Regarding evacuation and sheltering, if an accident occurred on or close to the county borders, the neighboring counties would reach out to each for assistance if an evacuation or re-routing is needed. For sheltering needs, both counties participate in the NCR Mass Care committee and contribute to shelter locations and resources to the NCR database. In the event either county needs to identify shelters in their neighboring counties, Jefferson and Douglas Counties would consult each other.

The counties worked together on the Waterton Canyon and Chatfield Reservoir project and have collaborated on grant applications. The counties developed grants for training, mass care planning, and animal evacuations. Jefferson County stated that leveraging each other's training and exercise planning are opportunities to optimize cooperation between the counties.

Teller County

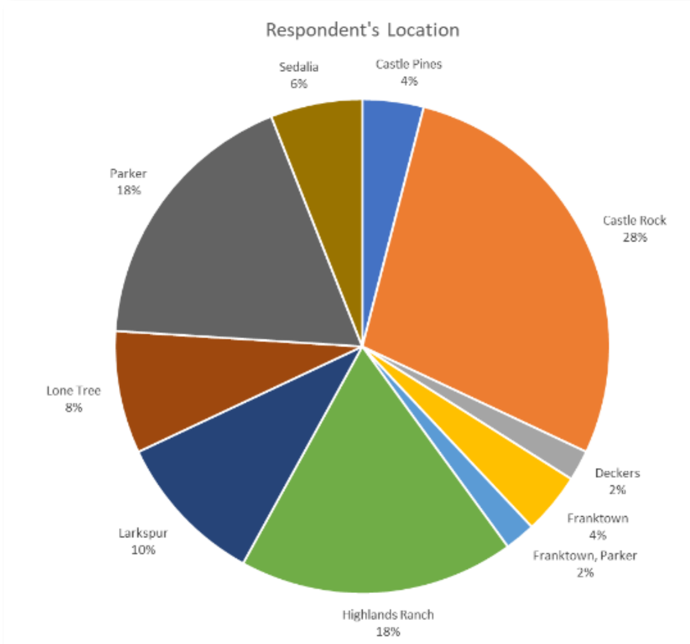
Teller County and Douglas County are both involved in each of their comprehensive emergency operations planning through collaboration with Mountain Communities Fire District. Teller County is also involved in Douglas County's continuity of operations planning. Emergency communications between the two counties is done through dispatch, car-to-car, and between OEMs. They also share risk and vulnerability assessments. Information regarding mitigation is also shared between the two counties.

3.3.4 Public Outreach

The Core Planning Team and Local Planning Committee have made the following efforts toward public participation in the development and review of the HMP:

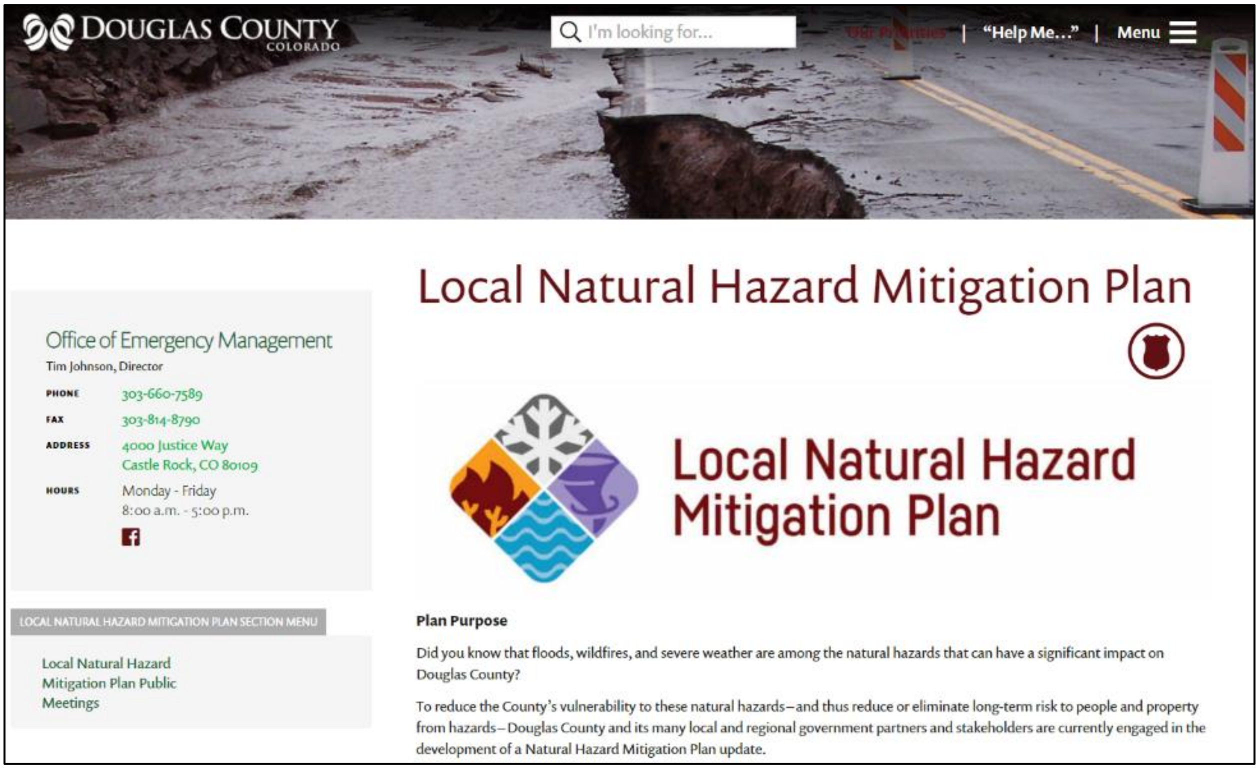
- A public outreach strategy was developed by the Douglas County Department of Communication and Public Affairs. Refer to Appendix D (Public and Stakeholder Outreach) for a copy of the developed outreach strategy.
- A public project webpage was developed and is being maintained to facilitate communication between the Core Planning Team, Local Planning Committee, public and stakeholders (https://www.douglas.co.us/natural-hazard-mitigation-plan/). The public webpage contains a project overview, contact information, access to the citizen's survey, Local Planning Committee meeting notes and bulletins; and sections of the HMP for public review and comment (see Figure 3-1).
- Participating jurisdictions, such as the City of Lone Tree, created links on their respective pages to the Douglas County HMP webpage.
- All LPC meetings were open to the general public and notifications of all LPC meetings and public workshops were posted on the Douglas County HMP webpage along with the corresponding meeting agendas. Additionally, notifications were sent out via social media outlets such as the County's Facebook and Twitter accounts. Meetings were also advertised on the project webpage. Follow-up materials such as meeting minutes were also posted on the project webpage.

- A series of questions, online polls, and a public survey were used to gauge household preparedness relevant to hazards in Douglas County and to assess the level of knowledge of tools and techniques to assist in reducing risk and loss of those hazards.



  - A public survey was posted on the Douglas County HMP webpage starting in October 2020. The survey closed on January 1, 2021. A total of 50 responses were received. A majority of the responses came from residents who live in Castle Rock and Highlands Ranch. See Appendix D (Public and Stakeholder Outreach) for a copy of the survey and summary of the results.
  - Additionally, the County utilized Nextdoor to generate four polling questions over the course of three months. A total of 66 responses were received. When asked if residents considered the impact that a natural or non-natural disaster could have on their home, 56% said yes that they considered the potential impact while 44% responded no. When asked if residents live in a wildfire risk area, 61% said yes and 39% said no. When asked if their home was located in or near a FEMA designated floodplain, 9% said yes, 57% said no and 35% said they were unsure. Lastly, when asked if they know of multiple ways to evacuate or get out of their neighborhood in the event of a hazard, 76% said yes and 24% said no.

Figure 3-1. Douglas County HMP Webpage



Starting in December 2021, draft sections of the plan (as available) were posted on the project website for public review and comment.

Once approved by Colorado DHSEM and FEMA Region VIII, the final HMP will be available on the County's website.

3.4 Integration with Existing Planning Mechanisms and Programs

Effective mitigation is achieved when hazard awareness and risk management approaches and strategies become an integral part of public activities and decision-making. Within the planning area there are many existing plans and programs that support hazard risk management, and thus it is critical that this hazard mitigation plan integrate, coordinate with, and complement, those existing plans and programs.

The *Capability Assessment* section of Section 6 (Mitigation Strategy) provides a summary and description of the existing plans, programs and regulatory mechanisms in the County that support hazard mitigation. A similar analysis of existing capabilities for each participating jurisdiction can be found in their respective annex in Section 9. A further summary of these continued efforts to develop and promote a comprehensive and holistic approach to hazard risk management and mitigation is presented in Section 7 (Plan Maintenance).

3.5 Continued Public Involvement

Douglas County is committed to the continued involvement of the public in the hazard mitigation process. This HMP update will be posted online at (https://www.douglas.co.us/natural-hazard-mitigation-plan/).

Due to COVID-19 and efforts to limit physical contact, electronic copies of the plan are available for download from the website.

A notice regarding annual updates of the plan and the location of plan copies will be publicized annually after the Steering Committee's annual evaluation and posted on the public website at: https://www.douglas.co.us/natural-hazard-mitigation-plan/.

The public will have an opportunity to comment on the plan as a part of the annual mitigation planning evaluation process and the next five-year mitigation plan update. The HMP Coordinator is responsible for coordinating the plan evaluation portion of the meeting, soliciting feedback, collecting and reviewing the comments, and ensuring their incorporation in the five-year plan update as appropriate. The purpose of these meetings would be to provide the public an opportunity to express concerns, opinions, and ideas about the plan.

Further details regarding continued public involvement are provided in Section 7 (Plan Maintenance).

After completion of this plan, implementation and ongoing maintenance will continue to be a function of the Steering Committee. The Steering Committee will review the plan and accept public comment as part of an annual review and as part of five-year mitigation plan updates.

A notice regarding annual updates of the plan and the location of plan copies will be publicized annually after the Steering Committee's annual evaluation and posted on the public web site.

Tim Johnson, Director for Douglas County Office of Emergency Management, is identified as the Douglas County HMP Coordinator in Section 7 (Plan Maintenance), and is responsible for receiving, tracking, and filing public comments regarding this plan.

SECTION 4 COUNTY PROFILE

This profile provides general information for Douglas County critical facilities located within the County. Examining the County's physical setting, population and demographics, general building stock, and land use and population trends leads to a better understanding of the study area, including economic, structural, and population assets at risk, and concerns that could be related to hazards analyzed later in this plan.

4.1 General Information

Established on November 1, 1861, along with 16 other original counties in the Colorado Territory, Douglas County was created by the Colorado Territorial Legislature. Douglas County was named for U.S. Senator Stephen A. Douglas from Illinois, who had died five months prior to the creation of the County. The county seat was originally located first in Franktown and then in California Ranch in 1863 before its final establishment in Castle Rock in 1874. While Douglas County originally extended as far eastward as the Kansas state border, this eastern-most boundary of the County was annexed by Elbert County in 1874. Douglas County includes the following subdivisions: City of Castle Pines, City of Lone Tree, Town of Castle Rock, Town of Larkspur, Town of Parker, and Unincorporated Douglas County.

4.2 Major Past Hazard Events

Presidential disaster declarations are issued for hazard events that cause more damage than state and local governments can handle without assistance from the federal government. No specific dollar loss threshold has been established for these declarations. A presidential disaster declaration puts operationalizes federal recovery programs to assist disaster victims, businesses and public entities. Programs can be matched by state programs. Review of presidential disaster declarations helps establish the probability of reoccurrence for each hazard and identify targets for risk reduction. Table 4-1 shows FEMA disaster declarations that have included Douglas County through 2020.

Douglas County has been subject to federal disaster declarations for two flooding events, three fires, one drought event, one tornado event, and two snow events. Additionally, the County was subject to a disaster declaration pertaining to the COVID-19 pandemic.

Table 4-1. History of Hazard Events in Douglas County, Colorado

Disaster Number	Declaration Date	Event Date	Incident Type	Title
DR-200	June 19, 1965	June 19, 1965	Tornado	Tornadoes, Severe Storms, and Flooding
DR-261	May 19, 1969	May 19, 1969	Flood	Severe Storms and Flooding
DR-385	May 23, 1973	May 23, 1973	Flood	Heavy Rains, Snowmelt, and Flooding
EM-3025	January 29, 1977	January 29, 1977	Drought	Drought
DR-1421	June 19, 2002	April 23-August 26, 2002	Fire	Wildfires
FS-2407	May 23, 2002	May 21-May 29, 2002	Fire	Schoonover Fire
EM-3185	April 9, 2003	March 17-20, 2003	Snow	Snow
EM-3224	September 5, 2005	August 29- October 1, 2005	Coastal Storm	Hurricane Katrina Evacuation
EM-3270	January 7, 2007	December 18-22, 2006	Snow	Snow
FM-2510	October 29, 2003	October 29-31, 2003	Fire	Cherokee Ranch Fire
EM-3436	March 13, 2020	January 20, 2020- Ongoing	Biological	COVID-19
DR-4498	March 28, 2020	January 20, 2020- Ongoing	Biological	COVID-19 Pandemic

4.3 Physical Setting

This section presents the physical setting of the County, including land use/land cover, location, climate, hydrography and hydrology, topography and geology.

4.3.1 Location

Douglas County is located in the central region of Colorado along the I-25 Corridor. The County lies between two major urban activity centers: Denver and Colorado Springs. Within its jurisdiction lies 540,000 acres of mountain vistas, dramatic ridgelines, hills, and grass covered plains. Elevations vary drastically within Douglas County, from as low as 5,400 feet in the northeastern regions to as high as 9,836 feet at Thunder Butte in Pike National Forest. Castle Rock, the county seat, is named after a castle tower-shaped butte that is located north of the Town. Douglas County has a total land area of 840.25 square miles (U.S. Census Bureau 2020).

4.3.2 Topography and Geology

Douglas County's topography is known for its diverse range of land characteristics, from grassy plains and gently rolling hills to steep slopes and sharply rising scenic buttes. Several regions of the County are defined by undulating terrain and deep arroyos. Elevations also vary greatly throughout the County, ranging from around 5,360 feet to over 9,835 feet in some parts of Pike National Forest. The Douglas County CWPP provides a more in-depth discussion of topography by area in Douglas County.

4.3.3 Hydrography and Hydrology

Douglas County is located in the Denver Basin and is primarily located within the Middle South Platte and Upper South Platte Watersheds. A small portion of the County southeast of Spruce Mountain is located within the Fountain Watershed.

The South Platte River forms Douglas County's western boundary, flowing northerly from Park County. The River is impounded at Chessman Lake in the southwest portion of the County and at Chatfield Reservoir in the northwestern portion of the County. Tributaries of the Creek extend easterly into Pike National Forest.

Chatfield Reservoir also serves as an impoundment for Plum Creek, which branches south of Sedalia near the intersection of Routes 67 and 105. From that point, East Plum Creek parallels Interstate 25 and passing near Larkspur to its headwaters near the border with El Paso County. Route 105 follows West Plum Creek to Larkspur, where its headwaters are located up Stark Creek in Pike National Forest.

Cherry Creek is the third major surface water system in Douglas County. Its headwaters are also located in El Paso County, and is followed by Route 83 northward into Arapahoe County. Both Plum Creek and Cherry Creek are tributaries of the South Platte River.

4.3.4 Climate

Douglas County is characterized by its sunny and moderate climate, unlike its neighboring Rocky Mountains region to the west, which has extreme temperatures. The County averages over 300 days of sunshine a year. During the winter months, Douglas County typically has a short period of cold and snowy weather. The average high temperature is 87° F in July and 46°F in January. January's low temperatures can fall in the teens. The average annual precipitation is 18.6 inches, and average annual snowfall is 71.3 inches. Due to its low humidity, Douglas County boasts pleasant climates, where winter days are generally sunny with temperatures in the 40s (USA.com 2020).

4.3.5 Land Use and Land Cover

Douglas County's land cover predominantly consists of agriculture lands and forest lands, which together cover more than 84% of the County's land area. Urbanized land cover is increasing in the County and is taking the place of agriculture and ranching land. Figure 4-2 shows the distribution of land use in Douglas County. Urbanized land is concentrated in the northern and central portion of the County, with forest comprising a large portion of the western portion of the County that is within Pike National Forest. Agricultural land is concentrated along the County's waterways, as well as the burn area within Pike National Forest.

Table 4-2. Land Use Classification for Douglas County

Land Use Classification (National Land Use Land Cover 2016)	Area	
	Acres	Percent of Total
Agriculture	209,208	38.8%
Barren Land	78	<0.1%
Forest	244,368	45.3%
Urban Area	73,647	13.6%
Water	2,122	0.4%
Wetlands	10,284	1.9%
Douglas County (Total)	**539,707**	

Source: U.S.G.S. National Land Use Land Cover Dataset, 2016

Figure 4-1. Douglas County Base Map

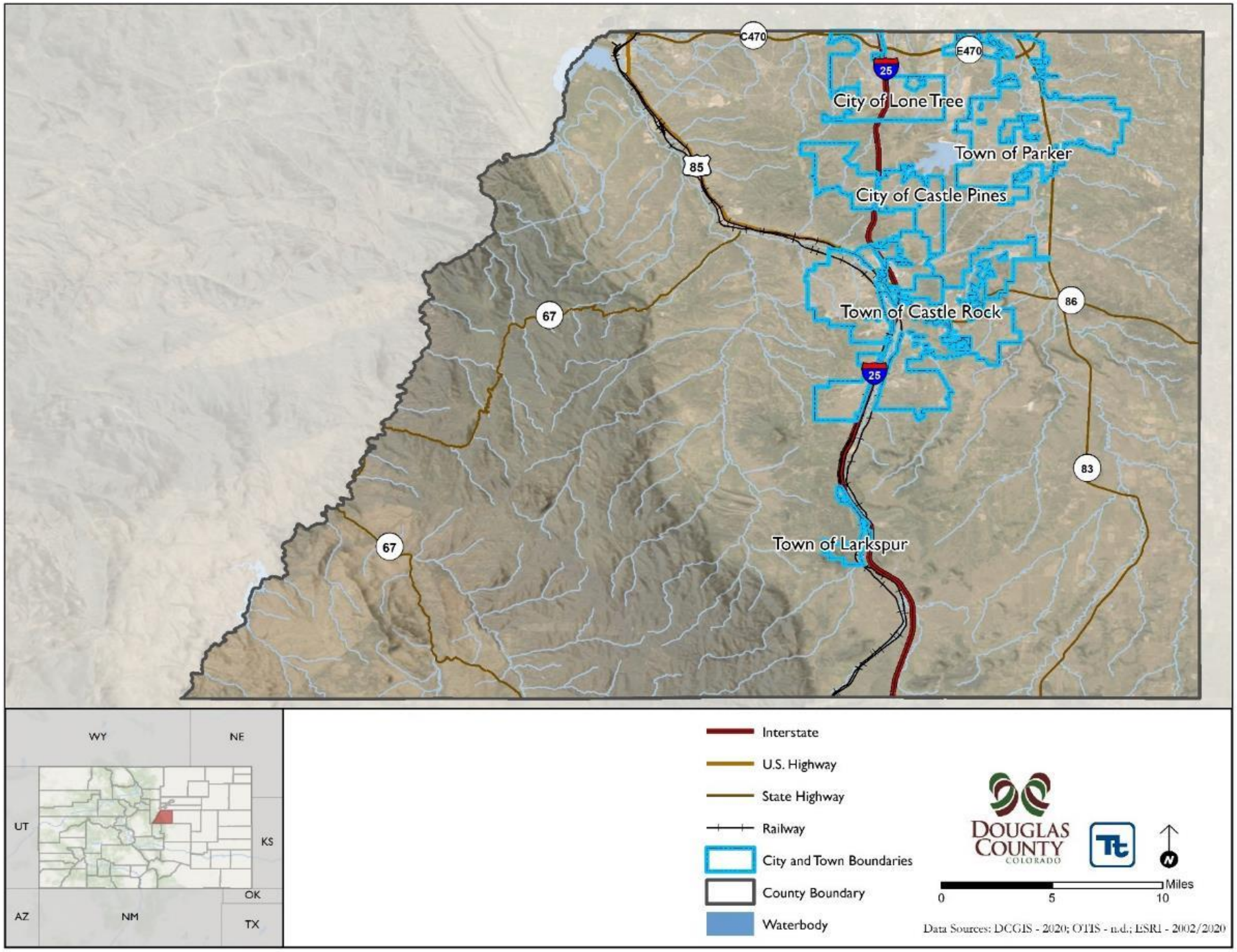
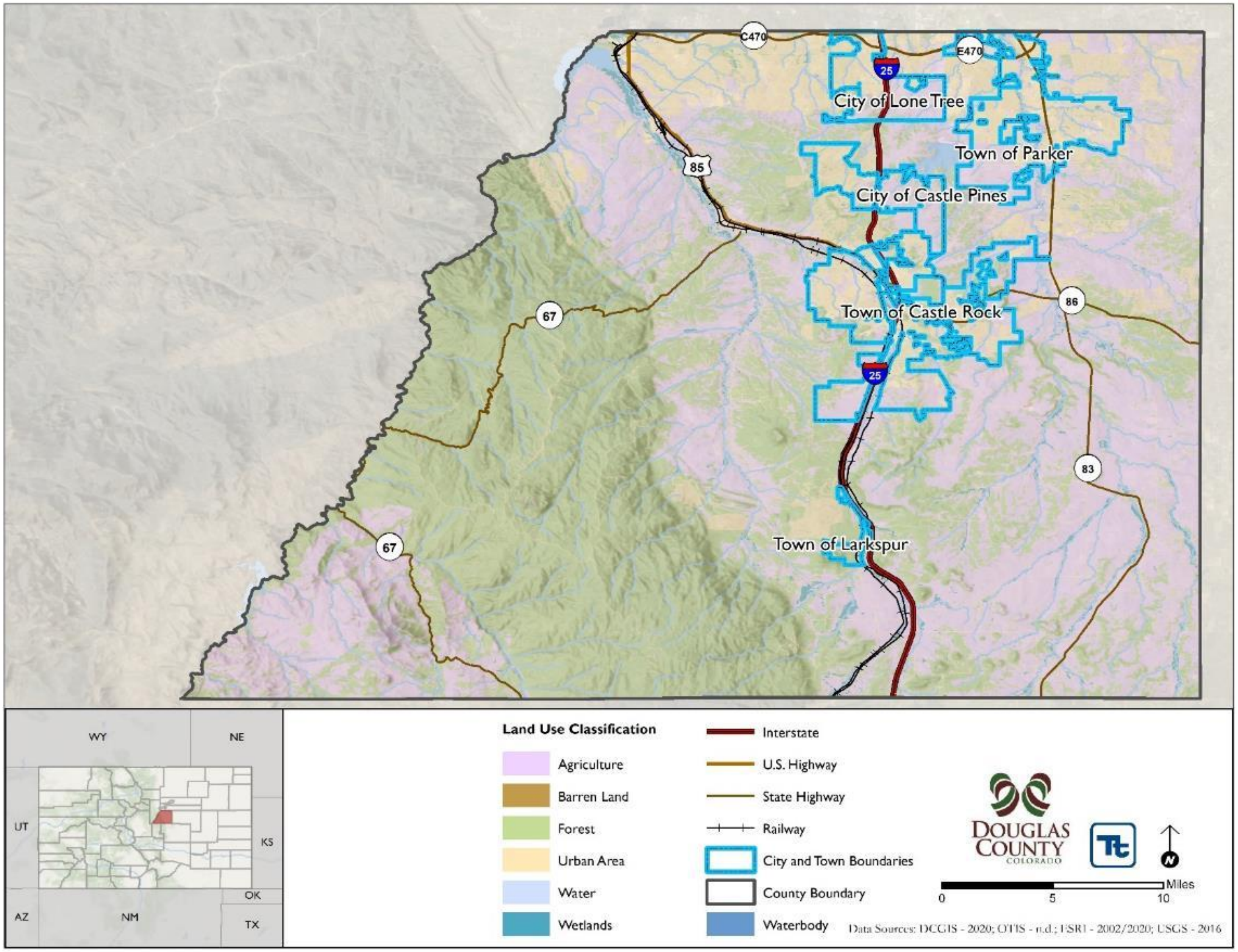


Figure 4-2. 2016 Land Use in Douglas County, Colorado



4.4 Population And Demographics

As of 2018, Douglas County has a population of 328,614 people, indicating a significant increase from the 2010 U.S. Census population of 285,465 people (United States Census Bureau 2018). Hazus demographic data will be used in the loss estimation analyses in Section 4 of this plan. All demographic data in Hazus corresponds to the 2010 U.S. Census data. The population statistics for Douglas County are highlighted in Table 3-3, which includes data from the 2000 and 2010 U.S. Census, along with the 2018 American Community Survey data. In Figure 3-3, data from the 2010 U.S. Census Bureau illustrates the distribution of the general population density (persons per square mile) in 2010 by Census block. For the purposes of this plan, the 2010 Census was used where the data was available and supplemented with Hazus data (representing 2010 data).

Table 4-3. Population Statistics in Douglas County

Municipality	2000 Census	2010 Census	2018 ACS
Douglas County	175,766	285, 465	328,614

Source: US Census Bureau

Population and Demographic Trends

This section discusses population trends to use as a basis for estimating future changes that could result from the seasonal character of the population and significantly change the character of the area. Population trends can provide a basis for making decisions on the type of mitigation approaches to consider and the locations in which these approaches should be applied. This information can also be used to support planning decisions regarding future development in vulnerable areas.

According to the U.S. Census Bureau, Douglas County's 2010 population was 285,465 people, indicating a population increase of 62.4% from 2000, when the 2000 Census showed a population of 175,166 people. This high growth rate has made Douglas County the fastest growing county in Colorado and has ranked the County as the 16th fastest growing county in the United States. During this 10 year period, the population aged 65 and over increased by 177.8%. Over the last 60 years, from 1960 to 2020, the County has seen notable population growth. The largest increase in absolute terms was between 2010 and 2018, whereas the largest increase in percentage came between 1980 and 1990.

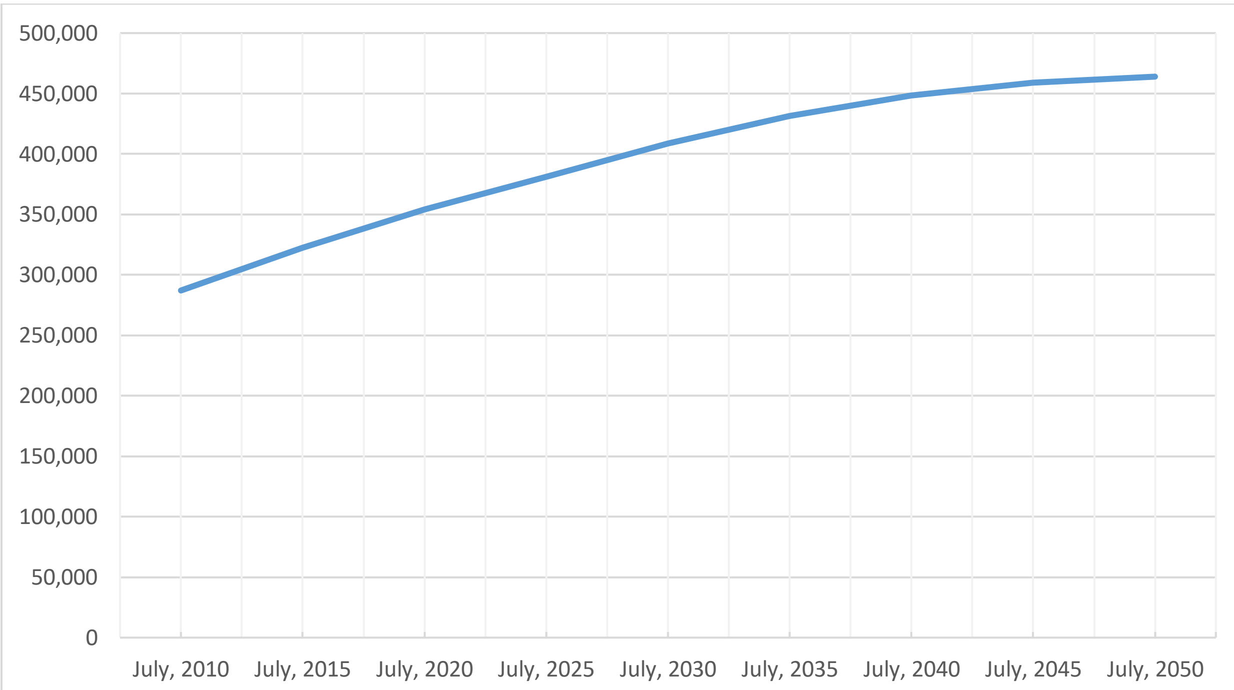
Table 4-4. Douglas County Population Trends, 1960 to 2018

Year	Population	Change in Population	Percent (%) Population Change
1960	4,816	-	-
1970	8,407	3,591	74.5%
1980	25,153	16,746	199.2%
1990	60,391	35,238	140.1%
2000	175,766	115,375	191.0%
2010	285,465	109,699	62.4%
2018	328,614	43,149	15.1%

Source: Colorado State Demography Office; U.S. American Community Survey 2018 (Five-Year)
Note: Change in population and percent in population change were calculated from available data.

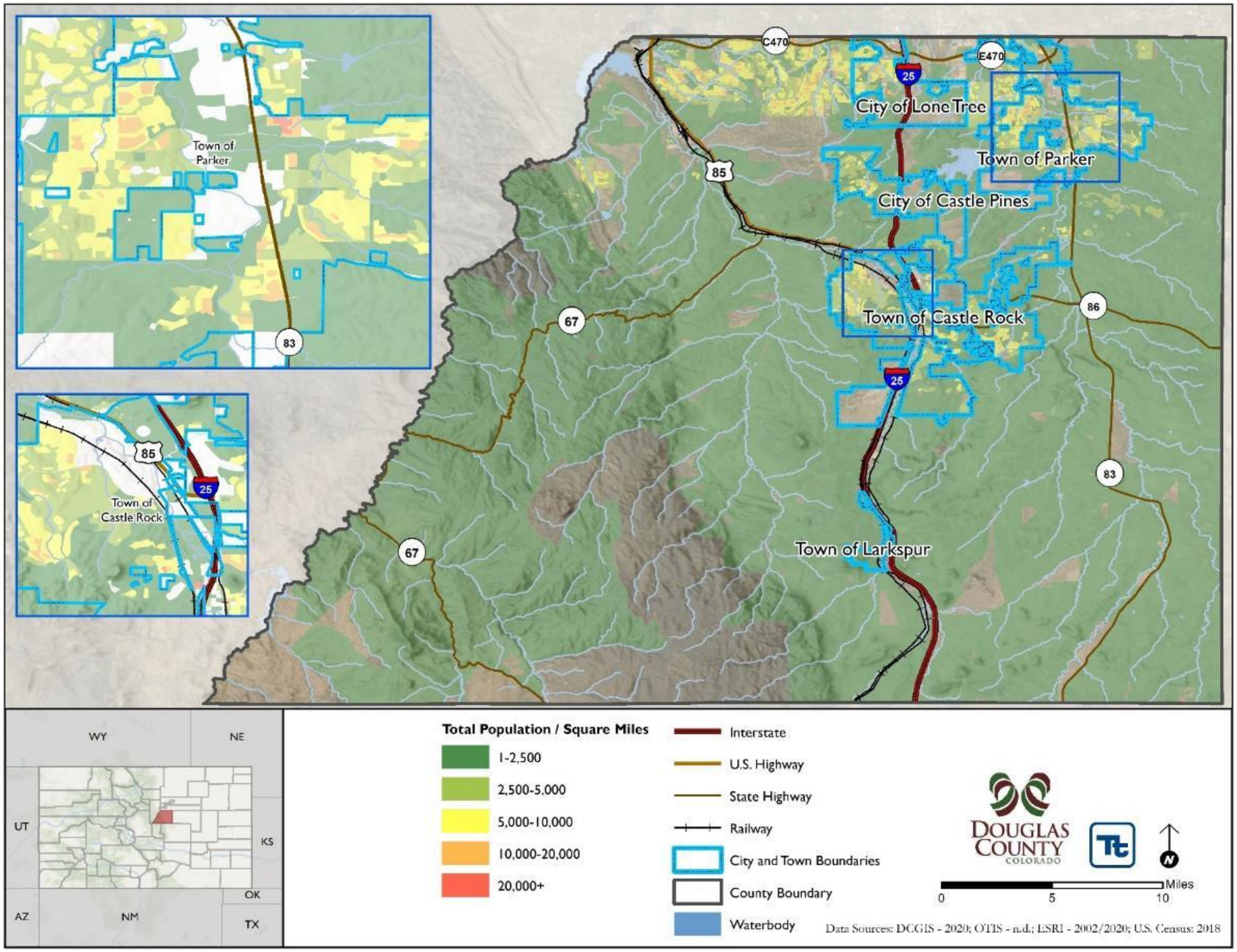
The Colorado State Demography Office has produced population estimates for the region based on 2010 Census data (Colorado State Demography Office 2020). The Office uses a demographic model that incorporates survival rates, fertility rates, migration, and other factors. Douglas County is considered part of the Denver-Metro Area, leading the SDO to calculate projections consistent with demographic distributions consistent with the methodology used by the Denver Regional Council of Governments.

Figure 4-3. Douglas County Population Estimates and Projection, 2015 to 2045



Source: Colorado State Demography Office

Figure 4-4. Distribution of General Population for Douglas County, Colorado



4.4.1 Vulnerable Populations

DMA 2000 requires that HMPs consider socially vulnerable populations. These populations can be more susceptible to hazard events, based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. For the purposes of this study, vulnerable populations shall include (1) the elderly (persons aged 65 and over) and (2) those living in low-income households. Figure 4-5 through Figure 4-7 illustrate the distribution of population under 5, population over 65, low-income population, population with a disability, and non-English-speaking population respectively.

It is noted that the Census data for household income provided in Hazus includes two ranges ($0-10,000 and $10,000-$20,000/year) that were totaled to provide the "low-income" data used in this study. This does not correspond exactly with the "poverty" thresholds established by the 2019 U.S. Census Bureau, which identifies households with three adults and no children with an annual household income below $19,998 per year, or households with one adult and two children with an annual household income below $20,598 per year as "low income" for this region. This difference is not believed to be significant for the purposes of this planning effort. The 2018 American Community Survey data identified approximately 2,114 households in Douglas County living below the poverty line. This represents approximately 2.3 percent of the population.

Income

The 2018 American Community Survey 5-Year Estimates provides that the median household income in Douglas County was $115,314. The U.S. Census Bureau identifies households with two adults and two children with an annual household income below $25,465 per year as *low income* (U.S. Census 2018). The 2018 American Community Survey 5-Year Estimates indicates that a total of 3.7% of people and 2.3% of families are below the poverty line.

The spatial U.S. Census data for household income provided in HAZUS-MH includes two ranges (less than $10,000 and $10,000-$20,000/year) that were totaled to provide the *low-income* data used in this study. This does not correspond exactly with the *poverty* thresholds established by the 2016 U.S. Census Bureau data. This difference is not believed to be significant for the purposes of this planning effort; therefore, for the exposure and loss estimations in the risk assessment, the 2010 U.S. Census data in HAZUS-MH is reported.

Physically or Mentally Disabled

According to the Centers for Disease Control, "Persons with a disability include those who have physical, sensory, or cognitive impairment that might limit a major life activity (Centers for Disease Control 2015)." Cognitive impairments can increase the level of difficulty that individuals might face during an emergency and reduce an individual's capacity to receive, process, and respond to emergency information or warnings. Individuals with a physical or sensory disability can face issues of mobility, sight, hearing, or reliance on specialized medical equipment. According to the 2018 American Community Survey, 6.6 percent of residents in Douglas County are living with a disability.

Non-English Speakers

Individuals who are not fluent or working proficiency in English are vulnerable because they can have difficulty with understanding information being conveyed to them. Cultural differences also can add complexity to how information is being conveyed to populations with limited proficiency of English (Centers for Disease Control 2015). According to the 2018 American Community Survey, nearly 9.2% of the County's population over the age of 5 primarily speaks a language other than English at home. Approximately, 6,749 people (or 2.2%) speak limited English.

Table 4-5. Douglas County Vulnerable Population Statistics

Jurisdiction	U.S. Census 2010							2014-2018 American Community Survey 5-Year Estimates										
	Total Population	Population Over 65	Percent Over 65	Population Under 16	Percent Under 16	Low Income*	Percent Low Income*	Total Population	Population Over 65	Percent Over 65	Population Under 5	Percent Under 5	Population Below Poverty Level*	Percent Below Poverty Level	Population with a Disability	Percent with a Disability	Non-English-Speaking Population	Percent of Non-English-Speaking population
Castle Pines (C)	12,217	911	7.5%	4,093	33.5%	45	0.4%	10,573	1,373	13.0%	446	4.2%	226	2.1%	440	4.2%	127	1.2%
Castle Rock (T)	51,608	3,419	6.6%	16,523	32.0%	1,116	2.2%	59,680	5,670	9.5%	4,601	7.7%	2,560	4.3%	4,142	6.9%	1,026	1.7%
Larkspur (T)	316	38	12.0%	62	19.6%	1	0.3%	257	57	22.2%	15	5.8%	43	16.7%	78	30.4%	6	2.3%
Lone Tree (C)	14,555	953	6.5%	3,632	25.0%	307	2.1%	14,209	1,691	11.9%	835	5.9%	410	2.9%	699	4.9%	576	4.1%
Parker (T)	51,038	2,622	5.1%	16,473	32.3%	941	1.8%	52,563	3,631	6.9%	3,929	7.5%	2,058	3.9%	3,308	6.3%	1,337	2.5%
Unincorporated Douglas County	190,766	14,775	7.7%	56,185	29.5%	2,532	1.3%	191,332	23,379	12.2%	10,098	5.3%	6,036	3.2%	12,922	6.8%	3,677	1.9%
Douglas County (Total)	**320,500**	**22,718**	**7.1%**	**96,968**	**30.3%**	**4,942**	**1.5%**	**328,614**	**35,801**	**10.9%**	**19,924**	**6.1%**	**11,333**	**3.4%**	**21,589**	**6.6%**	**6,749**	**2.1%**

Source: American Community Survey (2018); Census 2010 (U.S. Census Bureau), Hazus v4.2;
Note: (C) = City, (T) = Town
** Individuals below poverty level (Census poverty threshold for a 3-person family unit is approximately $18,500)*

Figure 4-5. Distribution of Population Under 5 for Douglas County by Census Tract

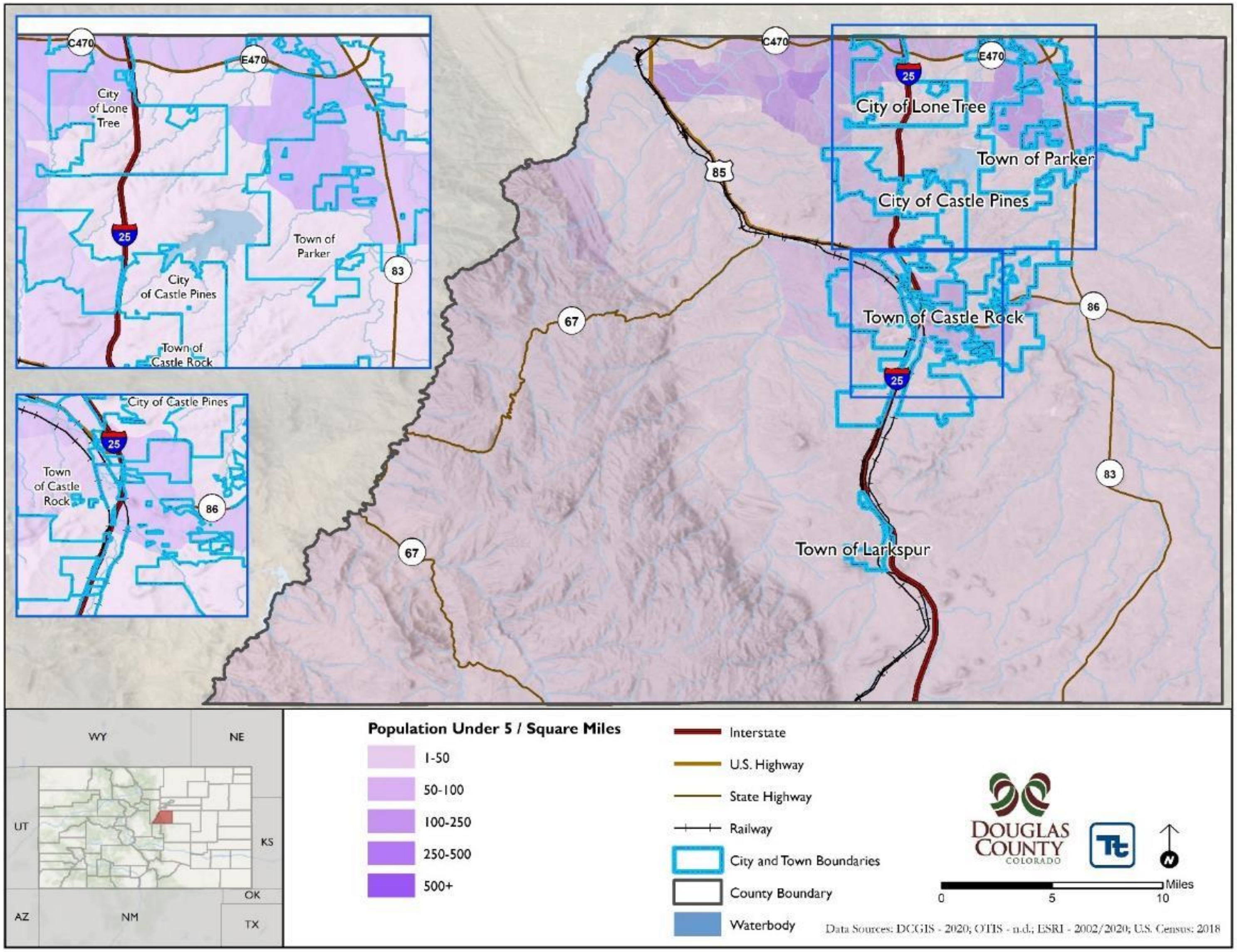


Figure 4-6. Distribution of Population Over 65 for Douglas County by Census Tract

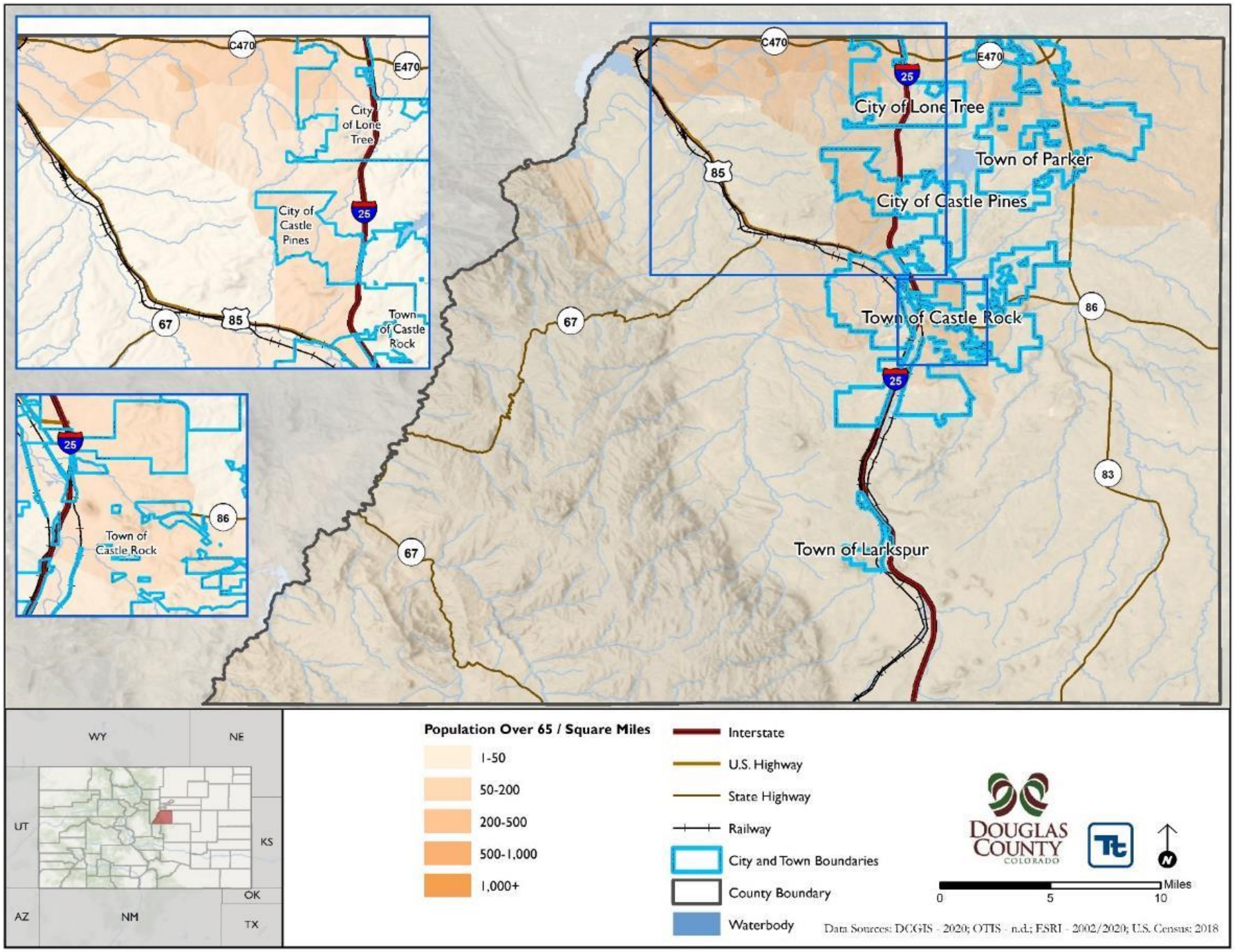


Figure 4-7. Distribution of Low-Income Population for Douglas County by Census Tract

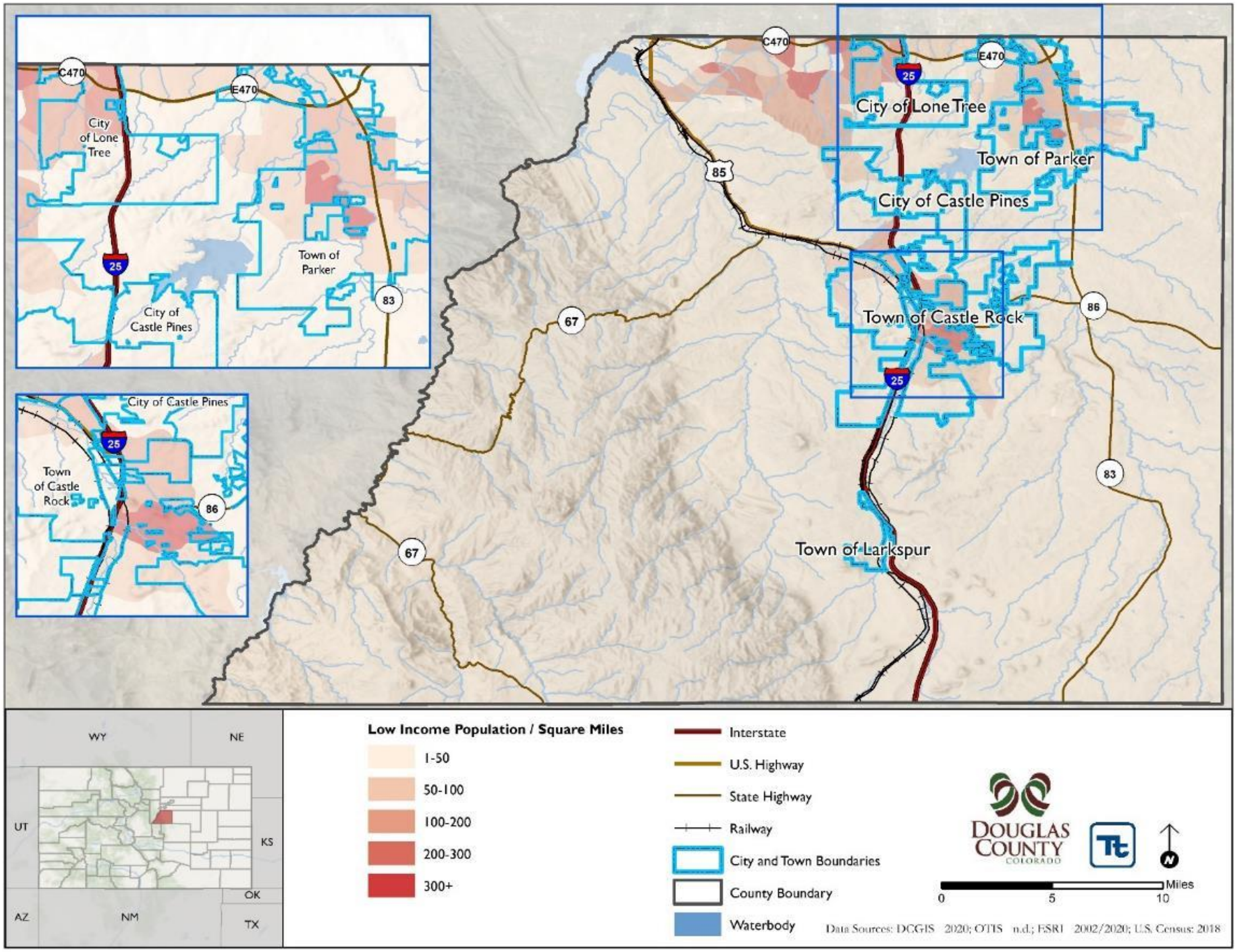


Figure 4-8. Distribution of Population with a Disability for Douglas County by Census Tract

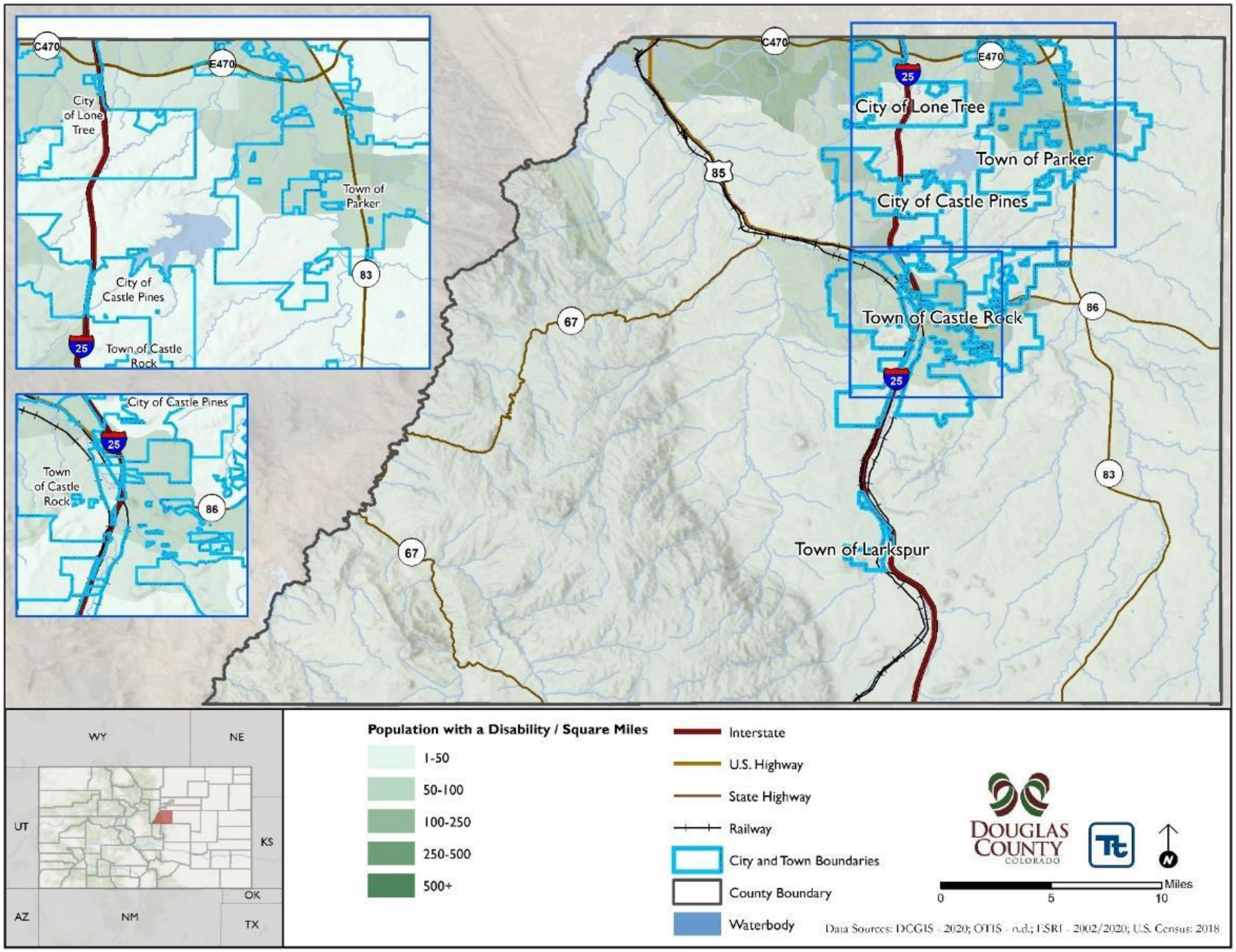
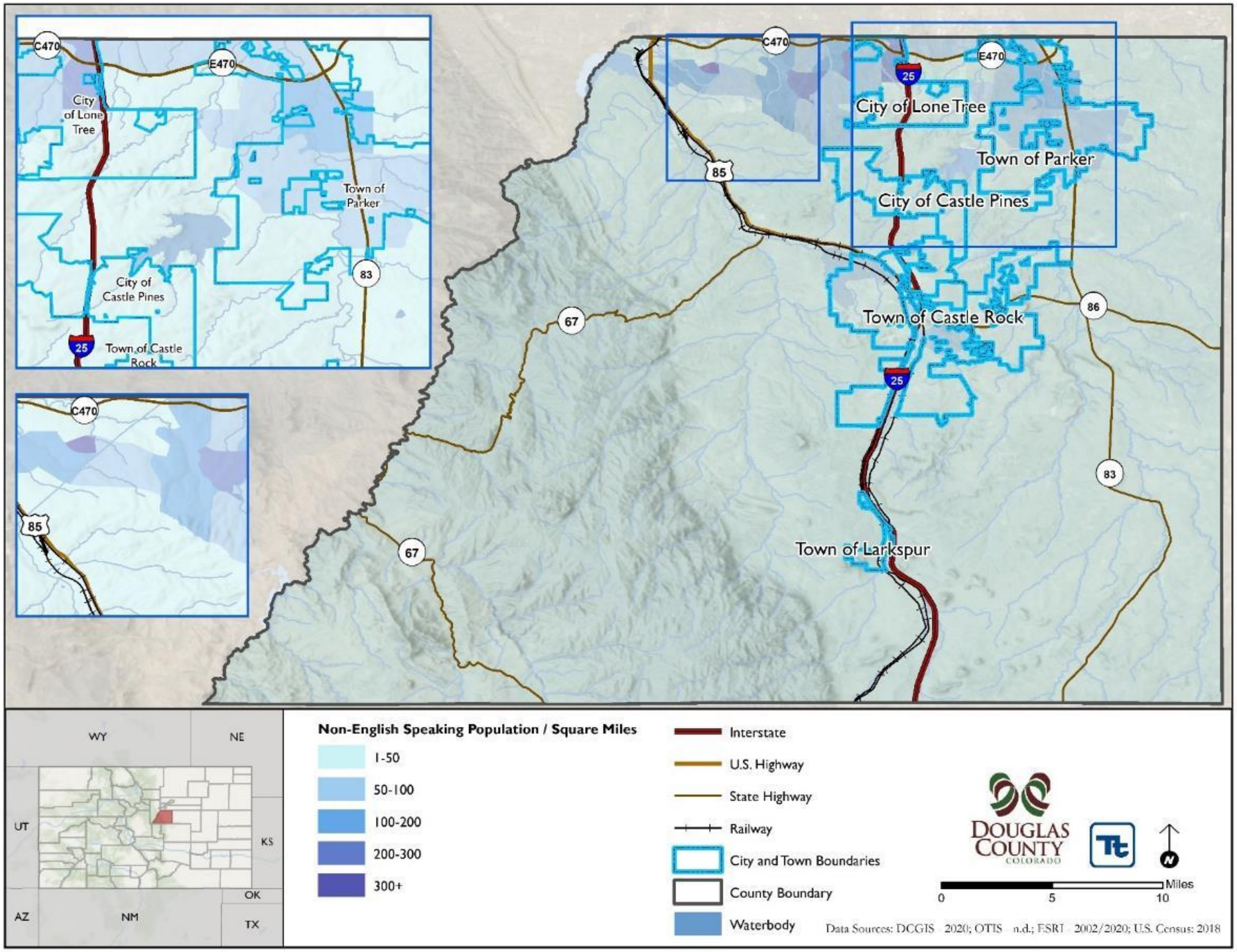


Figure 4-9. Distribution of Non-English-Speaking Population for Douglas County by Census Tract



4.4.2 General Building Stock

The 2018 American Community Survey data identified 117,426 households and 121,541 housing units in Douglas County. This represents a significant increase from 2010, when the American Community Survey identified 107,056 occupied units and 121,524 total units in the County. The U.S. Census defines household as all the persons who occupy a housing unit, and a housing unit as a house, an apartment, a mobile home, a group of rooms, or a single room that is occupied (or if vacant, is intended for occupancy) as separate living quarters. Therefore, there may be more than one household per housing unit. The median price of an owner-occupied housing unit in Douglas County was estimated at $441,100 (U.S. American Community Survey, 2018).

For the HMP update, a custom-building inventory was developed to assess the current built environment's risk to natural hazards. The default general building stock in Hazus was updated and replaced with a custom building inventory for Douglas County both at the aggregate and structure level. The building stock update was performed using tax parcel and assessor data and building footprints provided by the County GIS Office. The replacement cost value was calculated using the square footage value of each building derived from the assessor information or the building footprint and RS Means 2020 data. There are approximately 135,156 structures included in the custom-building inventory with an estimated replacement cost value of approximately $182.4 billion (structure and contents). Estimated content value was calculated by using 50-percent of the residential replacement cost value, and 100-percent or 150-percent for non-residential values (refer to Section 5.2 Methodology and Tools for more information). Actual content value varies widely depending on the usage of the structure. Using this methodology, there is approximately $71.3 billion in contents within these properties. Approximately 93-percent of the total buildings in the County are residential, which make up approximately 72.1-percent of the building stock structural value associated with residential housing. Table 4-6 presents building stock statistics by occupancy class for the County.

The 2018 American Community Survey data identified that the majority of housing units (76.9% or 93,519 units) in Douglas County are single-family detached units. The Douglas County Economic Development Profile data identified 12,326 business establishments employing 125,683 people in Douglas County in 2018 (Douglas County, Colorado Department of Community Development 2019).

Figure 4-10 through Figure 4-12 show the distribution and exposure density of residential, commercial buildings, and industrial respectively, in Douglas County. Exposure density is the dollar value of structures per unit area, including building content value. The densities are shown in units of $1,000 ($K) per square mile.

Viewing exposure distribution maps, such as Figure 4-10 through Figure 4-12 can assist communities in visualizing areas of high exposure and in evaluating aspects of the study area in relation to the specific hazard risks.

Table 4-6. Number of Buildings and Improvement Value in Douglas County

Jurisdiction	All Occupancies				Residential		Commercial		Industrial	
	Count	Replacement Cost Value (Structure Only)	Replacement Cost Value (Contents Only)	Total Replacement Cost Value (Structure + Contents)	Count	Total Replacement Cost Value (Structure + Contents)	Count	Total Replacement Cost Value (Structure + Contents)	Count	Total Replacement Cost Value (Structure + Contents)
Castle Pines (C)	3,701	$3,277,009,014	$1,718,763,194	$4,995,772,208	3,610	$4,678,591,960	49	$117,118,414	2	$1,806,046
Castle Rock (T)	24,262	$17,484,620,825	$10,518,689,214	$28,003,310,038	22,939	$22,069,828,170	936	$3,742,436,370	74	$473,623,501
Larkspur (T)	394	$75,370,566	$60,354,010	$135,724,576	330	$61,629,261	32	$26,178,377	3	$10,251,063
Lone Tree (C)	4,190	$12,498,111,066	$11,166,692,151	$23,664,803,217	3,835	$9,414,618,130	289	$13,868,238,675	3	$60,684,598
Parker (T)	17,864	$14,481,128,039	$9,116,786,673	$23,597,914,712	16,792	$17,580,831,920	697	$4,279,983,009	77	$278,071,935
Unincorporated Douglas County	84,745	$63,251,218,946	$38,767,618,767	$102,018,837,713	78,320	$77,647,371,278	2,215	$16,865,120,359	263	$1,743,727,236
Douglas County (Total)	**135,156**	**$111,067,458,455**	**$71,348,904,009**	**$182,416,362,464**	**125,826**	**$131,452,870,718**	**4,218**	**$38,899,075,203**	**422**	**$2,568,164,380**

Source: Douglas County GIS – 2020, RS Means 2020
Notes: RCV = Replacement cost value.

Figure 4-10. Distribution of Residential Building Stock and Value Density in Douglas County

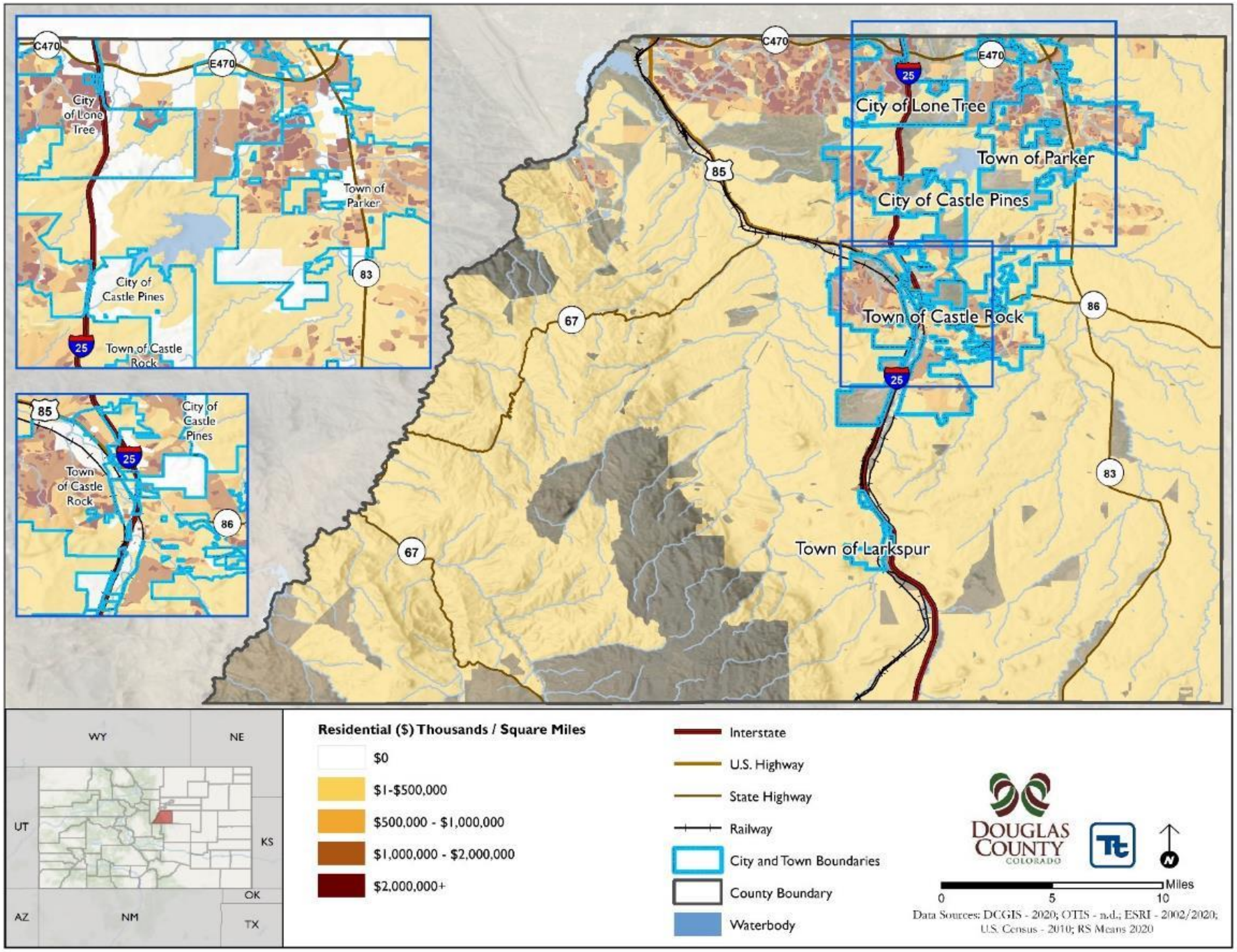


Figure 4-11. Distribution of Commercial Building Stock and Exposure Density in Douglas County

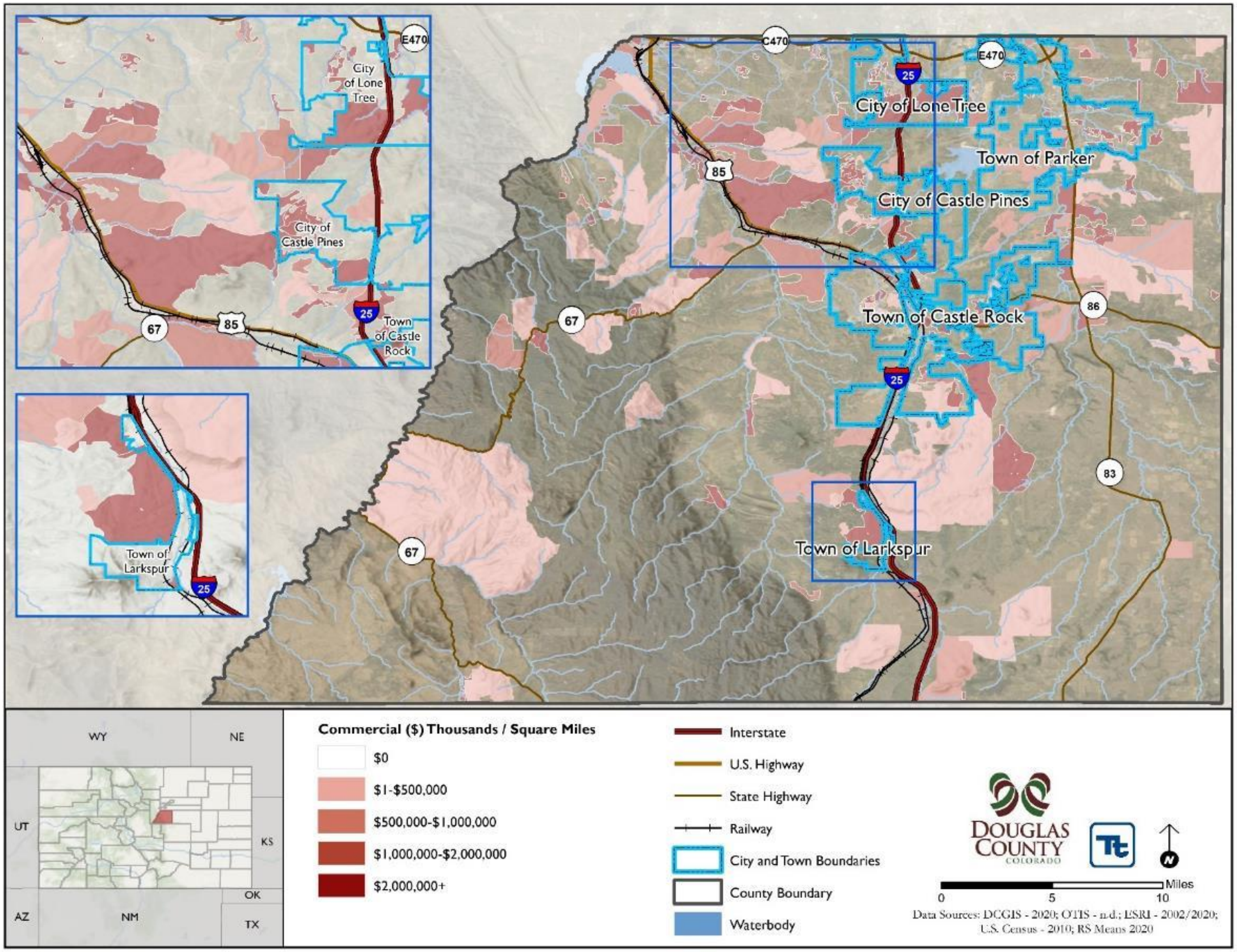
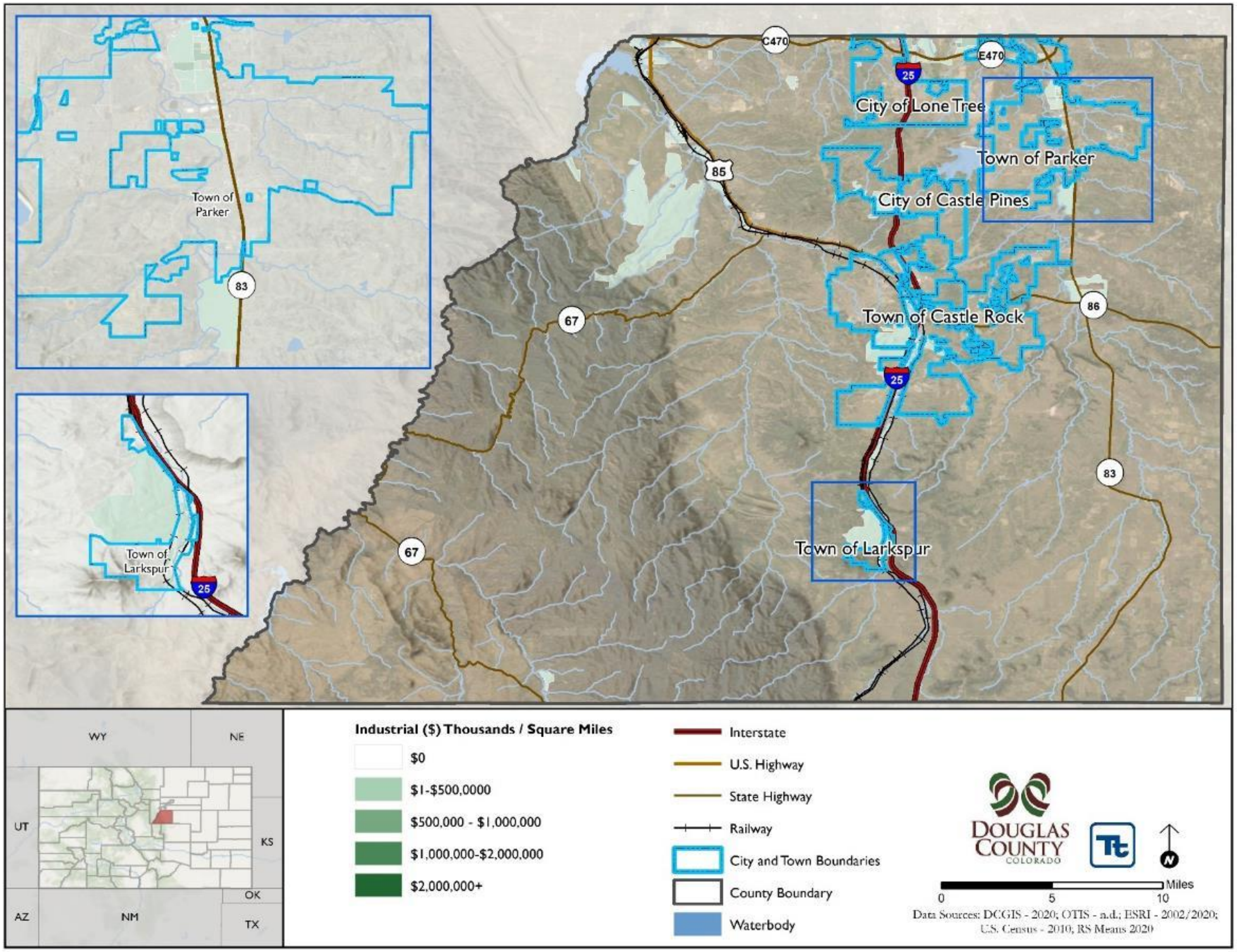


Figure 4-12. Distribution of Industrial Building Stock and Value Density in Douglas County



4.5 Land Use And Population Trends

The Colorado Constitution enables home rule charters for municipalities, allowing the city or town to have greater authority to regulate at the municipal level. The Local Government Land Use Control Enabling Act allows home rule communities to plan for land use, protect the environment, and regulate activities that impact a community and the surrounding area. As of 2018, there are four home rule municipalities in Douglas County: Lone Tree, Parker, Castle Rock, and Larkspur (Legislative Council Staff 2018). In 2019, Castle Pines became a home rule community. Additionally, the County government controls land use for unincorporated portions of the County.

This Hazard Mitigation Plan provides a general overview of population, land use, and types of development occurring within the study area. An understanding of these development trends can assist in planning for further development and ensuring that appropriate mitigation, planning, and preparedness measures are in place to protect human health and community infrastructure.

4.5.1 Land Use Trends

According to the Douglas County 2040 Comprehensive Master Plan, the County was one of the fastest growing in the United States during the 1990s. The County continues to grow in population through the 2010s, albeit at a slower rate. The County was initially rural in nature but has grown to become more suburban particularly in the northern and central portions of the County. New neighborhoods and communities are developing on former ranch and farmlands, and the County is seeing an increased amount of higher-density development in town centers. The County is growing alongside both the State and Denver Metro region in both population and employment.

Economy

The U.S. Census Bureau's Economic Census provides an annual series of sub-national economic data by industry covering the majority of the country's economic activity. According to the 2018 County Business Patterns data, there are more than 9,500 businesses in the County that employ nearly 115,000 workers. Annual payroll in the County totals $6.9 billion. The largest employment sector in the County in terms of the number of employees is the retail trade, which employs approximately 18,558 workers. The professional services industry generates the largest payroll of any sector ($946 million). This industry represents nearly 13.6 percent of the County's total payroll but employs only eight percent of the County's workforce. By contrast, the retail trade's payroll is approximately eight percent of the County's total yet employs more than 16 percent of the workforce.

Table 4-7. 2018 County Business Patterns for Douglas County, Colorado

Sector	# of Establishments	# of employees	Annual payroll ($1,000)
Total for all sectors	9,504	114,980	$6,915,988
Agriculture, forestry, fishing and hunting	25	57	$1,606
Mining, quarrying, and oil and gas extraction	40	283	$54,942
Utilities	10	323	$64,066
Construction	956	9,435	$652,997
Manufacturing	142	7,539	$954,371
Wholesale trade	360	2,877	$211,892

Sector	# of Establishments	# of employees	Annual payroll ($1,000)
Retail trade	924	18,558	$538,151
Transportation and warehousing	109	926	$45,894
Information	223	7,781	$647,312
Finance and insurance	706	7,309	$626,224
Real estate and rental and leasing	819	1,829	$97,310
Professional, scientific, and technical services	1,874	9,185	$946,039
Management of companies and enterprises	67	1,587	$297,984
Administrative and support and waste management and remediation services	488	8,021	$346,438
Educational services	212	3,924	$123,347
Health care and social assistance	1,003	13,770	$796,960
Arts, entertainment, and recreation	162	2,848	$64,017
Accommodation and food services	584	13,090	$264,321
Other services (except public administration)	787	5,625	$181,089
Industries not classified	13	13	$1,028

Source: U.S. Census County Business Patterns (2018)

Agriculture

The amount of farmland in Douglas County has slightly increased, and farmland continues to play an important role in the County. The US Department of Agriculture produces a Census of Agriculture that tracks agricultural data on the County level. In Douglas County, the number of farms has increased by 10% since 2012, though the acreage of farms has decreased 8% in the same time. Though crops account for a significantly larger share of sales (62%) than livestock and poultry (38%), about three quarters (78%) of the County's farm acreage is pastureland. Douglas County's agriculture products generate almost $19 million in sales each year (an increase of 38%), with nursery products; cattle and calves livestock and products; and horses, ponies, mules, burros, and donkeys livestock and products generating the vast majority of farm sales (USDA 2017).

Corridors and Gateways

Douglas County is located in the greater Denver metropolitan area and functions as suburban and exurban area of Denver. However, the County is centrally located between both Denver and Colorado Springs along the Interstate 25 corridor that connects Colorado's most populous communities. From Castle Rock near the center of the County, downtown Denver is just 35 minutes by car and Colorado Springs is just 42 minutes by car. Douglas County has strong connectivity to the surrounding counties of Teller, El Paso, Elbert, Arapahoe, and Jefferson via Interstate 25 as well as major highways such as US-85, Highway 67, Highway 105, Highway 83, Highway 86, Highway 121, and C-470.

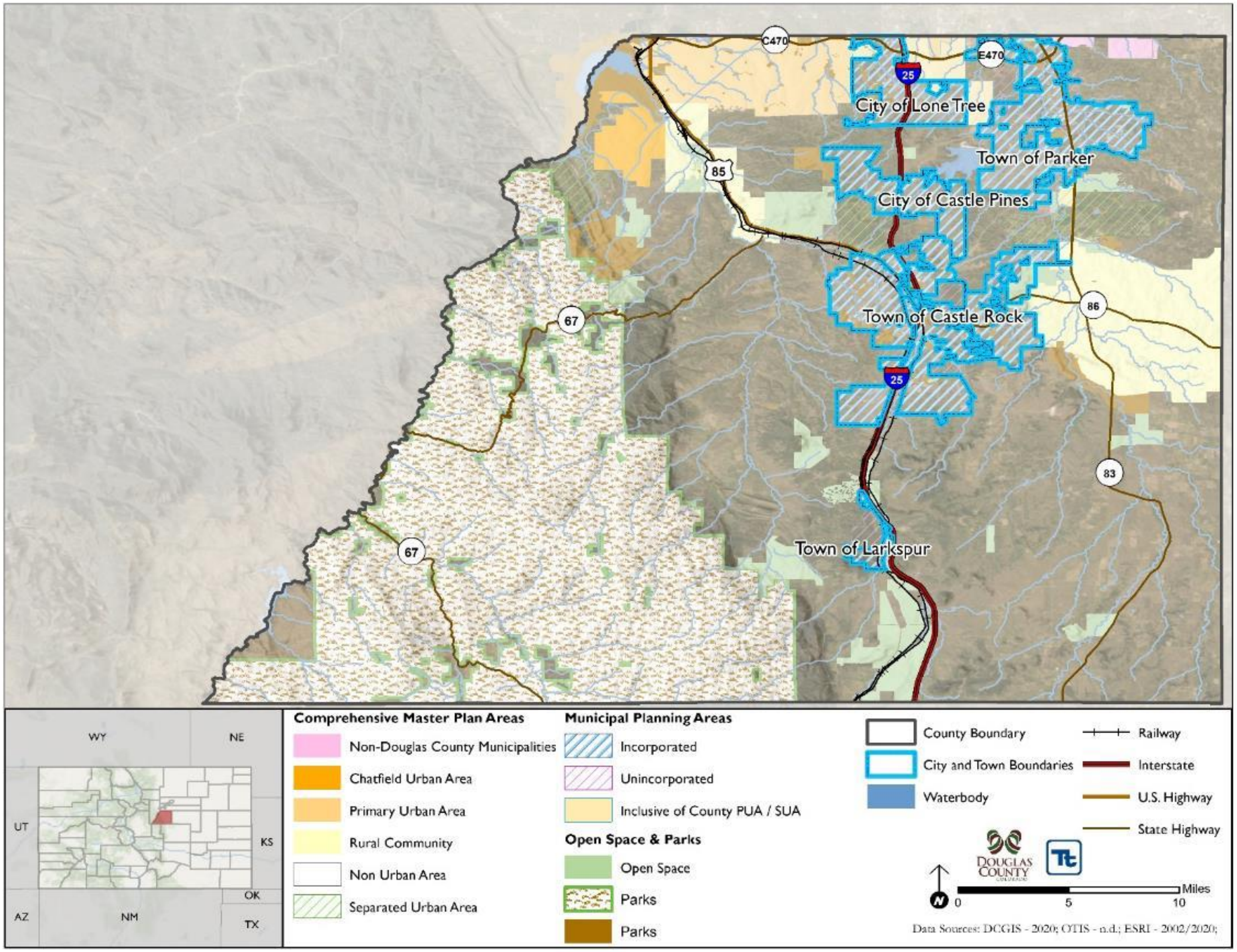
4.5.2 Population Trends

Douglas County, has grown significantly in recent years. Between 2010 and 2018 alone, the estimated population has increased from 285,465 residents to 328,614 residents- a 15% increase. The County has grown steadily since 1960. By 1980, the County's population had multiplied more than 6 times to 25,153 residents. By 1990, it increased to 60,391 residents. Between 1990 and 2000, the County added 115,375 residents- almost doubling in size. The vast majority (91.5%) of the County's residents live in urban areas, with just 8.5% of residents living in nonurban areas. Douglas County's growth has slowed from its massive population increases in the 1980s and 1990s. However, the County continues to add new residents and employment, as well as see increases in wages and real estate sales. Development of non-commercial and residential space is continuing, with more than 1.5 million square feet of non-commercial space and 3,404 housing units added in 2019.

4.5.3 Future Growth and Development

Figure 4-13 shows the distribution of growth areas as determined by the 2040 Comprehensive Master Plan. A significant amount of development has occurred along Interstate 25, and new development is planned for the incorporated portions of municipalities and designated urban areas in the unincorporated county. Much of the County is in a designated non-urban area or is open space owing to Pike National Forest.

Figure 4-13. Future Land Use Map of Douglas County, Colorado



4.6 CRITICAL FACILITIES AND LIFELINES

Critical Facilities are those facilities considered critical to the health and welfare of the population and that are especially important following a hazard. As defined for this HMP, critical facilities include transportation systems, lifeline utility systems, high-potential loss facilities, and hazardous material facilities, and essential facilities

Essential facilities are a subset of critical facilities that include those facilities that are important to ensure a full recovery following the occurrence of a hazard event. For the county risk assessment, this category was defined to include police, fire, EMS, schools/colleges, shelters, senior facilities, and medical facilities.

Lifelines enable the continuous operation of critical business and government functions and are essential to human health and safety or economic security.

Critical infrastructure and facilities are those that are essential to the health and welfare of the population. These facilities are especially important after any hazard event. Critical facilities are those that maintain essential and emergency functions and are typically defined to include police and fire stations, schools, and emergency operations centers. Critical infrastructure can include the roads and bridges that provide ingress and egress and allow emergency vehicles access to those in need and the utilities that provide water, electricity, and communication services to the community. Also included are Tier II facilities (hazardous materials) and rail yards; rail lines hold or carry significant amounts of hazardous materials with a potential to impact public health and welfare in a hazard event.

Beginning in 2017, FEMA developed a new construct to increase effectiveness for disaster operations and position response to catastrophic incidents. This construct, known as "community lifelines", represents the most fundamental services in the community that, when stabilized, enable all other aspects of society. Following a disaster event, intervention is required to stabilize community lifelines. Lifelines are divided into seven categories which include:

- Safety and Security
- Food, Water, Shelter
- Health and Medical
- Energy (Power and Fuel)
- Communications
- Transportation
- Hazardous Materials

To facilitate consistency with the National Response Framework, FEMA Strategic Plan, and guidance for the Building Resilient Infrastructure and Communities grant program, critical facilities in Douglas County are discussed in terms of lifelines.

A comprehensive inventory of critical facilities and lifelines in Douglas County was developed from various sources including input from the Planning Committees. Overall, there are 1,164 critical facilities identified in the County of which 971 are considered community lifelines by the Planning Committee. The inventory of critical facilities presented in this section represents the current state of this effort at the time of publication of the HMP and was used for the risk assessment in Section 5 (Risk Assessment). Figure 4-14 through Figure 4-23 show the location of Douglas County lifelines.

4.1.1 Safety and Security

This section provides information on Safety and Security lifelines. Components of this lifeline category include law enforcement/security, fire services, search and rescue services, government services, and community safety (e.g. dams).

Emergency Facilities

For the purposes of this Plan, emergency facilities include police, fire, emergency medical services (EMS) and emergency operations centers (EOC). There are 48 identified lifeline emergency facilities in Douglas County. Figure 4-14 identifies these facilities within Douglas County.

Law enforcement in the County includes the following agencies:

- Castle Rock Police Department
- Douglas County Sheriff's Office (Unincorporated Douglas County, Castle Pines, Larkspur)
- Lone Tree Police Department
- Parker Police Department

Fire departments and districts located in Douglas County include the following:

- Aurora Fire Rescue – Municipal Fire Department
- Castle Rock Fire and Rescue Department – Municipal Fire Department and Fire District (Title 32)
- Franktown Fire Protection District – Title 32
- Larkspur Fire Protection District – Title 32
- Jackson 105 Fire Protection District – Title 32
- West Douglas County Fire Protection District – Title 32
- South Metro Fire Rescue Authority – Title 32
- Mountain Communities Volunteer Fire Protection District -Title 32
- North Fork Fire Protection District – Title 32

Schools

Douglas County has approximately 108 school facilities identified as lifelines. The County's students attend the Douglas County School District, which is Colorado's third-largest in size. Figure 4-15 identifies educational facilities in Douglas County.

Dams

There are 51 identified dams in Douglas County. Refer to Section 5.4.2 which covers dams in more detail.

Government Facilities

There are 33 identified government facility lifelines in Douglas County, which include post offices, town halls, civic centers, administrative buildings, and similar structures. Figure 4-16 identifies government facilities in Douglas County.

Figure 4-14. Essential Facilities in Douglas County

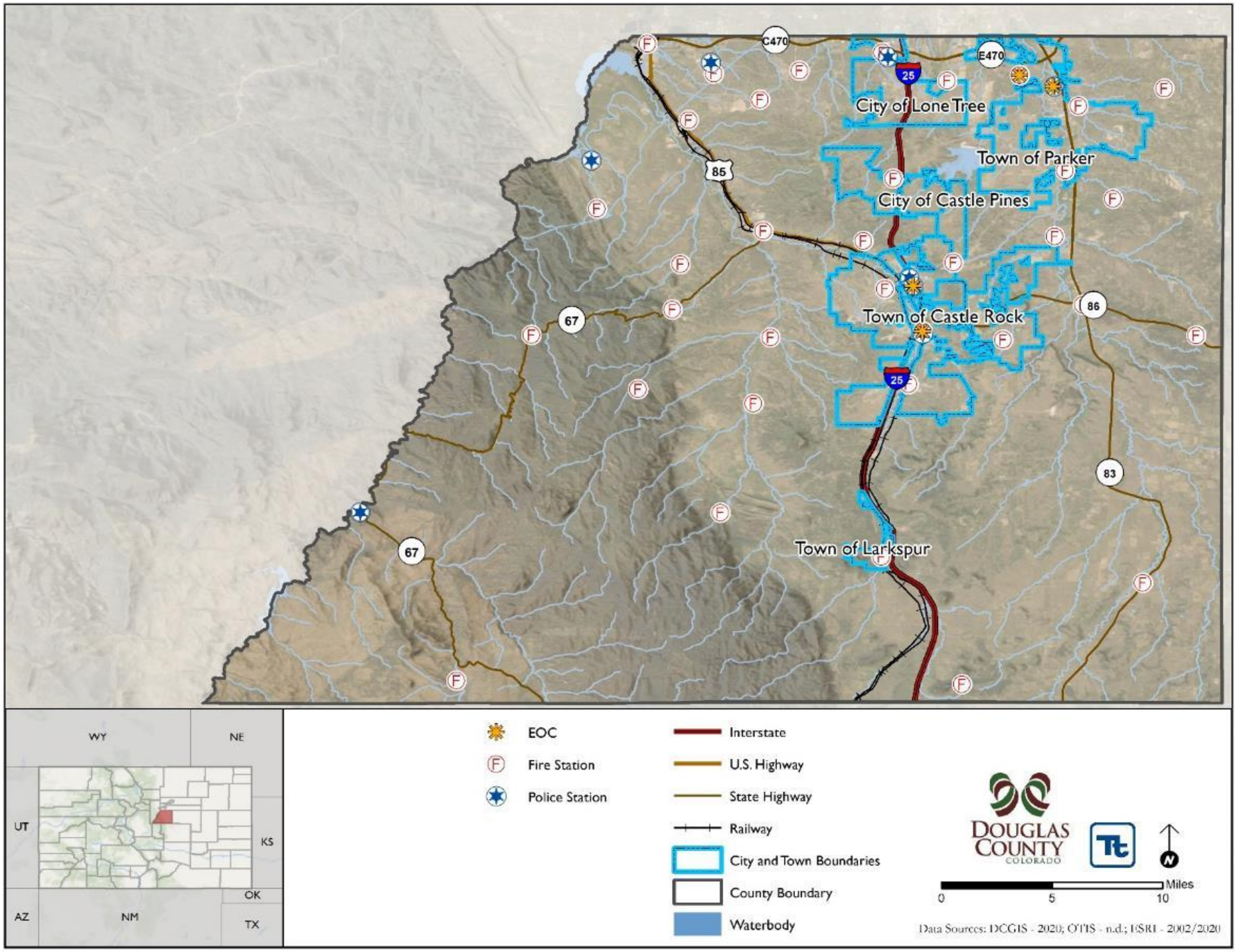


Figure 4-15. School Facilities in Douglas County

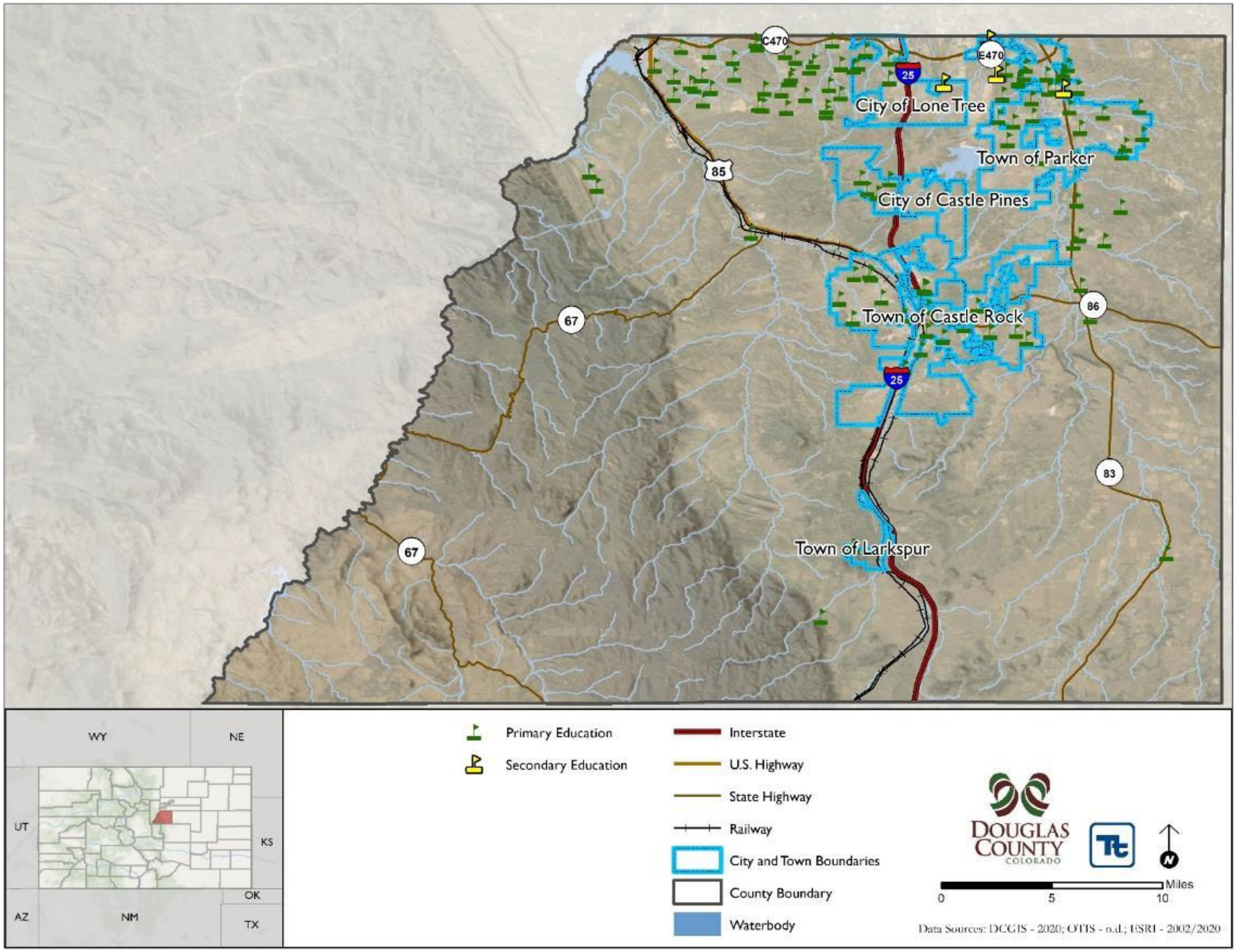
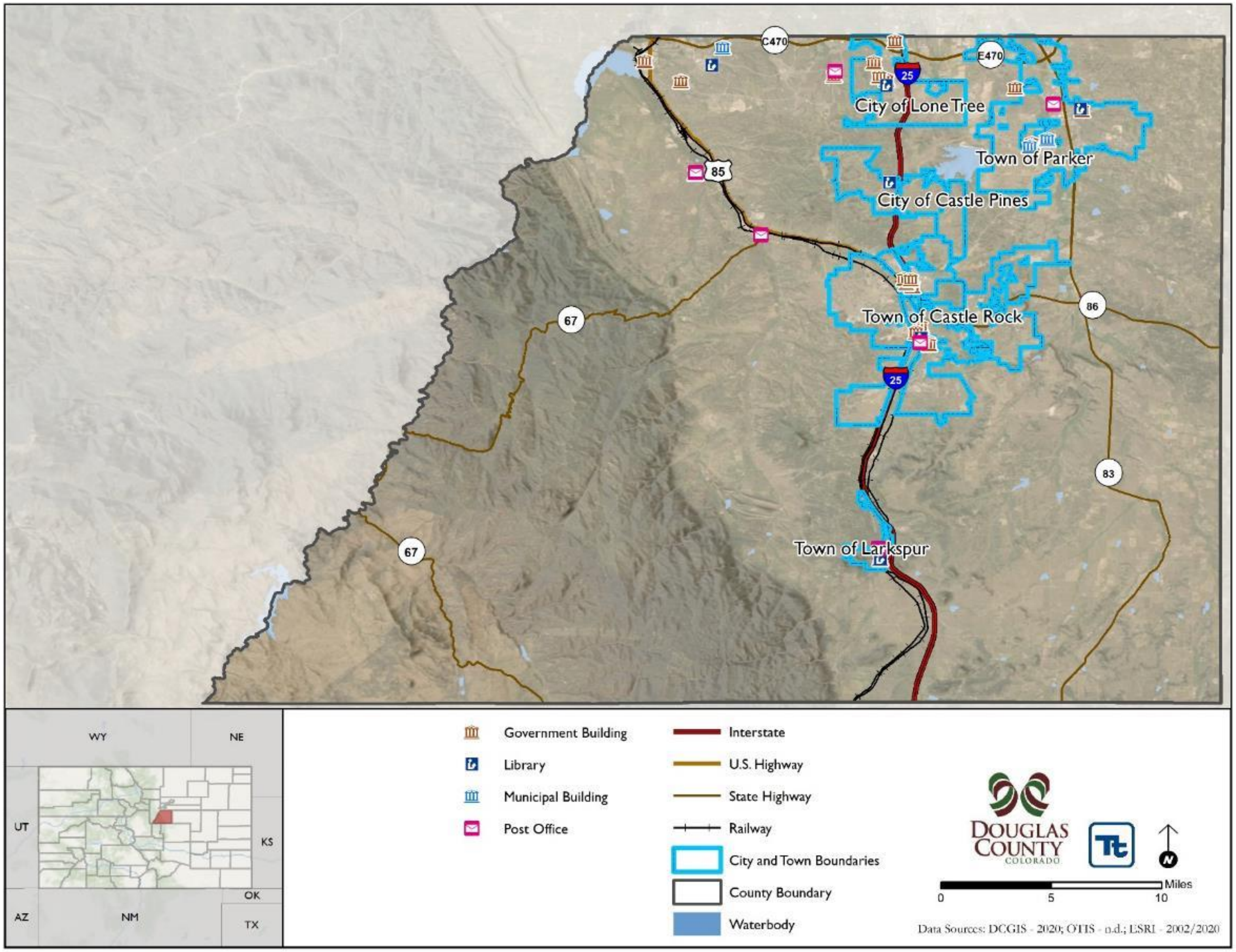


Figure 4-16. Government Facilities in Douglas County



4.6.1 Food, Water, Shelter Lifelines

Food, Water, and Shelter lifelines include facilities pertaining to food supply (distribution facilities, programs, and supply chain), water supply (including both potable and wastewater systems), shelter (housing and hotels), and agricultural facilities.

Food

There are 20 food distribution lifelines identified for Douglas County. Facilities are distributed throughout the County and are shown in Figure 4-17.

Shelter

There are 26 identified shelter lifelines in Douglas County, inclusive of educational facilities, County buildings, and religious buildings. Shelter lifelines are shown in Figure 4-18.

Potable Water

There are 375 potable water facilities in Douglas County, the vast majority of which consist of potable wells spread throughout the County. Additional facilities include lift stations, tanks, and treatment facilities. Much of Douglas County's water supply consists of groundwater derived from the Denver Basin aquifers. Potable water facilities are identified in Figure 4-19.

Douglas County water providers include the following organizations:

- Arapahoe County Water and Wastewater Authority
- Aurora Water
- Bell Mountain Ranch Metro District
- Beverly Hills Mutual Water Company
- Castle Pines Metropolitan District
- Castle Pines North Metro District
- Castleton Water and Sanitation
- Centennial Water and Sanitation District
- Chatfield South Water District
- City of Littleton
- Cottonwood Water and Sanitation District
- Dominion Water & Sanitation District
- Inverness Water and Sanitation District
- Louviers Water and Sanitation District
- Meridian Metropolitan District
- Parker Water and Sanitation District
- Perry Park Water and Sanitation District
- Pinery - Denver SE Suburban
- Ravenna Metro District
- Roxborough Park Metropolitan District
- Sedalia Water and Sanitation District
- Sierra Vista Douglas Mutual Water Company
- Silver Heights Water and Sanitation
- Soliltude Metro District
- Southgate Water District
- Southwest Metro WSD
- Stonegate Village Metro
- Thunderbird Water and Sanitation District (4/3/08)
- Titan Road Industrial Park Water Association Inc.
- Town of Castle Rock
- Town of Larkspur
- View Ridge Mutual Water Company
- Westcreek Lakes Water District

Wastewater Facilities

There are six identified wastewater treatment lifelines in the County inclusive of treatment facilities and pump stations. Wastewater facilities in Douglas County are identified in Figure 4-20.

Douglas County water and sanitation districts include the following organizations:

- Airport Vista Metro District 1
- Airport Vista Metro District 2
- Arapahoe County Water & Wastewater PID
- Arapahoe County Water & Wastewater PID
- BMR Metropolitan District fka Bell Mtn Metro
- Castle Pines Metro District
- Castle Pines North Metro District
- Castle Pines Town Center Metro District 1,2,3
- Castle Pines Town Center Metro District 2
- Castle Pines Town Center Metro District 3
- Castleton Center Water & San District
- Castleton Center Water & San District and Town of Castle Rock
- Centennial Water & Sanitation District
- Centennial Water & Sanitation District and Highlands Ranch Metro and Highlands Ranch Metro #5
- Chatfield South Water District
- City of Aurora
- Compark Business Campus Metro District
- Concord Metro District
- Consolidated Bell Mountain Ranch Metro District
- Cottonwood Water & Sanitation District
- Crowfoot Valley Ranch Metro District 1
- Crowfoot Valley Ranch Metro District 2
- Denver SE Suburban Water & San District
- Dominion Water & Sanitation District
- E-470 Potomac Metro District
- Hidden Pointe Metro District
- Highlands Ranch Metro District
- Highlands Ranch Metro District 5
- Highlands Ranch Metro District and Highlands Ranch Metro District 5
- Highlands Ranch Metro District and Southgate Sanitation District and Southgate Water District
- Inverness Water & Sanitation District
- Lincoln Park Metro District
- Lincoln Park Metro District
- Lincoln Park Metropolitan District and Parker Water & Sanitation District
- Louviers Water & Sanitation District
- Meridian Metro District
- Meridian Village Metro District 2
- North Meridian Metro District
- Northern Douglas County Water & San District
- Parker Water & Sanitation District
- Perry Park Water & Sanitation District
- Perry Park Water & Sanitation District (Water)
- Perry Park Water & Sanitation District and Remuda Ranch Metro District
- Perry Park Water & Sanitation District and Town of Larkspur
- Ravenna Metro District
- Remuda Ranch Metro District
- Roxborough Water & Sanitation District
- Sedalia Water & Sanitation District
- Silver Heights Water & San District
- Silver Heights Water & San District and Town of Castle Rock
- Soliltude Metro District
- South Meridian Metro District
- South Meridian Metro District Debt Service
- South Park Metro District
- South Santa Fe Metro District 1
- South Santa Fe Metro District 2
- Southgate Sanitation District and Southgate Water District
- Southgate Water District
- Southwest Metro Water & San District
- Stonegate Village Metro District
- Thunderbird Water & Sanitation District

- Town of Castle Rock
- Town of Larkspur
- Westcreek Lakes Water District

Figure 4-17. Food Distribution Facilities in Douglas County

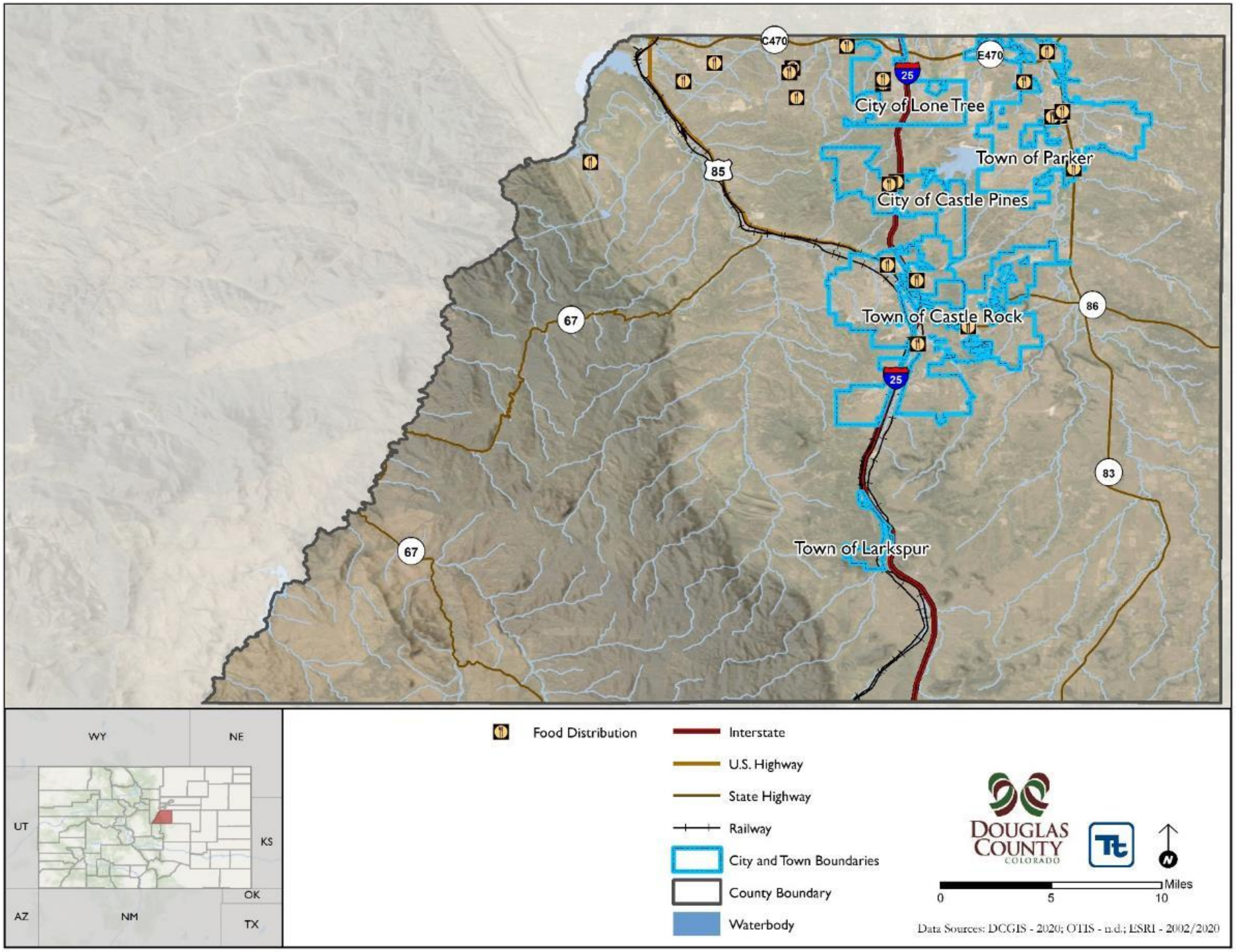


Figure 4-18. Shelters in Douglas County

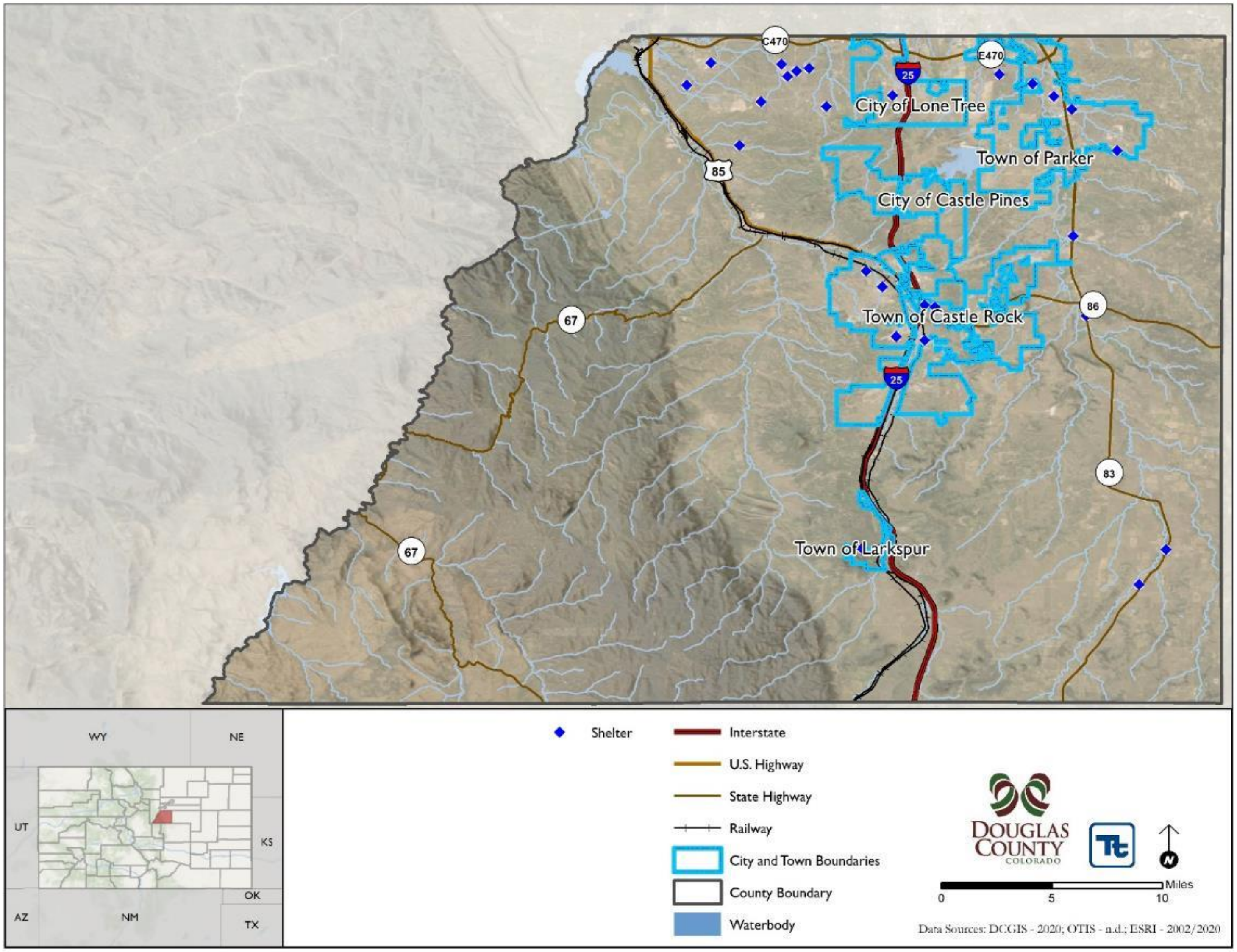


Figure 4-19. Potable Water Facilities in Douglas County

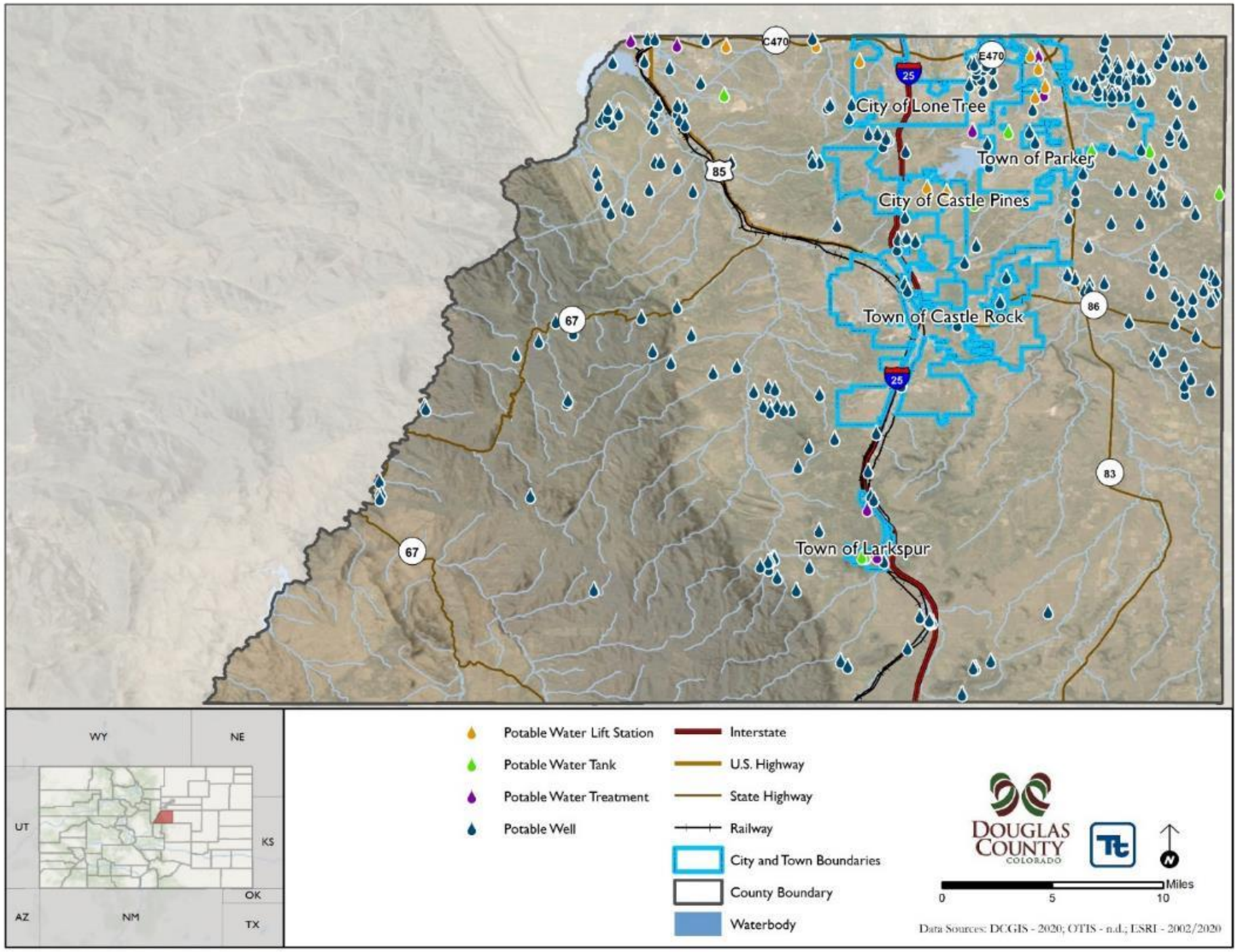
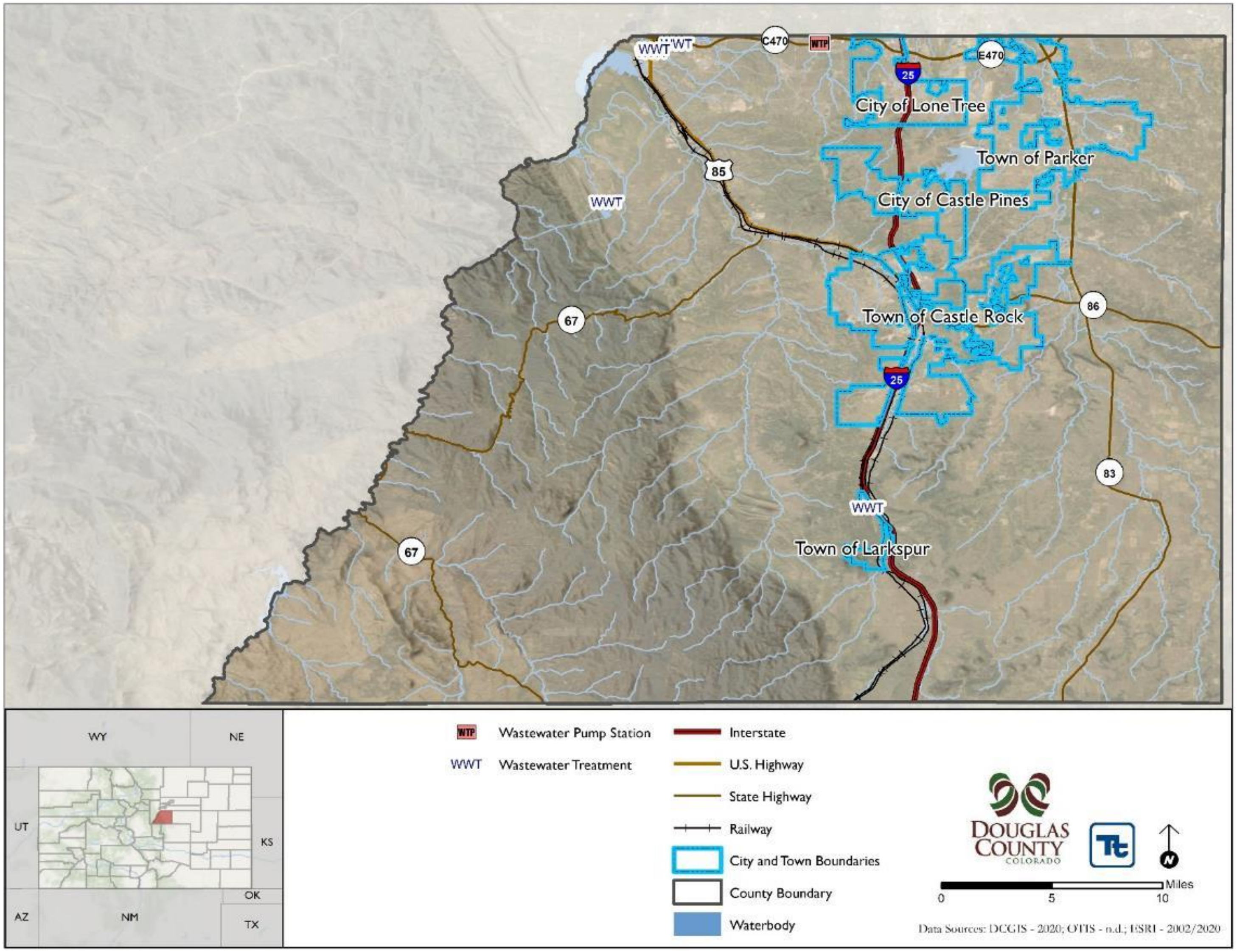


Figure 4-20. Wastewater Facilities in Douglas County



4.6.2 Health and Medical Lifelines

Hospitals and Medical Facilities

There are 203 health and medical facility lifelines identified in Douglas County. These lifelines are inclusive of assisted living facilities, hospitals, medical care offices, pharmacies, and urgent care facilities.

Figure 4-21 identifies hospitals and medical facilities in Douglas County.

4.6.3 Energy (Power and Fuel) Lifelines

Energy Resources

There are three electricity providers for Douglas County. The largest in size is the Intermountain Rural Electric Association, which is a non-profit electric cooperative that serves the vast majority of the County. Power from the IREA is generated outside Douglas County. Xcel Energy (Public Service Corporation of Colorado) provides electric services to Highlands Ranch. The Mountain View Electric Association, an electric cooperative, provides electric utility service along Colorado Route 83 between Castlewood Canyon State Park and El Paso County.

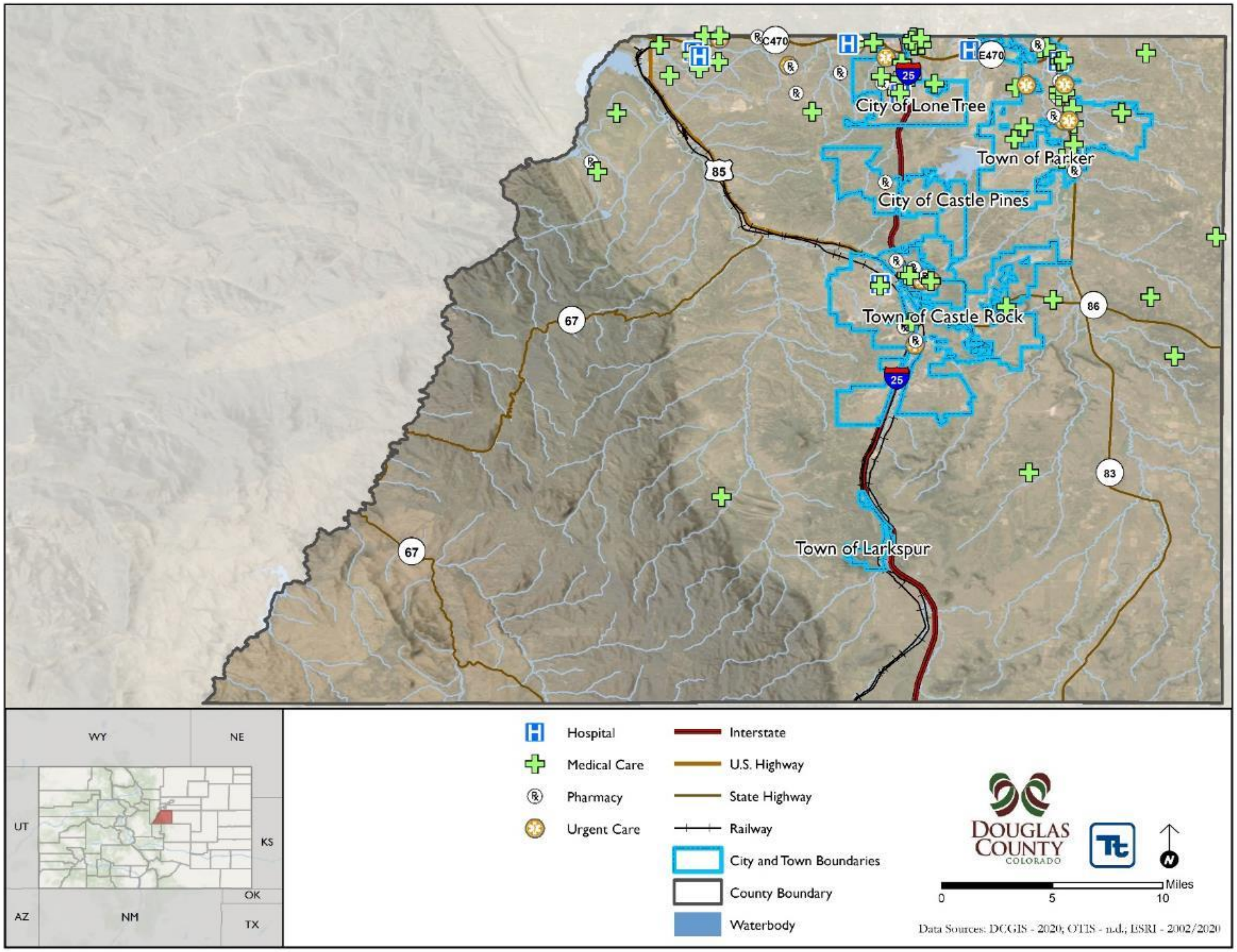
Much of Douglas County also receives natural gas service from utilities. The northern portion of the County, including Highlands Ranch, Lone Tree, and Parker, has natural gas service available through Xcel Energy. Black Hills Energy provides natural gas service south of the area served by Xcel Energy to the El Paso county line, inclusive of Castle Rock and Larkspur.

There are no identified energy lifelines in Douglas County. A discussion of energy infrastructure related to pipelines is found in Section 5.4.7.

Communications

There are no identified communication lifeline facilities in Douglas County. Various cell phone companies provide 4G cell phone service throughout the County, though gaps in coverage exist in Pike National Forest. Certain portions of the County also have fiber optic connectivity. There are 25 registered antennas with the Federal Communications Commission (Federal Communications Commission, 2020).

Figure 4-21. Health and Medical Facilities in Douglas County



4.6.4 Transportation Lifelines

The transportation system of Douglas County is a network of roadways, highways, and rail lines that provide for travel within the Denver metro area. Figure 4-22 identifies the transportation systems found in Douglas County including airports, bridges, bus facilities, and light rail facilities.

Airport Facilities

There is one identified airport lifeline in Douglas County. The Federal Aviation Administration identifies 10 private heliports and airports in the County. Figure 4-22 shows the location of the identified airport, which is located near Larkspur. Though many of the facilities for Centennial Airport are located in Arapahoe County, a portion of the runways for the Airport are located in northern Douglas County between Parker and Highlands Ranch.

Bridges

There are 66 bridges identified as lifelines in Douglas County, of which, 51 bridges are under County jurisdiction. Figure 4-22 shows the location of bridges in Douglas County.

Mass Transit

Douglas County has 12 identified transportation lifelines related to mass transit in Douglas County. This includes seven bus facilities and five light rail stations served by the RTD E, F, and R lines. Figure 4-22 shows the location of these facilities.

4.6.5 Hazardous Materials Lifelines

Due to heightened security concerns, local utility lifeline data needed to complete the analysis were only partially obtained. There were no identified hazardous material lifelines in the County. A discussion of hazardous materials as a hazard is discussed in Section 5.4.7.

4.6.6 User Defined Facilities

The Planning Committee identified additional facilities as critical to be analyzed on an individual basis as part of the HMP risk assessment. These facilities include assisted living facilities, childcare facilities, historic locations, major businesses, polling sites, and recreation sites. shows the distribution of these additional facilities throughout the County. Figure 4-23 shows the location of user defined facilities in Douglas County.

Figure 4-22 Transportation Facilities in Douglas County

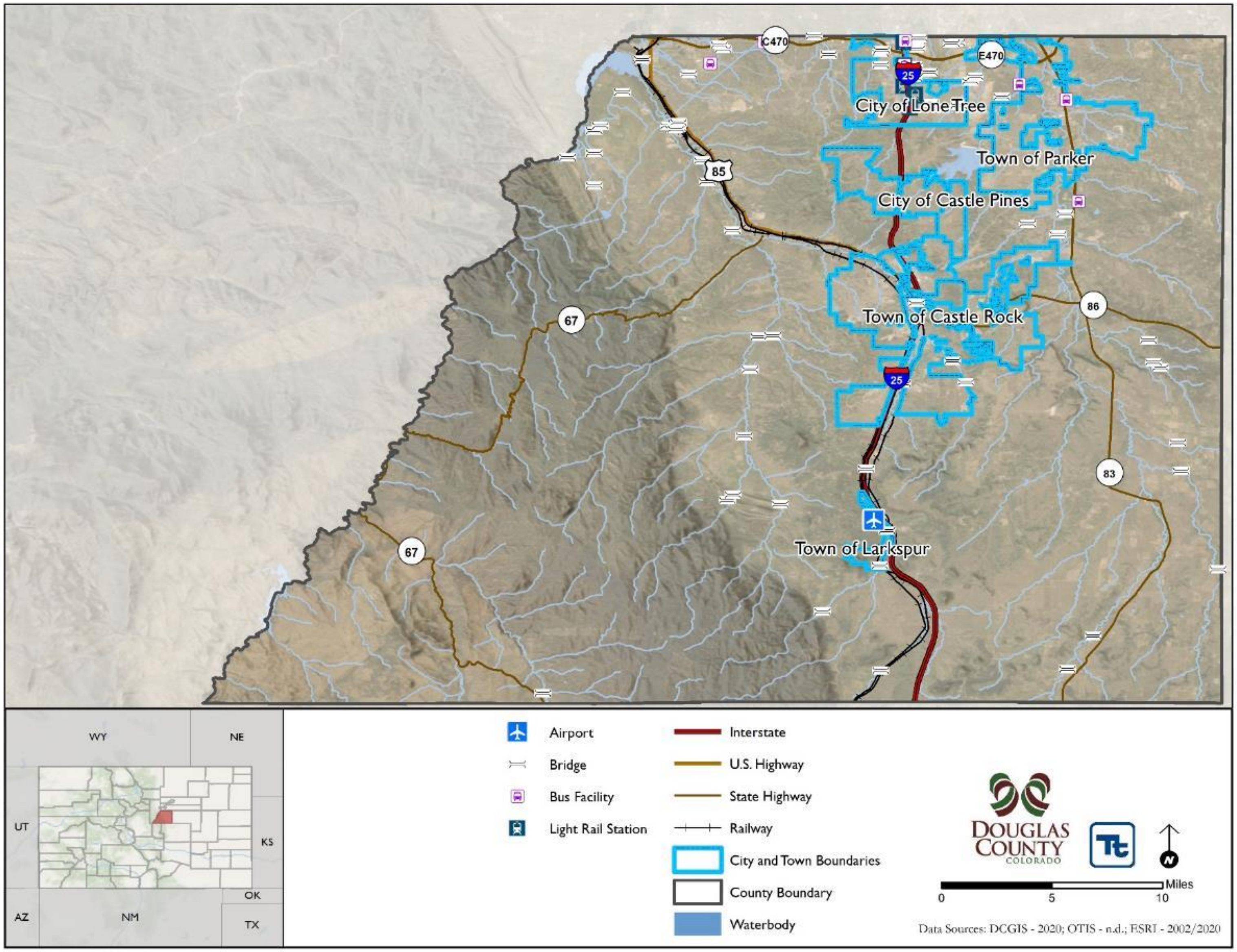
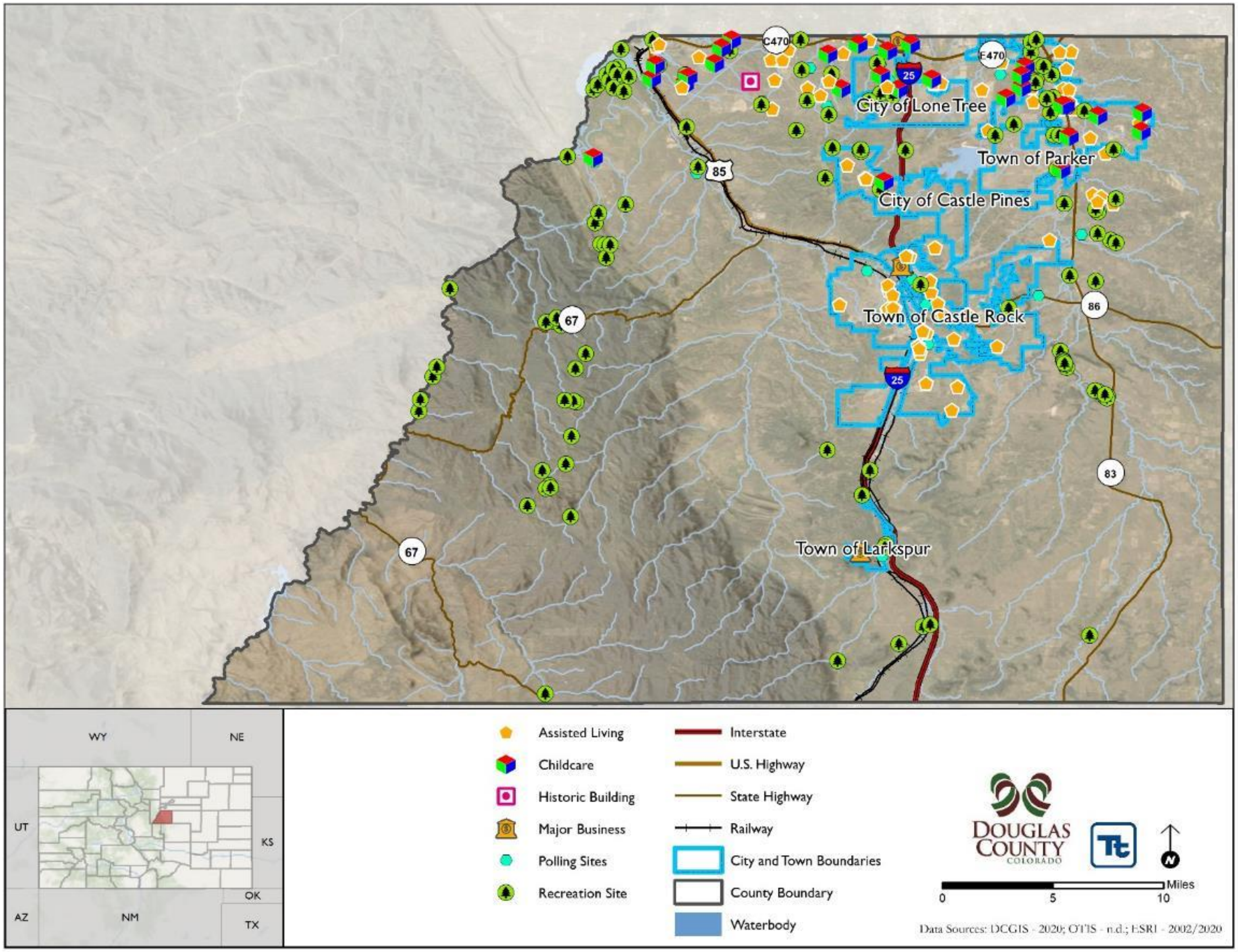


Figure 4-23 User Defined Facilities in Douglas County



SECTION 5 RISK ASSESSMENT

5.1 Methodology

A risk assessment is the process of measuring the potential loss of life, personal injury, and economic and property damage resulting from identified hazards. Identifying potential hazards and vulnerable assets allows planning personnel to address and reduce hazard impacts and emergency management personnel to establish early response priorities. Results of the risk assessment are used in subsequent mitigation planning processes, including determining and prioritizing mitigation actions that reduce each jurisdiction's risk to a specified hazard. Past, present, and future conditions must be evaluated to most accurately assess risk for the county and each jurisdiction. The process focuses on the following elements:

- **Hazard identification**—Use all available information to determine what types of hazards may affect a jurisdiction.
- **Profile each hazard**—Understand each hazard in terms of:
    - Extent—Severity of each hazard.
    - Location—Geographic area most affected by the hazard.
    - Previous occurrences and losses
- **Assess Vulnerability –**
    - Exposure identification—Estimate the total number of assets in the jurisdiction that are likely to experience a hazard event if it occurs by overlaying hazard maps with the asset inventories.
    - Vulnerability identification and loss estimation—Assess the impact of hazard events on the people, property, economy, and lands of the region, including estimates of the cost of potential damage or cost that can be avoided by mitigation.
    - Future changes that may impact vulnerability—Analyze how demographic changes, projected development and climate change impacts can alter current exposure and vulnerability.

The Douglas County risk assessment was updated using best available information.

- A custom-building stock inventory was created from tax assessor information, parcel data, and building footprints provided by Douglas County Office of GIS.
- 2014-2018 American Community Survey 5-year Population Estimates were utilized.
- A critical facility list was generated and reviewed by the Planning Partnership and County jurisdictions.
- Lifelines were identified in the critical facility inventory to align with FEMA's lifeline definition.
- Hazus was used to estimate potential impacts to the flood and seismic hazards.
- Best available hazard data was used as described in this section.

The following summarizes the asset inventories, methodology and tools used to support the risk assessment process.

5.1.1 Asset Inventories

Douglas County assets were identified to assess potential exposure and loss associated with the hazards of concern. For the HMP update, Douglas County assessed exposure and vulnerability of the following types of assets: population, buildings and critical facilities/infrastructure, new development, and the environment. Some assets may be more vulnerable because of their physical characteristics or socioeconomic uses. To protect individual privacy and the security of critical facilities, information on properties assessed is presented in aggregate, without details about specific individual personal or public properties.

The risk assessment included the collection and use of an expanded and enhanced asset inventory to estimate hazard exposure and vulnerability.

Population

Total population statistics from the 2014-2018 American Community Survey (ACS) 5-year estimate were used to estimate the exposure and potential impacts to the County's population in place of the 2010 U.S. Census block estimates. Population counts at the jurisdictional level were averaged among the residential structures in the County to estimate the population at the structure level. This estimate is a more precise distribution of population across the County compared to only using the Census block or Census tract boundaries. Limitations of these analyses are recognized, and thus the results are used only to provide a general estimate for planning purposes.

As discussed in Section 4 (County Profile), research has shown that some populations are at greater risk from hazard events because of decreased resources or physical abilities. Vulnerable populations in Douglas County included in the risk assessment are children, elderly, population below the poverty level, non-English speaking individuals, and persons institutionalized with a disability.

Buildings

A custom-building stock inventory was developed for the HMP using tax assessor information, parcel data, and building footprints provided by Douglas County Office of GIS. The occupancy classes available in Hazus were condensed into the following categories (residential, commercial, industrial, agricultural, religious, governmental, and educational) to facilitate the analysis and the presentation of results. Residential loss estimates address both multi-family and single-family dwellings. Replacement cost value (RCV) is the current cost of returning an asset to its pre-damaged condition, using present-day cost of labor and materials. Total replacement cost value consists of both the structural cost to replace a building and the estimate value of contents of a building. Structural and content RCV were calculated for each building utilizing RS Means 2020 values. A regional location factor for Douglas County was applied (1.05 for residential buildings and 0.91 for all other building types). The content cost of a building was estimated to be about 50-percent of the structural cost for residential structures and parking garages, about 100-percent for most commercial structures, primary schools, government services, religious/non-profit structures, and agricultural structures, and approximately 150-percent for most industrial buildings, secondary education facilities, and essential government facilities.

Critical Facilities and Lifelines

> *A **lifeline** provides indispensable service that enables the continuous operation of critical business and government functions, and is critical to human health and safety, or economic security (FEMA).*

A custom critical facility inventory, which includes essential facilities, utilities, transportation features and user-defined facilities was created from local, state, and federal data made available and was reviewed and accepted by the Planning Partnership and County jurisdictions. The inventory indicated if the critical facility is considered a lifeline in accordance with FEMA's definition; refer to Appendix E (Risk Assessment Supplement). To protect individual privacy and the security of assets, information is presented in aggregate, without details about specific individual properties or facilities.

Environment and Land Use Area

National land use land cover data created by the U.S. Geological Survey (USGS) in 2016 was used to assess land use characteristics of the County. This dataset was converted from a raster to a vector polygon, which informed spatial areas of residential, non-residential, and natural land use areas. Residential land-use types incorporated all classes listed as developed land use, except for those identified as vacant (i.e., Developed – Low Intensity, Developed – Medium Intensity, Developed – High Intensity). Non-residential land-use types included all other classes. Within non-residential land-use types, natural land areas were extracted into a new category, which includes forest, water, and wetlands. The natural land areas were referenced to calculate the total acres of natural land area exposed to hazard areas of concern.

New Development

In addition to assessing the vulnerability of the built environment, Douglas County examined recent development over the last 5 years and anticipated new development in the next 5 years. Each jurisdiction was asked to provide a list by parcel ID or address of major development that has taken place within these timeframes.

New development was identified as 1) anticipated in the next five years and 2) recently developed over the last five years. An exposure analysis was conducted in Geographic Information System (GIS) to determine hazard exposure to these development sites. Projects built on multiple parcels were assessed as one unit. If one parcel identified within the project boundary intersected a spatial hazard layer, the entire project was considered 'exposed' to the hazard area of concern.

Identifying these changes and integrating new development into the risk assessment provides communities information to consider when developing the mitigation strategy to reduce these vulnerabilities in the future (one tool in the Mitigation Toolbox discussed in Section 6 – Mitigation Strategy). The new development is listed in Section 4 (County Profile) and hazard exposure analysis results are presented in Section 9 (Jurisdictional Annexes) as a table in each annex.

5.1.2 Methodology

To address the requirements of the DMA 2000 and to better understand potential vulnerability and losses associated with hazards of concern, Douglas County used standardized tools, combined with local, state, and federal data and expertise to conduct the risk assessment. Three different levels of analysis were used depending upon the data available for each hazard as described below. Table 5-1 summarizes the type of analysis conducted by hazard of concern.

1. ***Historic Occurrences and Qualitative Analysis** – This analysis includes an examination of historic impacts to understand potential impacts of future events of similar size. In addition, potential impacts and losses are discussed qualitatively using best available data and professional judgement.*
2. ***Exposure Assessment** – This analysis involves overlaying available spatial hazard layers, or hazards with defined extent and locations, with assets in GIS to determine which assets are located in the impact area of the hazard. The analysis highlights which assets are located in the hazard area and may incur future impacts.*
3. ***Loss estimation** — The FEMA Hazus modeling software was used to estimate potential losses for the following hazards: flood and earthquake. In addition, an examination of historic impacts and an exposure assessment was conducted for these spatially-delineated hazards.*

Table 5-1. Summary of Risk Assessment Analyses

Hazard	Population	General Building Stock	Critical Facilities	New Development
Animal Disease	Q	Q	Q	Q
Dam Failure	Q	Q	Q	Q
Drought	Q	Q	Q	Q
Earthquake	Q	H	H	Q
Extreme Temperature	Q	Q	Q	Q
Flood	E, H	E, H	E, H	E
Hazmat Spill and Transportation	Q	Q	Q	Q
Pandemic	Q	Q	Q	Q
Severe Weather – Hail	Q	Q	Q	Q
Severe Weather – Tornadoes	Q	Q	Q	Q
Severe Weather – Wind	Q	Q	Q	Q
Severe Winter Storm	Q	Q	Q	Q
Soil Hazard – Erosion	E	E	E	E
Soil Hazard – Expansive Soil	E	E	E	E
Soil Hazard – Landslide Subsidence	E	E	E	E
Soil Hazard – Slope Failure	E	E	E	E
Wildfire	E	E	E	E

E – Exposure analysis; H – Hazus analysis; Q – Qualitative analysis

Hazards U.S. – Multi-Hazard (Hazus)

In 1997, FEMA developed a standardized model for estimating losses caused by earthquakes, known as Hazards U.S. or Hazus. Hazus was developed in response to the need for more effective national-, state-, and community-level planning and the need to identify areas that face the highest risk and potential for loss. Hazus was expanded into a multi-hazard methodology, Hazus with new models for estimating potential losses from wind (hurricanes) and flood (riverine) hazards. Hazus is a GIS-based software tool that applies engineering and scientific risk calculations, which have been developed by hazard and information technology experts, to provide defensible damage and loss estimates. These methodologies are accepted by FEMA and provide a consistent framework for assessing risk across a variety of hazards. The GIS framework also supports the evaluation of hazards and assessment of inventory and loss estimates for these hazards.

Hazus uses GIS technology to produce detailed maps and analytical reports that estimate a community's direct physical damage to building stock, critical facilities, transportation systems and utility systems. To generate this information, Hazus uses default data for inventory, vulnerability, and hazards; this default data can be supplemented with local data to provide a more refined analysis. Damage reports can include induced damage (inundation, fire, threats posed by hazardous materials and debris) and direct economic and social losses (casualties, shelter requirements, and economic impact) depending on the hazard and available local data. Hazus' open data architecture can be used to manage community GIS data in a central location. The use of this software also promotes consistency of data output now and in the future and standardization of data collection and storage. More information on Hazus is available at http://www.fema.gov/hazus.

In general, modeled losses were estimated in the program using depth grids for the flood analysis and probabilistic analyses were performed to develop expected/estimated distribution of losses (mean return period losses) for hurricane wind and seismic hazards. The probabilistic model generates estimated damages and losses for specified return periods (e.g., 100- and 500-year). Table 5-2 displays the various levels of analyses that can be conducted using the Hazus software.

Table 5-2. Summary of Hazus Analysis Levels

Hazus Analysis Levels	
Level 1	Hazus provides hazard and inventory data with minimal outside data collection or mapping.
Level 2	Analysis involves augmenting the Hazus provided hazard and inventory data with more recent or detailed data for the study region, referred to as "local data"
Level 3	Analysis involves adjusting the built-in loss estimation models used for the hazard loss analyses. This Level is typical done in conjunction with the use of local data.

Animal Disease

Animal Disease/Infestation is a new hazard of concern for the Douglas County HMP. All of Douglas County is exposed to animal disease/infestation occurrences, with the most vulnerable places being agricultural facilities and Pike National Forest. A qualitative assessment was conducted using data from the US Department of Agriculture, Colorado State Forest Service, and the Colorado Department of Public Health and the Environment.

Dam Failure

Dam failure was assessed qualitatively. Research from the Federal Emergency Management Agency, Colorado Division of Water Resources, US Army Corps of Engineers, and Association of State Dam Safety Officials was used to complete this profile.

Drought

Drought is a new hazard of concern for the Douglas County HMP. To assess the vulnerability of Douglas County to drought and its associated impacts, a qualitative assessment was conducted. The United States Department of Agriculture (USDA) Census of Agriculture 2017 was used to estimate economic impacts. Information regarding the number of farms and farmland area was extracted from the report and summarized in the vulnerability assessment. Data from the US Drought Monitor was used to understand the extent and frequency of recent droughts.

Earthquake

A probabilistic assessment was conducted for Douglas County for the 500-year and the 2,500-year mean return period (MRPs) through a Level 2 analysis in Hazus to analyze the earthquake hazard and provide a range of loss estimates. The probabilistic method uses information from historic earthquakes and inferred faults, locations and magnitudes, and computes the probable ground shaking levels that may be experienced during a recurrence period by Census tract.

As noted in the Hazus Earthquake User Manual, "*Although the software offers users the opportunity to prepare comprehensive loss estimates, it should be recognized that uncertainties are inherent in any estimation methodology, even with state-of-the-art techniques. Any region or city studied will have an enormous variety of buildings and facilities of different sizes, shapes, and structural systems that have been constructed over a range of years under diverse seismic design codes. There are a variety of components that contribute to transportation and utility system damage estimations. These components can have differing seismic resistance.*" (FEMA 2020). However, Hazus' potential loss estimates are acceptable for the purposes of this HMP.

Ground shaking is the primary cause of earthquake damage to man-made structures and soft soils **amplify** ground shaking. One contributor to the site amplification is the velocity at which the rock or soil transmits shear waves (S-waves). The National Earthquake Hazard Reductions Program (NEHRP) has developed five soil classifications defined by their shear-wave velocity that impact the severity of an earthquake. The soil classification system ranges from A to E, where A represents hard rock that reduces ground motions from an earthquake and E represents soft soils that amplify and magnify ground shaking and increase building damage and losses. Class D and E NEHRP soils are the two classes most susceptible to amplified ground motion during an earthquake.

Douglas County did not have an available dataset to indicate class D or E class soils. For the Hazus input, the FEMA 100-year and 500-year flood hazard area was used to assume class D soils. Generally, floodplain soils are softer and more susceptible to erosion and ground motion. As a result, an exposure analysis was not conducted for the County's assets (population, building stock, critical facilities, and new development).

Groundwater was set at a depth of five (5) feet (default setting). The default assumption is a magnitude 7.0 earthquake for all return periods. Although damages are estimated at the census tract level, results were presented at the municipal level. Since there are multiple census tracts that contain more than one jurisdiction, the general building stock was used to determine the percent coverage of census tracts within a jurisdiction. The percentage was multiplied against the results calculated for each tract and summed for each jurisdiction.

Damage estimates are calculated for losses to buildings (structural and non-structural) and contents; structural losses include load carrying components of the structure, and non-structural losses include those to architectural, mechanical, and electrical components of the structure, such as nonbearing walls, veneer and finishes, HVAC systems, boils, etc.

Extreme Temperatures

All of Douglas County is exposed to extreme temperature events. A qualitative assessment was conducted for the extreme temperatures hazard. Information from the National Weather Service, Centers for Disease Control and Prevention, Midwestern Regional Climate Center, and the Planning Partnership were used to assess the potential impacts to the County's assets.

Flood

The 1- and 0.2-percent annual chance flood events were examined to evaluate the County's risk from the flood hazard. These flood events are generally those considered by planners and evaluated under federal programs such as NFIP.

The following data was used to evaluate exposure and determine potential future losses for this plan update:

- The Douglas County FEMA Effective Digital Flood Insurance Rate Map (DFIRM) dated September 4, 2020.
- The depth grid developed for the Douglas County HMP using data from the USGS 1 Meter resolution 2016 Digital Elevation Model, and the 2020 FEMA Effective DFIRM.

The effective Douglas County FEMA DFIRM published in 2020 was used to evaluate exposure and determine potential future losses. The depth grid generated for the HMP was integrated into the Hazus riverine flood model used to estimate potential losses for the 1-percent annual chance flood event.

To estimate exposure to the 1-percent- and 0.2-percent annual chance flood events, the DFIRM flood boundaries were overlaid on the centroids of updated assets (population, building stock, critical facilities, and new development). Centroids that intersected the flood boundaries were totaled to estimate the building replacement cost value and population vulnerable to the flood inundation areas. A Level 2 Hazus riverine flood analysis was performed. Both the critical facility and building inventories were formatted to be compatible with Hazus and its Comprehensive Data Management System (CDMS). Once updated with the inventories, the Hazus riverine flood model was run to estimate potential losses in Douglas County for the 1-percent annual chance flood events. A user-defined analysis was also performed for the building stock. Buildings located within the floodplain were imported as user-defined facilities to estimate potential losses to the building stock at the structural level. Hazus calculated the estimated potential losses to the population (default 2010 U.S. Census data across dasymetric blocks), potential damages to the general building stock, and potential damages to critical facility inventories based on the depth grids generated and the default Hazus damage functions in the flood model.

Hazardous Material Spill and Transportation

Hazardous material spills and transportation incidents occurrences were sourced from reports in news media, the US Department of Transportation- Pipeline and Hazardous Materials Safety Administration (PHMSA), and the North American Hazmat Situations and Deployments map. Additional transportation data was sourced from the Colorado Department of Transportation, US Department of Transportation – Federal Aviation Administration, and the National Transportation Safety Board.

Pandemic

Disease outbreak is a new hazard of concern for the Douglas County HMP. All of Douglas County is exposed to disease outbreak events, with impacts falling heavily on health and medical lifelines, people, and the economy. A qualitative assessment was conducted. Research from the Centers for Disease Control and Prevention and the Colorado Department of Public Health & Environment was utilized to qualitatively assess the most recent COVID-19 outbreak. Data from the Colorado Department of Public Health & Environment was used to evaluate the occurrence of a range of infectious diseases, including COVID-19.

Severe Weather – Hail and Lightning, Tornadoes, and Wind

Because Douglas County is not located in an area impacted by tropical storm, Hazus models for probabilistic wind speeds were not used. More than 20 years of NOAA-NCEI severe weather events did not yield damage estimates. Though Douglas County located west of Interstate 25 is located within a Special Wind Region, damages from severe weather events appear to be limited. Aurora, Colorado, located to the northeast of Douglas County, noted annualized losses from hail, lightning, and severe wind events to be less than 0.01 percent of the total exposed value in the City. Given the lack of data, potential losses were estimated at 0.01-percent, 1-percent, and 5-percent thresholds. However, damage experienced in Douglas County from a severe weather event is likely to be closer to the 0.01-percent figure.

Severe Winter Storm

All of Douglas County is exposed and vulnerable to the winter storm hazard. In general, structural impacts include damage to roofs and building frames, rather than building content. Current modeling tools are not available to estimate specific losses for this hazard. A percentage of the custom-building stock structural replacement cost value was utilized to estimate damages that could result from winter storm conditions (i.e., 1-percent, 5-percent, and 10-percent of total replacement cost value). Given professional knowledge and currently available information, the potential losses for this hazard are considered to be overestimated; hence, providing a conservative estimate for losses associated with winter storm events.

Soil Hazard – Erosion, Expansive Soils, Land Subsidence, Slope Failure

The geological hazard data was obtained through the Douglas County GIS program, The Colorado Geological Survey and the United States Geological Survey (USGS). The GIS data included spatial layers for low and moderate risk to erosion susceptibility, dipping bedrock, karst topography, carbonate rock, slope failure, and debris flow. An exposure analysis was conducted on these spatial layers to determine what assets are exposed to geological hazards. The risk to erosion was categorized by low or moderate susceptibility. Dipping bedrock was used to assess risk to expansive soils fur to the potential to expand or swell under exposure to flood and steep topography and could significantly damage infrastructure. The USGS karst topography and carbonate rock spatial layers were used to assess potential impact to land subsidence and the Colorado geological survey slope failure and debris flow spatial layers were used to analyze risk for slope failure. Assets with their centroid located in the hazard area were totaled to estimate the totals and values exposed to geological hazards.

Wildfire

The Wildland-Urban Interface (Interface and Intermix), Fire Intensity Scale (FIS), and Wildfire Risk data obtained through the Colorado CO-WRAP program. An exposure analysis was conducted on the wildfires risk spatial layer in reference to wildfire risk levels: highest, high, moderate, low, and lowest.

To determine what assets are exposed to wildfire, available and appropriate GIS data were overlaid with the hazard area. Assets with their centroid located in the hazard area were totaled to estimate the totals and values exposed to a wildfire event.

Considerations for Mitigation and Next Steps

The following items are to be discussed for considerations for the next plan update to enhance the vulnerability assessment:

- All Hazards
  - Create an updated user-defined general building stock dataset
  - Utilize updated and current demographic data. If 2020 U.S. Census demographic data is available at the U.S. Census block level during the next plan update, use the census block estimates and residential structures for a more precise distribution of population, or the current American Community Survey 5-Year Estimate populations counts at the Census tract level.
- Dam Failure
  - Identify and study exposure to dam inundation areas
- Earthquake
  - Identify unreinforced masonry in critical facilities and privately-owned buildings (i.e., residences) by accessing local knowledge, tax assessor information, and/or pictometry/orthophotos. These buildings may not withstand earthquakes of certain magnitudes and plans to provide emergency response/recovery efforts at these properties can be developed.
  - Integrate NEHRP soil data into Hazus as spatial information becomes more available.
- Extreme Temperatures
  - Track extreme temperature data for injuries, deaths, shelter needs, pipe freezing, agricultural losses, and other impacts to determine distributions of most at risk areas.
- Flood
  - Conduct a Hazus loss analysis for more frequent flood events (e.g., 10 and 50-year flood events).
  - Conduct a repetitive loss area analysis.
  - Continue to expand and update urban flood areas to further inform mitigation.
  - As more current FEMA floodplain data become available (i.e., DFIRMs), update the exposure analysis and generate a more detailed flood depth grid that can be integrated into the current Hazus version.
- Geological Hazards
  - As more current studies on land subsidence, erosion risk, expansive soils, and slope failure become available, update the exposure analysis and updated the general building stock inventory to include attributes of building codes. These attributes can be weighed and assessed for likelihood of damaged cause by geological hazards.
  -
- Severe Storm
  - The general building stock inventory can be updated to include attributes regarding protection against strong winds, such as hurricane straps, to enhance loss estimates.
  - Integrate evacuation route data that is currently being developed.
- Wildfire
  - General building stock inventory can be updated to include attributes such as roofing material or fire detection equipment or integrate distance to fuels as another measure of vulnerability.

5.1.3 Data Source Summary

Table 5-3 summarizes the data sources used for the risk assessment for this plan.

Table 5-3. Risk Assessment Data Documentation

Data	Source	Date	Format
Population data	U.S. Census Bureau; American Community Survey 5-Year Estimates	2010; 2018	Digital (GIS) format
Building Inventory	Douglas Parcel Data, Tax Assessor Data, Tetra Tech	2020	Digital (GIS) format
Wildfire Fuel Hazard	CO-WRAP	2017	Digital (GIS) format
Critical facilities	Douglas Local Planning Committee and County Jurisdictions	2020	Digital (GIS) format
Digitized Effective FIRM maps (2020)	FEMA	2020	Digital (GIS) format
1-meter Resolution Digital Elevation Model	USGS	2016	Digital (GIS) format
Geological Hazards (Low/Moderate Erosion, Dipping Bedrock)	Colorado GIS/ Colorado Geological Survey	n.d.	Digital (GIS) format
Karst Topography	United States Geological Survey	n.d.	Digital (GIS) Format
Carbonate Rock	United States Geological Survey	1984	Digital (GIS) Format
New Development Data	Douglas Planning Partnership and County Jurisdictions	2020	Digital (GIS) Format
Disease Data	Colorado DPH&E; Tri-County Health Department	2020	Digital (CSV) Format
Weather Event Data	NOAA-NCEI	2020	Digital (CSV) Format

Limitations

Loss estimates, exposure assessments, and hazard-specific vulnerability evaluations rely on the best available data and methodologies. Uncertainties are inherent in any loss estimation methodology and arise in part from incomplete scientific knowledge concerning natural hazards and their effects on the built environment. Uncertainties also result from the following:

1) Approximations and simplifications necessary to conduct such a study
2) Incomplete or dated inventory, demographic, or economic parameter data
3) The unique nature, geographic extent, and severity of each hazard
4) Mitigation measures already employed by the participating municipalities
5) The amount of advance notice residents have to prepare for a specific hazard event
6) Uncertainty of climate change projections

These factors can result in a range of uncertainty in loss estimates, possibly by a factor of two or more. Therefore, potential exposure and loss estimates are approximate. These results do not predict precise results and should be used to understand relative risk. Over the long term, Douglas County will collect additional data to collect additional data, update and refine existing inventories, to assist in estimating potential losses.

Potential economic loss is based on the present value of the general building stock utilizing best available data. The County acknowledges significant impacts may occur to critical facilities and infrastructure as a result of these hazard events causing great economic loss. However, monetized damage estimates to critical facilities and infrastructure, and economic impacts were not quantified and require more detailed loss analyses. In addition, economic impacts to industry such as tourism and the real-estate market were not analyzed.

5.2 IDENTIFICATION OF HAZARDS OF CONCERN

Hazards of Concern are those hazards that are considered most likely to impact a community. These are identified using available data and local knowledge.

Natural Hazards are those hazards that are a source of harm or difficultly created by a meteorological, environmental, or geological event.

To provide a strong foundation for mitigation actions considered in Sections 6 (Mitigation Strategy) and 9 (Jurisdictional Annexes), Douglas County focused on considering a full range of hazards that could impact the area and then identified and ranked those hazards that presented the greatest concern. The hazard of concern identification process incorporated input from the county and participating jurisdictions; review of the Colorado Enhanced State Hazard Mitigation Plan (CO E-SHMP 2018); review of the 2015 Douglas County Local Hazard Mitigation Plan Update; research and local, state, and federal information on the frequency, magnitude, and costs associated with the various hazards that have previously, or could feasibly, impact the region; and qualitative or anecdotal information regarding natural (not manmade) hazards and the perceived vulnerability of the study area's assets to them. Table 5.2-1 documents the process of identifying the natural hazards of concern for further profiling and evaluation. Specific hazards not identified as a hazard of concern for Douglas County will not be further discussed in detail.

5.2.1 Changes from 2015 Hazard Mitigation Plan

Since the development of the last plan, hazards and disasters not assessed in the prior plan have occurred in the County. These hazards were identified by the Project Management Team and Local Planning Committee as areas to address in this plan update.

Animal Disease/Infestation: The prior plan did not address animal disease and infestation as a hazard of concern. This plan identifies and assesses the hazard in light of the incidence of impacts to Pike National Forest from the Douglas-fir beetle, Douglas-Fir Tussock Moth, and increasing cases of animal bites.

Pandemic: The prior plan did not address pandemics and disease outbreaks as a hazard of concern. In 2020, Douglas County saw a number of infections of COVID-19. The County has seen more than 15,000 cases as of February 1, 2021. Incidence rates in Douglas County were slightly below those experienced in Adams and Arapahoe Counties and were lower than the State of Colorado's overall infection rates.

Table 5-4. COVID-19 Infection by Municipality

Municipality	Count (1/29/21)	Population (ACS 5-Year 2018)	Rate per 1,000
Castle Pines	616	10,573	58.26
Castle Rock	3,935	59,680	65.93
Larkspur	9	257	35.02
Lone Tree	707	14,209	49.76
Parker	3,310	52,563	62.97
Unincorporated Douglas County	6,463	191,332	33.78
Douglas County Total	**15,040**	328,614	45.77
Statewide Total	396,179	5,513,141	71.86

Source: Colorado DPH&E; Tri-County Health Department 2020

The 2021 Douglas County Hazard Mitigation Plan Update includes best available data throughout the plan to present an updated understanding Douglas County's risk. This includes the use of 2017 WUI data, updated HAZUS models using new Census estimates, 2020 Flood Insurance Rate Maps, new temperature data from the Midwest Regional Climate Center, new data from the US Drought Monitor, and exposure to soil hazards.

5.2.2 Hazard Groupings

As per the 2015 Douglas County HMP, the Project Management Team grouped hazards based on the similarity of hazard events, typical concurrence or impacts, consideration of how hazards have been grouped in Federal Emergency Management Agency (FEMA) guidance documents (*FEMA 386-2 Understanding Your Risks, Identifying Hazards and Estimating Losses*; *Multi-Hazard Identification and Risk Assessment – The Cornerstone of the National Mitigation Strategy*; *Local Mitigation Planning Handbook*), and consideration of hazard grouping in the Colorado E-SHMP.

Table 5-5. Identification of Natural Hazards of Concern for Douglas County

Hazard	Is this a hazard that may occur in Douglas County?	If yes, does this hazard pose a significant threat to Douglas County?	Why was this determination made?	Source(s)
Animal Disease and Plant Infestation	Yes	Yes	• The 2018 Colorado E-SHMP identifies Animal Disease as a hazard of concern for the State. • Douglas County's livestock inventory totals more than 20,000 animals. The County also has large sections of forest that are vulnerable to pests. • Douglas County has seen a significant increase in animal bites since the last plan. • Residents, flora, and fauna of Douglas County are at risk of animal disease and plant infestation.	• CDPH&E • CSFS • Input from Project Management Team and Local Planning Committee
Avalanche	Yes	No	• The 2018 Colorado E-SHMP indicates that the County has negligible exposure to avalanches. • Avalanches can occur in any situation where snow, slope and weather conditions combine to create proper conditions. About 90 percent of all avalanches start on slopes of 30 to 45 degrees and about 98 percent of all avalanches occur on slopes of 25 to 50 degrees. Steep slopes in Douglas County are a defining part of the landscape. • Colorado experiences frequent occurrence of avalanche events based on statistics provided by Colorado Avalanche Information Center (CAIC) between 2000 and 2020. • Due to Douglas County's geography and the lack of occurrences, the Project Management Team and Local Planning Committee do not consider the hazard to be a significant concern.	• CO DHSEM • CAIC • Input from Project Management Team and Local Planning Committee
Dam Failure	Yes	Yes	• The 2018 Colorado E-SHMP identifies dam failure as a hazard of concern for the State. • There are 51 dams in Douglas County, seven of which are considered high hazards dams. • Douglas County has experienced one historic dam failure incident, which occurred in Castlewood Canyon in 1933. • The County is currently seeking to mitigate all high hazards dams. • The Project Management Team and Local Planning Committee identified dam failure as a hazard of concern for the County.	• ASDO • CO DHSEM • NPDP • NID • Input from Project Management Team and Local Planning Committee
Drought	Yes	Yes	• The 2018 Colorado E-SHMP identifies drought as a hazard of concern for the state. Douglas County has been impacted by several drought events that have occurred in the State. • Colorado was included in one FEMA drought-related disaster declaration, which included Douglas County. • There have been eight USDA disaster declarations due to drought in Douglas County since 2013.	• CO DHSEM • FEMA • USDA • Input from Project Management Team and Local Planning Committee • NOAA-NCEI

Table 5-5. **Identification of Natural Hazards of Concern for Douglas County**

Hazard	Is this a hazard that may occur in Douglas County?	If yes, does this hazard pose a significant threat to Douglas County?	Why was this determination made?	Source(s)
			• According to the US Drought Monitor, protracted drought conditions have been experienced in Douglas County in 2016-2017, 2018, and 2020. • Douglas County has experienced moderate drought conditions at least annually since 2016. The current drought has taken place since May 2020. • Based on previous occurrences and input from the Project Management Team and Local Planning Committee, drought is identified as a hazard of concern for Douglas County.	• NRCC
Earthquake	Yes	Yes	• The 2018 Colorado E-SHMP identified earthquake as a hazard of concern for the state, though the frequency of damaging earthquakes within the State is relatively low. • Colorado has not had a federal disaster declaration for earthquakes. • Douglas County has experienced two earthquakes since 1900. Neither earthquake caused major damage. • Based on the potential for significant loss and input from the Project Management Team, earthquake has been identified as a hazard of concern for Douglas County, even though it does not pose a significant threat to the county and there have not been any previous occurrences of major earthquakes within the county.	• CO DHSEM • Input from Project Management Team and Local Planning Committee • USGS – Earthquake Hazards Program, Review of USGS Seismic Maps
Extreme Temperature	Yes	Yes	• The 2018 Colorado E-SHMP identified extreme heat as a hazard of concern for the State. Extreme cold was included as part of the State's Severe Winter Weather hazard profile. • Douglas County experiences an increasing number of days with maximum temperatures greater than 90 degrees and a varying number of days each year with a maximum temperature of less than 32 degrees. • The Project Management Team identified extreme temperature as a hazard of concern for Douglas County.	• CO DHSEM • Input from Project Management Team and Local Planning Committee • Midwest Regional Climate Center • NOAA-NCEI • USDA
Flood (riverine and flash)	Yes	Yes	• The 2018 Colorado E-SHMP identified flooding as a hazard of concern for Colorado. Between 1864 and 2017, the State experienced approximately three dozen flood events causing 372 deaths and $7.5 billion in damages. • Between 2014 and 2020, there have been two floods and two flash floods in the County. Approximately $15,000 in damage was reported in each event. • Based on the history of flooding and its impacts on Douglas County and input from the Project Management Team identified flooding as a hazard of concern for the county.	• CO DHSEM • Input from Project Management Team and Local Planning Committee • FEMA • NOAA-NCEI
Hailstorm	Yes	Yes	Please see Severe Storm	

Table 5-5. **Identification of Natural Hazards of Concern for Douglas County**

Hazard	Is this a hazard that may occur in Douglas County?	If yes, does this hazard pose a significant threat to Douglas County?	Why was this determination made?	Source(s)
Hazardous Material Transportation Incidents	Yes	Yes	• The 2018 Colorado E-SHMP identified Hazardous Material releases as a hazard of concern. The E-SHMP notes significant damages to Douglas County owing to hazardous material incidents. • Douglas County is crossed by a number of railroads, pipelines, and major roadways on which hazardous substances are transported. • Eighteen hazardous material events have occurred in Douglas County since 2014. • The Project Management Team identified hazardous material transportation incidents as a hazard of concern for Douglas County.	• North American Hazmat Situations and Deployments • PHMSA • Input from Project Management Team and Local Planning Committee
Ice Storm	Yes	Yes	Please see Severe Winter Storm	
Pandemic/Disease Outbreak	Yes	Yes	• The 2018 Colorado E-SHMP identifies pandemic as a hazard of concern for the State. • The County has been impacted by various diseases, including influenza, Lyme disease, and COVID-19. As of October 16, 2020, Douglas County totaled more than 15,000 COVID-19 infections. • The Project Management Team and Local Planning Committee identified disease outbreak as a hazard of concern for Douglas County.	• CO DHSEM • CO DPH&E • Input from Project Management Team and Local Planning Committee
Severe Storm (windstorms, thunderstorms, lightning, hail and tornados)	Yes	Yes	• The 2018 Colorado E-SHMP identified severe storms as a hazard of concern for Colorado. Severe storm events include severe wind, tornadoes, hail, and thunderstorms and lightning. • Between 1954 and 2020, Douglas County was included in one FEMA severe storm-related declarations. ○ FEMA-DR-200 (Tornado) – June 19th, 1965 • According to the SPC, three tornados impacted Douglas County between 2014 and 2020. • There have been more than 358 hail events and 26 lightning events since 1996 in Douglas County. There have been more than 180 wind events since 1953. Since 2014, wind storm events have caused few property damages. • Based on previous occurrences and input from the Project Management Team and Local Planning Committee, severe storms are identified as a hazard of concern for Douglas County.	• CO DHSEM • FEMA • NOAA-NCEI • SPC • Input from Project Management Team and Local Planning Committee
Severe Winter Storm (heavy snow, blizzards, ice storms)	Yes	Yes	• The 2018 Colorado E-SHMP identified severe winter weather, including extreme cold events, as a hazard of concern for the State. According to the E-SHMP, Douglas County experienced 267 events between 1960 and 2017 causing more than $49.6 million in damages. • FEMA included Douglas County in five winter storm-related disaster declarations:	• CO DHSEM • FEMA • NOAA-NCEI • Input from Project Management Team

Table 5-5. Identification of Natural Hazards of Concern for Douglas County

Hazard	Is this a hazard that may occur in Douglas County?	If yes, does this hazard pose a significant threat to Douglas County?	Why was this determination made?	Source(s)
			○ FEMA-DR-3185 (Snow) – 2003 ○ FEMA-EM-3270 (Snow) – 2007 • Based on previous occurrences and input from the Project Management Team, severe winter weather is identified as a hazard of concern for Douglas County.	and Local Planning Committee
Soil Hazards: Erosion, Expansive Soils, Land Subsidence, Slope Failure	Yes	Yes	• The 2018 Colorado E-SHMP identifies Erosion and Deposition; Expansive Soils and Heaving Bedrock; Landslides, Mud/Debris Flows, and Rockfalls; and Subsidence as hazards of concern for the State. • There are no FEMA soil-related disaster declarations for Douglas County. • Douglas County has experienced soil hazards to varying degrees of severity. Many of the mapped soil hazards have past occurrences and anticipated occurrences in the foothills of the Rampart Range, such as the area stretching between Roxborough State Park and Perry Park. Isolated incidents of soil hazards have occurred throughout the County. • Based on available data, the Project Management Team identified soil hazards as a hazard of concern for Douglas County.	• CO DHSEM • CGS • Input from Project Management Team and Local Planning Committee • FEMA
Tornado	Yes	Yes	Please see Severe Storm	
Volcano	No	No	• The 2018 Colorado E-SHMP analyzed volcanos as a hazard but did not identify volcano as a hazard of concern for Douglas County and, therefore, the Project Management Team does not consider volcano to be a hazard of concern for Douglas County.	• CO DHSEM • Input from Project Management Team and Local Planning Committee
Wildfire	Yes	Yes	• The 2018 Colorado E-SHMP identified wildfire as a hazard of concern for Colorado. Douglas County is ranked in the E-SHMP as one of the County's with the highest risk, and has the fourth-largest percent of area at risk of wildfire. • Douglas County has been included in three FEMA wildfire-related disaster declarations. ○ FEMA-DR-1421: Colorado Wildfires (April 2002-August 2002) ○ FSA-2407-CO: Colorado Schoonover Fire (May 2002) ○ FEMA-EM-2510-C: Cherokee Ranch Fire (October 2003) • Based on available data, the Project Management Team identified wildfire as a hazard of concern for Douglas County.	• CO DHSEM • Input from Project Management Team and Local Planning Committee • FEMA
Windstorm	Yes	Yes	Please see Severe Storm: Wind/Thunderstorm	

CGS	*Colorado Geological Survey*	*DR*	*Presidential Disaster Declaration Number*
CO DHSEM	*Colorado Division of Homeland Security and Emergency Management*	*EM*	*Presidential Disaster Emergency Number*
CO DPH&E	*Colorado Department of Public Health and Environment*	*FEMA*	*Federal Emergency Management Agency*

M	*Million ($)*
MRCC	*Midwest Regional Climate Center*
NCEI	*National Centers for Environmental Information*
PGA	*Peak ground acceleration*
SPC	*Storm Prediction Center*
USDA	*U.S. Department of Agriculture*
USGS	*United States Geologic Survey*

5.2.3 Summary of Hazards of Concern

In summary, a total of 17 hazards of concern were identified as significant hazards affecting the planning area, to be addressed at the county level in this plan (shown here in alphabetical order):

- Animal Disease/Infestation
- Dam Failure
- Drought
- Earthquake
- Extreme Temperatures
- Flood (riverine and flash)
- Hazardous Materials
- Pandemic/Disease Outbreak
- Severe Weather: Hail and Lightning
- Severe Weather: Tornado
- Severe Weather: Wind
- Severe Winter Storm
- Soil Hazards: Erosion
- Soil Hazards: Expansive Soils
- Soil Hazards: Land Subsidence
- Soil Hazards: Slope Failure
- Wildfire

Other hazards of concern that might occur in Douglas County were deemed to have a low potential to result in significant impacts and can be considered in future updates to this plan.

5.3 HAZARD RANKING

As discussed in Section 5.2 (Identification of Hazards of Concern), a comprehensive range of natural hazards that pose a significant risk to Douglas County were selected and considered during development of this plan; however, each community in Douglas County has differing levels of exposure and vulnerability to each of these hazards. It is important for each community participating in this plan to recognize those hazards that pose the greatest risk to their community and direct their attention and resources accordingly to most effectively and efficiently manage risk and reduce losses. The hazard ranking for the county and each participating jurisdiction can be found in their jurisdictional annexes in Volume II, Section 9 of this plan.

To this end, a hazard risk ranking process was conducted for Douglas County and its municipalities using the method described below. This method includes four risk assessment categories—probability of occurrence, impact (population, property, and economy), adaptive capacity, and changing future conditions (climate change). Each were assigned a weighting factor to calculate an overall ranking value for each hazard of concern. Depending on the calculation, each hazard was assigned a high, medium, or low ranking. Details regarding each of these categories is described below.

5.3.1 Hazard Ranking Methodology

The methodology used to rank the hazards of concern for Douglas County is described below. Estimates of risk for the county were developed using methodologies promoted by FEMA's hazard mitigation planning guidance, generated by FEMA's HAZUS-MH risk assessment tool, and input from Douglas County and participating jurisdictions. Table 5-6 shows the four risk assessment categories' values for each of Douglas County's hazards. Details for each category are further described below.

Probability of Occurrence

The probability of occurrence is the likelihood of a hazard event occurring in any given year. A review of historic events assists with this determination. Each hazard of concern is rated in accordance with the numerical ratings and definitions described in Table 5-6.

Impact

The impact of each hazard is considered in three categories: impact on population, impact on property (general building stock including critical facilities), and impact on the economy. Based on documented historic losses and individual assessments by each participating municipality, an impact rating of high, medium, or low is assigned with a corresponding numeric value for each hazard of concern. In addition, a weighting factor is assigned to each impact category: 3 for population, 2 for property, and 1 for economy. This gives the impact on population the greatest weight in evaluating the impact of a hazard. The total of each category is assigned a weighted value of 30%. Table 5-6 presents the numerical rating, weighted factor and description for each impact category.

Table 5-6. Summary of Hazard Ranking Approach

Category		Level / Category*	Degree of Risk / Benchmark Value	Numeric Value
Probability of Occurrence		No Exposure	There is no probability of occurrence	0
		Low	Hazard event is not likely to occur within 100 years	1
		Medium	Hazard event is likely to occur within 100 years	2
		High	Hazard event is likely to occur within 25 years	3
Impact (Sum of all 3)	Population	Low Impact	9% or less of population is exposed to a hazard with potential for measurable life safety impact due to its extent and location.	1
		Medium Impact	10% to 24% of population is exposed to a hazard with potential for measurable life safety impact due to its extent and location.	2
		High Impact	25% or more of population is exposed to a hazard with potential for measurable life safety impact due to its extent and location.	3
	Property	Low Impact	Property exposure is 14% or less of the total number of structures for community.	1
		Medium Impact	Property exposure is 15% to 29% of the total number of structures for community.	2
		High Impact	Property exposure is 30% or more of the total number of structures for community.	3
	Economy	Low Impact	Loss estimate is 9% or less of the total replacement cost for community.	1
		Medium Impact	Loss estimate is 10% to 19% of the total replacement cost for community.	2
		High Impact	Loss estimate is 20% or more of the total replacement cost for community.	3

Note: A numerical value of zero is assigned if there is no impact.
** For the purposes of this exercise, "impacted" means exposed for population and property and loss for economy.*

Risk Ranking Value

Each impact was then weighted and the risk ranking for each hazard is then calculated using the following formula:

Example Risk Ranking Equation
Risk Ranking = [(Impact on Population x 3) + (Impact on Property x 2) + (Impact on Economy x 1) x 30%] x [Probability of Occurrence]

Based on the total for each hazard, a priority ranking is assigned to each hazard of concern (high, medium, or low). The rankings were categorized as follows: Low = values less than 14; Medium = values between 15 and 30; High = values greater than 31.

5.3.2 Hazard Ranking Results

Using the process described above, the risk ranking for the identified hazards of concern was determined for Douglas County. The hazard ranking for Douglas County is detailed in the subsequent tables that present the step-wise process for the ranking. The countywide risk ranking includes the entire planning area and might not reflect the highest risk indicated for any of the participating jurisdictions. The resulting ranks of each municipality indicate the differing degrees of risk exposure and vulnerability. The results support the appropriate selection and prioritization of initiatives to reduce the highest levels of risk for each municipality. Both the county and the participating jurisdictions have applied the same methodology to develop the countywide risk and local rankings to ensure consistency in the overall ranking of risk; jurisdictions had the ability to alter rankings based on local knowledge and experience in handling each hazard.

This hazard ranking exercise serves two purposes: 1) to describe the probability of occurrence for each hazard; and 2) to describe the impact each would have on the people, property, and economy. Estimates of risk for Douglas County were developed using methodologies promoted by FEMA's hazard mitigation planning guidance, generated by FEMA's HAZUS-MH risk assessment tool and input from the county and participating municipalities.

Table 5-7 shows the probability ranking assigned for likelihood of occurrence for each hazard.

Table 5-7. Probability of Occurrence Ranking for Hazards of Concern for Douglas County

Hazard of Concern	Probability	Numeric Value
Animal Disease	High	3
Dam and Levee Failure	Low	1
Drought	High	3
Earthquake	Medium	2
Erosion	Medium	2
Expansive Soils	Medium	2
Extreme Temperatures	Medium	2
Flood	Medium	2
Hail	High	3
Land Subsidence	Medium	2
Landslide	Medium	2

Hazard of Concern	Probability	Numeric Value
Lightning	High	3
Pandemic	High	3
Severe Thunderstorms	High	3
Severe Winter Storm	High	3
Slope Failure	Medium	2
Tornadoes	Medium	2
Transportation Accidents	High	3
Wildfire	High	3

Table 5-8 shows the impact evaluation results for each hazard of concern, including impact on property, structures, and the economy on the county level. It is noted that several hazards that have a high impact on the local jurisdictional level can have a lower impact when analyzed countywide. Jurisdictional ranking results are presented in each local annex in Section 9 (Jurisdictional Annexes) of this plan. The weighting factor results and a total impact for each hazard also are summarized.

Table 5-8. Impact Ranking for Hazards of Concern for Douglas County

Hazard of Concern	Population		Property		Economy		Relative Risk Factor (Population + Property + Economy)
	Numeric Value	Impact	Numeric Value	Impact	Numeric Value	Impact	Numeric Value
Animal Disease	1	Low	1	Low	1	Low	6.0
Dam and Levee Failure	1	Low	1	Low	1	Low	6.0
Drought	2	Medium	1	Low	2	Medium	10.0
Earthquake	1	Low	2	Medium	1	Low	8.0
Erosion	1	Low	1	Low	1	Low	6.0
Expansive Soils	1	Low	1	Low	1	Low	6.0
Extreme Temperatures	1	Low	1	Low	1	Low	6.0
Flood	1	Low	1	Low	1	Low	6.0
Hail	1	Low	2	Medium	1	Low	8.0
Land Subsidence	1	Low	1	Low	1	Low	6.0
Landslide	1	Low	1	Low	1	Low	6.0
Lightning	1	Low	1	Low	1	Low	6.0
Pandemic	2	Medium	1	Low	2	Medium	10.0
Severe Thunderstorms	1	Low	1	Low	1	Low	6.0
Severe Winter Storm	1	Low	1	Low	1	Low	6.0
Slope Failure	1	Low	1	Low	1	Low	6.0
Tornadoes	1	Low	2	Medium	1	Low	8.0
Transportation Accidents	1	Low	1	Low	1	Low	6.0
Wildfire	3	High	2	Medium	3	High	16.0

Table 5-9 presents the total calculations for each hazard ranking value for the hazards of concern.

Table 5-9. Total Hazard Ranking Values for the Hazards of Concern for Douglas County

Hazard of Concern	Probability Value	Relative Risk Factor	Risk Ranking Score	Risk Ranking
Animal Disease	3	6.0	18	Medium
Dam and Levee Failure	1	6.0	6	Low
Drought	3	10.0	30	Medium
Earthquake	2	8.0	16	Medium
Erosion	2	6.0	12	Low
Expansive Soils	2	6.0	12	Low
Extreme Temperatures	2	6.0	12	Low
Flood	2	6.0	12	Low
Hail	3	8.0	24	Medium
Land Subsidence	2	6.0	12	Low
Landslide	2	6.0	12	Low
Lightning	3	6.0	18	Medium
Pandemic	3	10.0	30	Medium
Severe Thunderstorms	3	6.0	18	Medium
Severe Winter Storm	3	6.0	18	Medium
Slope Failure	2	6.0	12	Low
Tornadoes	2	8.0	16	Medium
Transportation Accidents	3	6.0	18	Medium
Wildfire	3	16.0	48	High

Table 5-10 presents the jurisdictional hazard ranking for each hazard. An evaluation of the total risk ranking score determined ranking categories that were grouped into three categories, low, medium, and high. It also includes input by the municipalities. The rankings were categorized as follows: Low = values less than 14 colored yellow; Medium = values between 15 and 30 colored amber; High = values greater than 31 colored red.

These rankings have been used as one of the bases for identifying the jurisdictional hazard mitigation strategies included in Section 9 (Jurisdictional Annexes) of this plan. The summary rankings for the county reflect the results of the vulnerability analysis for each hazard of concern and can vary from the specific results of each jurisdiction. For example, the severe storm hazard may be ranked low in one jurisdiction, but due to the exposure and impact countywide, it is ranked as a high hazard county-wide and is addressed in the county mitigation strategy accordingly. This table was distributed to municipalities and any changes are noted in the municipal annex.

Table 5-10. Summary of Overall Ranking of Natural Hazards by Jurisdiction

HAZARD	Douglas County (Overall)	Castle Pines	Castle Rock	Larkspur	Lone Tree	Parker	Unincorporated Douglas County
Animal Disease	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Dam and Levee Failure	Low	Low	Low	Low	Low	Low	Low
Drought	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Earthquake	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Erosion	Low	Low	Low	Medium	Low	Low	Low
Expansive Soils	Low	Low	Low	Low	Low	Low	Low
Extreme Temperatures	Low	Low	Low	Low	Low	Low	Low
Flood	Low	Low	Low	Low	Low	Low	Low
Hail	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Land Subsidence	Low	Medium	Medium	Medium	Low	Low	Low
Landslide	Low	Low	Low	Low	Low	Low	Low
Lightning	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Pandemic	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Severe Thunderstorms	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Severe Winter Storm	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Slope Failure	Low	Low	Low	Low	Low	Low	Low
Tornadoes	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Transportation Accidents	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Wildfire	High	High	High	High	Medium	High	High

5.4 Hazard Profiles

5.4.1 Animal Disease and Infestation and Plant Disease

This section provides a hazard profile and vulnerability assessment of the animal and plant disease/pest infestation hazard for Douglas County.

Hazard Profile

This section presents information regarding the description, extent, location, previous occurrences and losses, climate change projections and probability of future occurrences for the animal disease and infestation hazard.

Description

Animal and plant diseases are disease outbreaks or infestations that are transmitted from plant-to-plant or from animal-to-animal. As a natural hazard profiled for this hazard mitigation plan, diseases of concern include those that generate significant impacts for ecosystems, economy, and the human population. Animal diseases, also known as Zoonotic diseases, include a new strain of virus not previously seen in the animal population, the reintroduction of a previously eliminated disease, and the accidental or intentional introduction of a foreign animal disease. The Colorado Enhanced State Hazard Mitigation Plan identifies zoonotic diseases as a significant hazard to State residents and livestock (State of Colorado 2018).

The Colorado Department of Public Health and Environment has identified the following Zoonotic disease outbreaks occurring between 2014 and 2019:

- Anthrax
- Brucellosis
- Chikungunya
- Colorado Tick Fever
- Dengue
- Hantavirus
- Lyme Disease
- Malaria
- Plague
- Psittacosis
- Q-Fever, Acute
- Q-Fever, Chronic
- Rabies, Human
- Rabies, Animal
- Rocky Mountain Spotted Fever
- Tick-borne Relapsing Fever
- Tularemia

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 plant, wildlife, and livestock. 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. Human populations are generally impacted by insect or animal infestations that can result in health impacts and can lead to potential epidemics or endemics, such as hantavirus and tularemia.

Extent and Location

The extent and location of infestations depends on the preferred habitat of the species, as well as the species' ease of movement and establishment. However, each of these threats can impact most areas of Colorado, including Douglas County. Douglas County's land use patterns are marked by relatively dense development in the northern section of the County, forest land in the western portion of the County, and exurban and agricultural areas in the southern section of the County. All areas of the County are vulnerable to these hazards to varying degrees.

Douglas County has over 200,000 acres of farms, 78% of which is pastureland and 13% of which is cropland. As of 2017, Douglas County's livestock inventory totaled 20,773 animals, inclusive of 8,005 cattle and calves; 4,744 horses and ponies; 4,542 layers; and 1,127 goats. In 2017, the market value of agricultural products totaled $18.8 million (USDA 2017). Livestock in Douglas County's pastureland may be significantly impacted by animal diseases.

The magnitude of infestations ranges from nuisance to widespread. The threat is typically intensified when the ecosystem or host species is already stressed, such as periods of drought. The already weakened state of the ecosystem causes it to more easily be impacted to an infestation

Previous Occurrences and Losses

Information about animal disease and infestation events is limited. Many sources of information were sought in the documentation of previous occurrences, including various agencies at the State and County levels. Between 1953 and 2020, the Federal Emergency Management Agency (FEMA) did not declare a major disaster (DR) or emergency (EM) in the State of Colorado for animal disease or infestation. The U.S. Department of Agriculture (USDA) keeps records of agricultural disasters. Between 1996 and 2020, Douglas County was not included in disaster declarations related to infestation.

Table 5-11. Animal Disease and Infestation Events in Douglas County between 1996 and 2020

Dates of Event	Event Details*
1996- Ongoing	Pike National Forest is impacted by the Douglas-fir beetle. As of 2019, the Beetle continues to cause damage in County forests near Jarre Canyon, Perry Park, and Valley Park.
2014-2016	In 2014, larvae of Douglas-Fir Tussock Moth (DFTM) were observed in Douglas County forests. In 2015, 24,000 acres were defoiled by beetles, including nearly 6,000 acres near Perry Park and more than 2,800 acres at Jarre Canyon.
2014	Ten animal bites were reported in Douglas County
2015	A case of Brucellosis was reported in Douglas County. Twenty-two cases of animal bites were reported.
2015	A case of Dengue Fever was reported in Douglas County.
2016	Seventy-seven cases of animal bites were reported in Douglas County.
2017	Three cases of Dengue Fever and 86 animal bites were reported in Douglas County.
2018	Two cases of Dengue Fever and 141 animal bites were reported in Douglas County

Sources: CDPHE; CSFS

* *Many sources were consulted to provide an update of previous occurrences and losses; event details and loss/impact information may vary and has been summarized in the above table.*

Climate Change Projections

The relationship between diseases occurrence and climate change is difficult to predict with certainty. However, there may be linkages between the two. Changes in the environment may create a more livable habitat for vectors carrying disease as suggested by the Centers for Disease Control and Prevention (CDC n.d.). Localized changes in climate and human interaction may also be a factor in the spread of disease.

Probability of Future Occurrences

Based on historical documentation, increased incidences of infestation throughout Colorado and the overall impact of changing climate trends, Douglas County and its jurisdictions will continue to experience animal disease and infestation events that may induce secondary hazards and health threats to the County population if infestations are not prevented, controlled or eradicated effectively.

Predicting the likelihood of future occurrences of animal diseases, infestations, and plant diseases is difficult. However, it is possible for this hazard to occur in Douglas County. The high concentration of farms in the County makes them susceptible to outbreaks among livestock and crops (Colorado State HMP 2018). Based on input from the Core Planning Team, the probability for this hazard is considered *frequent* (hazard event likely to occur within 25 years). Refer to Sections 5.1 and 5.3 for additional information on the hazard ranking methodology and probability criteria.

Vulnerability Assessment

To understand risk, a community must evaluate assets exposed to and vulnerable to the identified hazard. All of Douglas County is exposed to the animal disease and pest infestation hazard; therefore, all assets within the County (population, structures, critical facilities, and lifelines), as described in Section 4 (County Profile), are potentially vulnerable to an animal disease or pest infestation event. The following text evaluates and estimates the potential impact of the animal disease and pest infestation hazard in the County.

Impact on Life, Health, and Safety

Though animal disease and infestation primarily impact non-human species, the potential exists for these hazards to impact life, health, and safety. Animals can serve as vectors of disease for human infection, such as in the case of rabies. Additionally, plant infestations can cause mass die-offs of vegetation that can generate large amounts of fuel for wildfires. Therefore, impacts to the life, health, and safety of the population of Douglas County can be impacted by the impacts of animal disease or pest infestations.

Impact on General Building Stock

Animal diseases and pest infestations are not anticipated to impact the building stock of Douglas County. However, indirect impacts from infestations (such as dead vegetation) can leads to downed trees, damaging structures and infrastructure throughout the County. It can also enhance the risk of wildfires and exposure of the general building stock to wildfire impacts.

Impact on Critical Facilities

Animal and plant diseases will have few direct impacts to critical facilities but may cause a number of secondary impacts. Diseases impacting animals may put strain on the County's and region's network of veterinary services. Plant diseases may impact natural resources in recreational facilities and preserved habitats. Furthermore, infestations can result in restrictions of the use of these facilities.

Impact on the Economy

Though diminished significantly as the County's population increased and the region grows, agriculture plays a role in the County's economy. According to Land Use Land Cover data, approximately 38.8% of

Douglas County's land area is agricultural land and 45.3% is forest land. Just 2,285 acres of Douglas County is irrigated farmland, and 10,500 acres of cropland (the most of any category of product) is forage. The Douglas County portion of Pike-San Isabel National Forest generated 513 CCF of timber in 2016, representing 2.5% of the Forest's timber (Simmons et al. 2019).

The 2017 Census of Agriculture reports 1,223 farms in Douglas County comprising 201,574 acres – an increase of 10% and 1% since 2012, respectively. The market value of goods sold from Douglas County totaled $18.8 million, with crops (predominantly nursery, greenhouse, floriculture, and sod) totaling $11.7 million and livestock (predominantly cattle and calves) totaling $7.1 million. Douglas County's nursery output is ranked eighth in the State, whereas its market value of horses, ponies, mules, burros, and donkeys is ranked third in the State. The USDA counts 2,174 total producers in Douglas County.

According to 2018 County Business Patterns data cited in the County Profile, the agriculture, forestry, fishing, and hunting sector includes 25 businesses, 57 employees, and $1.6 million in annual payroll for Douglas County. Incidence of animal disease and pest infestation can cause economic losses for agricultural businesses in Douglas County and the County as a whole.

Future Changes that May Impact Vulnerability

Understanding future changes that impact vulnerability in the County can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development.
- Projected changes in population.
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development

As discussed in Sections 4 (County Profile) and 9 (Jurisdictional Annexes), areas targeted for future growth and development have been identified across Douglas County. Land use changes have the potential to render some habitats more susceptible to invasive species, such as clearing the land and providing opportunities for invasive species to inhabit the area. Clearing the land may also reduce the habitat for predator species that could manage the spread of invasive species naturally. The specific areas of development are indicated in tabular form and/or on the hazard maps included in the jurisdictional annexes in Volume II, Section 9 of this plan.

Projected Changes in Population

The population of Douglas County is growing and is expected to continue growing into the future. Any growth can create changes in density throughout the County, which can affect the location of future development projects. As a result, habitat changes can impact the distribution of natural wildlife to mitigate against infestation and invasive species.

Furthermore, infestation to cropland and animals can have a wider impact on persons outside of Douglas County if the farmers within the County supply resources to areas outside of the County. Awareness of trends occurring around the County may reveal that infestations within agricultural and timber commodities provided by the County impacts a greater number of persons.

Climate Change

Climate change could exacerbate the impacts of these species in the County. As mentioned previously, changing weather patterns could create a change in the migration patterns for when these species move into and out of Douglas County. If the species have a more prolonged existence in the County, there may also be a greater number of animal disease or infestation events or a higher value of loss tied to infestation.

Change of Vulnerability since the 2015 HMP

The 2015 HMP did not include Animal Disease/Pest Infestation as a hazard. It is not anticipated that the County's vulnerability to this hazard has changed since 2015.

Issues Identified

The following have been identified as drought-related issues:

- Mass die-offs of vegetation can generate large amounts of fuel for wildfires. Spruce beetles and Douglas-fir beetles continue to result in dead trees in Douglas County and throughout Colorado.
- Animals in Douglas County have experienced Prairie Dog Disease, hantavirus, rabies, and tularemia. These diseases can cause infections in humans, posing serious health risks. The County has experienced an increase in cases of animal bites in the County between 2013-2018. Section 5.4.8 discusses the Pandemic/Disease Outbreak hazard in greater detail.

5.4.2 Dam Failure

The following section provides the hazard profile and vulnerability assessment for the dam failure hazard in Douglas County.

Profile

Hazard Description

Dams are man-made structures built across a stream or river that impound water and reduce the flow downstream (FEMA 2003). They are built for the purpose of power production, agriculture, water supply, recreation, and flood protection. However, at the same time, dams also present a risk to public safety. They require ongoing maintenance, monitoring, and safety inspections. Dam failure is any malfunction or abnormality outside of the design that adversely affects a dam's primary function of impounding water (FEMA 2018). The energy of water stored behind the dam is capable of causing rapid and unexpected flooding downstream, impacting lives and properties. Dams can fail for one or a combination of the following reasons:

- Overtopping caused by floods that exceed the capacity of the dam (inadequate spillway capacity due to uncontrolled release or exceedance of design);
- Prolonged periods of rainfall and flooding;
- Deliberate acts of sabotage (terrorism);
- Structural failure of materials used in dam construction;
- Movement and/or failure of the foundation supporting the dam;
- Settlement and cracking of concrete or embankment dams;
- Piping and internal erosion of soil in embankment dams;
- Inadequate or negligent operation, maintenance and upkeep;

- Failure of upstream dams on the same waterway; or
- Earthquake (liquefaction / landslides) (FEMA 2019).

Regulatory Oversight for Dams

Colorado Dam Safety Program

The Colorado Department of Natural Resources' Division of Water Resources, Dam Safety Branch monitors and regulates dams in Colorado. Dams having a statutory height of 10 feet or greater to the spillway crest or that create a reservoir with more than 100 acre-feet of water, or that cover more than 20 acres at the high water line are considered jurisdictional dams. Jurisdictional dams require plan review and approvals by the State Engineer. This program is governed by the Code of Colorado Regulations 2CCR-402-1 (Colorado Division of Water Resources 2020). The following structures are exempt from the Rules and Regulations for Dam Safety and Dam Construction (Colorado Secretary of State 2020):

- Highways, road-fills and railroad embankments with an ungated outlet conduit
- Diversion dams if less than jurisdictional size, and all diversion dams of any size if low hazard or NPH
- Refuse embankments
- Structures which only store water below the lowest point of the natural ground unless an outlet works is constructed to develop water

National Dam Safety Act

Potential for catastrophic flooding due to dam failures led to passage of the National Dam Safety Act (Public Law 92-367). The National Dam Safety Program requires a periodic engineering analysis of the majority of dams in the country; exceptions include the following:

- Dams under jurisdiction of the Bureau of Reclamation, Tennessee Valley Authority, or International Boundary and Water Commission
- Dams constructed pursuant to licenses issued under the Federal Power Act
- Dams that the Secretary of the Army determines do not pose any threat to human life or property.

The goal of this FEMA-monitored effort is to identify and mitigate the risk of dam failure so as to protect lives and property. The National Dam Safety Program is a partnership among states, federal agencies, and other stakeholders that encourages individual and community responsibility for dam safety. Under FEMA's leadership, state assistance funds have allowed all participating states to improve their programs through increased inspections, emergency action planning, and purchases of needed equipment. FEMA has also expanded existing and initiated new training programs. Grant assistance from FEMA provides support for improvement of dam safety programs that regulate most of the dams in the United States (FEMA 2020).

U.S. Army Corps of Engineers Dam Safety Program

The U.S. Army Corps of Engineers operates and maintains approximately 700 dams nationwide. It is also responsible for safety inspections of some federal and non-federal dams in the United States that meet the size and storage limitations specified in the National Dam Safety Act. The Corps has inventoried dams; surveyed each state and federal agency's capabilities, practices and regulations regarding design, construction, operation and maintenance of the dams; and developed guidelines for inspection and evaluation of dam safety. The Corps maintains the National Inventory of Dams, which contains information about a dam's location, size, purpose, type, last inspection and regulatory status (U.S. Army Corps of Engineers 2020).

Federal Energy Regulatory Commission Dam Safety Program

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

FERC inspects hydroelectric projects on an unscheduled basis to investigate the following:

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

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

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

FERC requires licensees to prepare emergency action plans and conducts training sessions on how to develop and test these plans. The plans outline an early warning system if there is an actual or potential sudden release of water from a dam due to failure. The plans include operational procedures that may be used, such as reducing reservoir levels and reducing downstream flows, as well as procedures for notifying affected residents and agencies responsible for emergency management. These plans are frequently updated and tested to ensure that everyone knows what to do in emergency situations (FERC 2020).

Extent

The Colorado Department of Natural Resources' Division of Water Resources, Dam Safety Branch classifies dams into four categories based on an evaluation of the consequences of the failure of the dam absent flooding conditions.

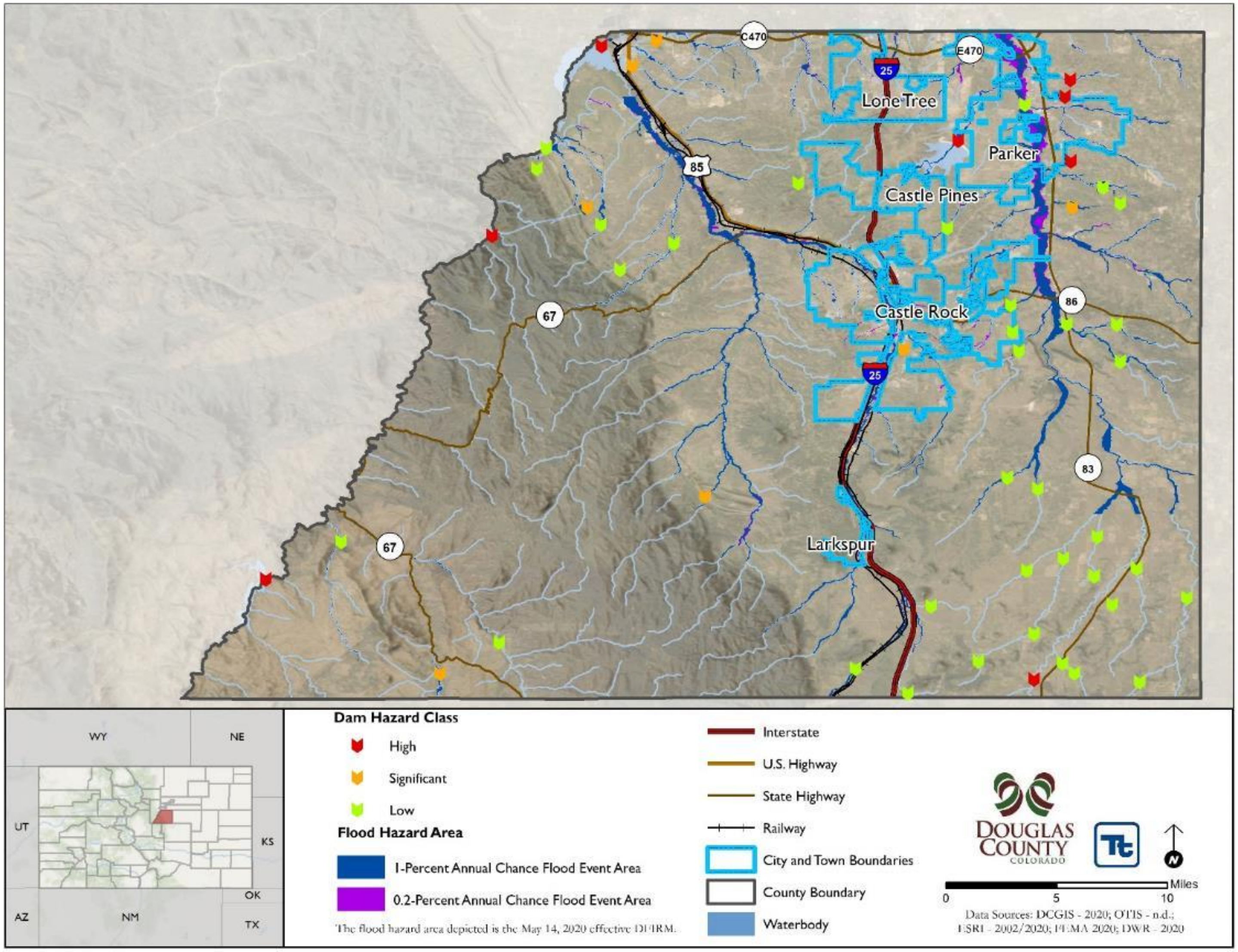
- A "Class I" (High Hazard) dam is a dam for which loss of human life is expected in the event of failure of the dam.
- A "Class II" (Significant Hazard) dam is a dam for which significant damage is expected to occur, but no loss of human life is expected in the event of failure of the dam. Significant damage is defined as damage to structures where people generally live, work, or recreate, or public or private facilities exclusive of unpaved roads and picnic areas. Damage means rendering the structures uninhabitable or inoperable

- A “Class III” (Low Hazard) dam is a dam for which loss of human life is not expected, and damage to structures and public facilities as defined for a “Class II” dam is not expected in the event of failure of the dam.
- A “Class IV” (No Public Hazard) dam is a dam for which no loss of human life is expected, and which damage will occur only to the dam owner's property in the event of failure of the dam (Code of Colorado Regulations).

Location

There are 51 dams in Douglas County and no levees. Of these dams, 7 are considered high hazard dams, 7 as significant hazard, and 35 as low hazard. Two dams did not have classifications. As of 2020, Douglas County is undertaking a mitigation project that will remove all high-hazard dams in the County. Upon completion, it is anticipated that the County’s risk to dam failures will be virtually eliminated. Figure 5-1 shows the location of these dams in Douglas County.

Figure 5-1. Dams in Douglas County



Source: Douglas County

Table 5-12. Dams in Douglas County

FACILITY NAME	LOCATION	PARCEL OWNER	OWNER TYPE	YEAR BUILT	DAM HAZARD CLASS
CASTLEWOOD RANCH POND B	CASTLE ROCK	TOWN OF CASTLE ROCK	PRIVATE	2003	LOW
MILLION DOLLAR	CASTLE ROCK	SW GREENS PLUM CREEK LLC	PRIVATE	1984	SIGNIFICANT
PARKER BAR CCC	PARKER	TOWN OF PARKER	DISTRICT	1984	LOW
ALLIS	UNINCORPORATED COUNTY	HARMONY LAND AND CATTLE LLC	PRIVATE	1906	LOW
AURORA-RAMPART	UNINCORPORATED COUNTY	CITY OF AURORA	CITY	1964	SIGNIFICANT
BAIRD #1	UNINCORPORATED COUNTY	COLORADO DEPT OF TRANSPORTATION	PRIVATE	1907	LOW
CHAMBERS RESERVOIR	UNINCORPORATED COUNTY	ARAPAHOE COUNTY WATER & WASTEWATER AUTHORITY	COUNTY	2012	HIGH
CHATFIELD DAM	UNINCORPORATED COUNTY	UNITED STATES OF AMERICA STATE OF COLORADO PARKS DEPT	<NULL>	<NULL>	<NULL>
CHEESMAN	UNINCORPORATED COUNTY	CITY & COUNTY OF DENVER	DISTRICT	1905	HIGH
CIRCLE 2 RANCH DET. #1	UNINCORPORATED COUNTY	REATA SOUTH METRO DISTRICT	DISTRICT	1964	LOW
FRANKTOWN PARKER FPA-1	UNINCORPORATED COUNTY	TONY M WARREN	COUNTY	1963	LOW
FRANKTOWN PARKER FPA-2	UNINCORPORATED COUNTY	HARMONY LAND AND CATTLE LLC	COUNTY	1963	LOW
FRANKTOWN PARKER FPA-4	UNINCORPORATED COUNTY	JOSEPH V TODD JR & MICHELE L TODD	COUNTY	1963	LOW
FRANKTOWN PARKER FPA-5	UNINCORPORATED COUNTY	HARMONY LAND AND CATTLE LLC	COUNTY	1963	LOW
FRANKTOWN PARKER FPA-6	UNINCORPORATED COUNTY	HARMONY LAND AND CATTLE LLC	COUNTY	1963	LOW
FRANKTOWN PARKER FPB-1	UNINCORPORATED COUNTY	CENTENNIAL RANCH HOMEOWNERS ASSOCIATION	COUNTY	1963	HIGH
FRANKTOWN PARKER FPE-7	UNINCORPORATED COUNTY	FLYING HORSE RANCH LLC	COUNTY	1964	LOW
FRANKTOWN PARKER FPE-8	UNINCORPORATED COUNTY	RONALD L PIETRAFESO & ADRIENNE E PIETRAFESO	COUNTY	1965	LOW
FRANKTOWN PARKER FPLG-1	UNINCORPORATED COUNTY	KEITH R PENRY & KAREN E PENRY	COUNTY	1962	LOW
FRANKTOWN PARKER FPLG-2	UNINCORPORATED COUNTY	TODD C MUCK	COUNTY	1962	LOW

FACILITY NAME	LOCATION	PARCEL OWNER	OWNER TYPE	YEAR BUILT	DAM HAZARD CLASS
FRANKTOWN PARKER FPM-1	UNINCORPORATED COUNTY	TENBAR INC	COUNTY	1962	LOW
FRANKTOWN PARKER FPP-1	UNINCORPORATED COUNTY	RANDY LASTAR & SARAH LASTAR	COUNTY	1963	HIGH
FRANKTOWN PARKER FPR-1	UNINCORPORATED COUNTY	INDIANOLA FARM INC	COUNTY	1964	LOW
FRANKTOWN PARKER FPR-2	UNINCORPORATED COUNTY	STEPHEN MALCOLM STRACHAN TRUST	COUNTY	1964	LOW
FRANKTOWN PARKER FPS-1	UNINCORPORATED COUNTY	DOUGLAS COUNTY BOARD OF COUNTY COMMISSIONERS	COUNTY	1963	HIGH
FRANKTOWN PARKER FPW-1	UNINCORPORATED COUNTY	LOST CANYON LLC	COUNTY	1963	LOW
GREENLAND L&C STOCKWATER	UNINCORPORATED COUNTY	HARMONY LAND AND CATTLE LLC	PRIVATE	1950	LOW
J. O. HILL	UNINCORPORATED COUNTY	WESTCREEK LAKES WATER DIST	DISTRICT	1964	SIGNIFICANT
JOE BLAKE WATER TREATMENT PLANT FOREBAY	UNINCORPORATED COUNTY	CENTENNIAL WATER & SAN DISTRICT	DISTRICT	1986	SIGNIFICANT
KIWANIS	UNINCORPORATED COUNTY	YMCA OF THE PIKES PEAK REGION INC C/O PROPERTY TAX DEPARTMENT	PRIVATE	1956	LOW
LAMBERT #3	UNINCORPORATED COUNTY	LAMBERT RANCH ASSOCIATION INC	DISTRICT	1996	LOW
LEMON GULCH	UNINCORPORATED COUNTY	LEMON GULCH LLC	PRIVATE	<NULL>	LOW
NELSON	UNINCORPORATED COUNTY	TOM BARENBERG	PRIVATE	1953	LOW
PINERY	UNINCORPORATED COUNTY	DENVER SOUTHEAST SUBURBAN WATER & SANITATION DISTRICT	DISTRICT	1970	SIGNIFICANT
PINERY #11 DETENTION POND	UNINCORPORATED COUNTY	DOUGLAS COUNTY BOARD OF COUNTY COMMISSIONERS	COUNTY	1988	LOW
PLATTE CANYON	UNINCORPORATED COUNTY	CITY & COUNTY OF DENVER BOARD OF WATER COMMISSIONERS	DISTRICT	1904	LOW
POND 14	UNINCORPORATED COUNTY	RAVENNA METRO DISTRICT	PRIVATE	2006	LOW
RAINBOW FALLS #5	UNINCORPORATED COUNTY	DOUGLAS L JAMESON & SUSAN L JAMESON & MARGARET SERVAAS	PRIVATE	1957	LOW
RUETER HESS	UNINCORPORATED COUNTY	PARKER WATER & SANITATION DISTRICT	DISTRICT	2012	HIGH
SANCTUARY POND NO. 14	UNINCORPORATED COUNTY	SANCTUARY INC C/O RUDY ZUPETZ	PRIVATE	1996	LOW
SPRING GULCH	UNINCORPORATED COUNTY	UNITED STATES OF AMERICA STATE OF COLORADO PARKS DEPT	FEDERAL	1973	SIGNIFICANT

FACILITY NAME	LOCATION	PARCEL OWNER	OWNER TYPE	YEAR BUILT	DAM HAZARD CLASS
SPRUCE MOUNTAIN	UNINCORPORATED COUNTY	SPRUCE MOUNTAIN PROPERTIES INC C/O SEMA CONSTRUCTION	PRIVATE	2002	LOW
STILLWATER	UNINCORPORATED COUNTY	CHARLES WHITESIDE	PRIVATE	1999	LOW
STRONTIA SPRINGS DAM AND RESERVOIR	UNINCORPORATED COUNTY	BETTGER CABIN TRUST	DISTRICT	<NULL>	<NULL>
W. CHERRY CREEK DET. #10	UNINCORPORATED COUNTY	DONNA J HARTMAN	COUNTY	1961	LOW
W. CHERRY CREEK DET. #11	UNINCORPORATED COUNTY	TERRY P OHLMAN	PRIVATE	1961	LOW
W. CHERRY CREEK DET. #7	UNINCORPORATED COUNTY	JAKE W THEKEN 2011 TRUST	COUNTY	1959	HIGH
W. CHERRY CREEK DET. #8	UNINCORPORATED COUNTY	CHARLES A KASTENS & CHRISTINE K KASTENS	COUNTY	1960	LOW
W. CHERRY CREEK DET. #9	UNINCORPORATED COUNTY	ROBERT LESTER COLODNY & JESSICA M COLODNY	COUNTY	1960	LOW
WAKEMAN	UNINCORPORATED COUNTY	DOUGLAS COUNTY BOARD OF COUNTY COMMISSIONERS	COUNTY	1959	LOW
WAUCONDA	UNINCORPORATED COUNTY	PERRY PARK COUNTRY CLUB INC	PRIVATE	1974	SIGNIFICANT

Source: Colorado Division of Water Resources Dam Safety Branch; Douglas County

**One Acre Foot=326,000 gallons*

Previous Occurrences and Losses

According to available records from the Douglas County 2015 HMP, State of Colorado 2018 HMP, USACE National Inventory of Dams, the Association of State Dam Officials, and the National Performance of Dams Program, there have been several dam incidents in Douglas County and one structural collapse.

Table 5-13: Dam Incidents in Douglas County, Colorado

Date	Dam Name	Description
August 3, 1933	Castlewood Canyon	The Castlewood Canyon dam failed as a result of a heavy rainfall and poor construction. The dam caused significant damage in Parker, which was an agricultural area at the time and is considered one of the worst floods in Colorado history. Two people died and nearly 5,000 people evacuated. The dam was not rebuilt and the surrounding area is a State Park.
Unknown	J.O. Hill Dam	The Dam experienced a storm which generated a 100-year rainfall event on approximately 15% of the Dam's basin. This generated a 100-year runoff event for the 56 square-mile basin.
Unknown	Stillwater Dam	Stillwater Dam experienced a crack in the spillway.
November 28, 2012	Gaynor	The Gaynor Dam experienced a previously-unobserved seepage issue beneath the outlet structure. The dam was temporarily sealed and placed under surveillance until repairs could be made.
August 8, 2013	Two Buttes	The Two Buttes Dam does not comply with the State's Dam Safety Rules. Following a period of heavy rainfall, the reservoir level rose significantly. This raised concern that the spillway could flow and overtop the dam. The EAP was activated in response.
September 18, 2013	Gaynor	The owner of the Gaynor Dam reported seepage at the piping around the outlet works. The seepage was associated with statewide flooding experienced during that month.
April 30, 2015	Two Buttes	Sand boils developed during construction at the downstream toe of the dam.
June 17, 2015	Cheesman	The Cheesman Reservoir featured a high reservoir level, resulting in the activation of the EAP.

Source: Association of State Dam Officials; Douglas County; History Colorado; National Inventory of Dams; National Performance of Dams Program; State of Colorado Hazard Mitigation Plan

Climate Change Projections

Climate change is anticipated to cause extreme precipitation events that strain dam infrastructure. With dams designed based on a river's behavior, physical attributes, and basin-wide drainage patterns, dams are very sensitive to hydrologic changes caused by climate change and can cause decreases in safety margins (State of Colorado HMP 2018). According to NOAA, models predicting future precipitation changes owing to climate change are highly variable, with outcomes ranging between a 5% decrease to a 6% increase through 2050. The lack of agreement on precipitation outcomes indicates that there is a broad range of potential outcomes regarding water resources in the State of Colorado (NOAA 2014). Earthfill dams may be vulnerable to changes in vegetation due to drought, and non-erodible dams may be at risk due to extreme temperatures causing cracking or joint movement (State of Colorado HMP 2018).

Probability of Future Occurrences

The likelihood of a dam failure in Douglas County is difficult to predict. For dams, the risk of a failure increases for each dam as the dam's age increases and/or frequency of maintenance decreases. Future climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration. Since dam overtopping are often caused by excessive rainfall, it is appropriate to relate the future vulnerability of dams directly with the potential for more intense rainfall in the County.

There has been only one structural failure of a dam in Douglas County's history, which occurred in 1933 at Castlewood Canyon. The failure resulted in the deaths of two residents and the evacuation of 5,000 people. Since 1933, there have been no dam failure incidents though some dams have experienced structural issues as reported in the previous section. The County's dam mitigation project will remove high hazard dams and is anticipated to mitigate the risk to human life from dam failures. Based on the lack of historical occurrences, the probability of a future event is considered *low* (not likely to occur in 100 years). Refer to Section 5.3 for additional information on the hazard ranking methodology and probability criteria.

Vulnerability Assessment

To understand risk, a community must evaluate assets exposed to and vulnerable to the identified hazard. The entire Douglas County is exposed and vulnerable to the dam failure hazard; therefore, all assets within the City (population, structures, critical facilities, and lifelines), as described in Section 4 (County Profile), are potentially vulnerable to a dam event. The following text evaluates and estimates the potential impact of the dam failure hazard in the County.

Impact on Life, Health and Safety

Dam failure impacts depend on several factors including severity of the event and whether or not adequate warning time is provided to residents. The population living in or near the inundation areas are considered exposed to the hazard. However, exposure should not be limited only to those who reside within a defined hazard zone, but everyone who may be affected by a hazard event (e.g., people are at risk while traveling in flooded areas, or their access to emergency services is compromised during an event); the degree of that impact varies and is not strictly measurable.

Vulnerable populations are all populations downstream from dam failures that are incapable of escaping the area within the allowable time frame. This population includes the elderly, young and individuals with disabilities, access or functional needs who may be unable to get themselves out of the inundation area. The vulnerable population also includes individuals who would not have adequate warning from the emergency warning system (e.g., television or radio); this would include residents and visitors. The population adversely affected by a dam failure may also include those beyond the disaster area that rely on the dam for providing potable water.

Floods created from a dam failure and their aftermath present numerous threats to public health and safety including exposure to unsafe food, contaminated drinking and washing water, mosquitoes, animals, mold and mildew. For more detailed descriptions of these and additional threats to public health and safety, refer to Section 5.4.6 (Flood). Current loss estimation models such as Hazus are not equipped to measure public health impacts such as these. The best preparation for these effects includes awareness that they can occur, education of the public on prevention, and planning to deal with them during responses to dam failure events.

Dam failures are severe threats to life and property in Douglas County. Areas downstream at a lower elevation are the most vulnerable to losses associated with a dam failure.

Impact on General Building Stock

Vulnerable properties are those closest to the dam inundation area. These properties would experience the largest, most destructive surge of water. Low-lying areas are also vulnerable since they are where the dam waters would collect. Transportation routes are vulnerable to dam inundation and have the potential to be wiped out, creating isolation issues. This includes all roads, railroads and bridges in the path of the dam inundation. Those that are most vulnerable are those that are already in poor condition and would not be able to withstand a large water surge. Utilities such as overhead power lines, cable and phone lines could also be vulnerable. Loss of these utilities could create additional isolation issues for the inundation areas.

Impact on Critical Facilities

Transportation routes are vulnerable to dam inundation and have the potential to be severely damaged, causing isolation for communities with limited access and significant disruption to travel, including all roads, railroads and bridges in the path of the dam inundation. Those that are most vulnerable are those that are transportation lifelines that are already in poor condition and would not be able to withstand a large water surge. Utilities such as overhead power lines, cable and phone lines in the inundation zone could also be vulnerable. If phone lines were lost, significant communication issues may occur in the planning area due to limited cell phone reception in many areas. In addition, emergency response would be hindered due to the loss of transportation routes as well as some protective-function facilities located in the inundation zone. Recovery time to restore many critical functions after an event may be lengthy, as wastewater, potable water, and other community facilities are located in the dam inundation zone.

Impact on the Economy

Dam failure events can significantly impact the local and regional economy. Similar to flooding, losses include, but are not limited to, damages to buildings and infrastructure, agricultural losses, business interruption and impacts on tax base. Flooding as a result of dam failure can cause extensive damage to public utilities and disruptions in delivery of services. Loss of power and communications may occur and drinking water and wastewater treatment facilities may be temporarily out of operation.

Impact on the Environment

The environment is vulnerable to a number of risks in the event of a dam failure. Water releases from dams usually contain very little suspended sediment; this can lead to scouring of river beds and banks. The inundation may introduce foreign elements into local waterways, resulting in destruction of downstream habitat and impacting many animal and plant species, especially endangered species. The subsequent rush of water downstream can rapidly increase flow rate and turbidity of streams and rivers in minor dam failures or overwhelm terrestrial habitat with floodwaters in severe dam failure events.

Dam failures can often result in the release of hazardous materials, either swept up in floodwaters or in sediment that is contained behind the dam as is often the case in areas that have had mining activities take place upstream. After the flood waters subside, contaminated and flood damaged building materials and contents must be properly disposed. Contaminated sediment must be removed from buildings, yards and properties.

Dam failures may result in significant water quality and debris disposal issues. Flood waters can back up sanitary sewer systems and inundate wastewater treatment plants, causing raw sewage to contaminate residential and commercial buildings and the flooding waterway. The contents of unsecured containers of oil, fertilizers, pesticides and other chemicals get added to flood waters. Water supplies and wastewater treatment could be off-line for weeks. After the flood waters subside, contaminated and flood damaged building materials and contents must be disposed of properly.

Future Changes that May Impact Vulnerability

Understanding future changes that effect vulnerability in the County can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change

Projected Development

Any areas of growth could be potentially impacted by the dam failure hazard because the entire County is exposed and vulnerable. Areas downstream at a lower elevation are the most vulnerable to losses associated with a dam failure; therefore, any development downstream from dams will be more susceptible to dam failure impacts.

Projected Changes in Population

The County has experienced an increase in population between the 2010 Census (285,465) and the estimated 2018 American Community Survey estimated population of 328,614. The population of the County is expected to increase over the next few years. The increase in population will expose more people to the dam failure hazard.

Climate Change

An increasing average annual temperature will directly impact the atmospheric moisture potential. The probability of expanding atmospheric moisture leads to an increasing amount of rainfall during storm events. The increased potential volume of rainfall will directly lead to an increasing pressure placed on dam systems during future riverine flood events. Additionally, the aging dams increase the possibility of dam failure and the risk of catastrophic flooding inside dam inundation zones. Finally, increased drought conditions and changes in vegetation, along with more frequent fluctuations in water levels, may cause erosion along embankments. This will make earthfill dams more vulnerable (State of Colorado HMP 2018).

Change of Vulnerability Since the 2015 HMP

Douglas County's population increased since the last plan; increasing the number of people vulnerable during a dam failure event. Though there is a relatively small number of people living in the shadow of the dam, an increasing population means that the overall impacts to County residents will increase. The County's ongoing mitigation project will continue to reduce the vulnerability to the hazard.

Identified Issues

Important issues associated with dam failures in Douglas County include the following:

- The County is actively mitigating existing high hazard dams. The dams will be converted and de-certified, resulting in the removal of all high hazard dams currently in the County.
- Dam failures can occur from periods of heavy rain, flooding, earthquakes, and landslides.
- Dam infrastructure may require repair and improvement to withstand climate change impacts, such as changing in the timing and intensity of rain events.

5.4.3 Drought

This section provides a hazard profile and vulnerability assessment of the drought hazard for Douglas County.

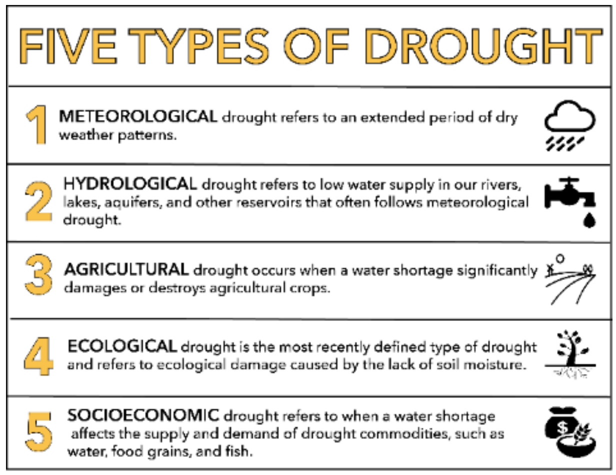
Hazard Profile

This section presents information regarding the description, extent, location, previous occurrences and losses, climate change projections and probability of future occurrences for the drought hazard.

Description

Drought is defined as the consequence of a natural reduction in the average amount of precipitation expected over an extended period of time, usually over a period of multiple years (State of Colorado HMP 2018). Drought conditions occur in virtually all climatic zones. Drought characteristics vary significantly from one region to another and are relative to the normal precipitation in that region. Drought can increase wildfire/brush fire risk and can affect agriculture, water supply, aquatic ecology, wildlife, and plant life. There are five classifications of drought, as presented in Figure 5-2

Figure 5-2: Types of Drought



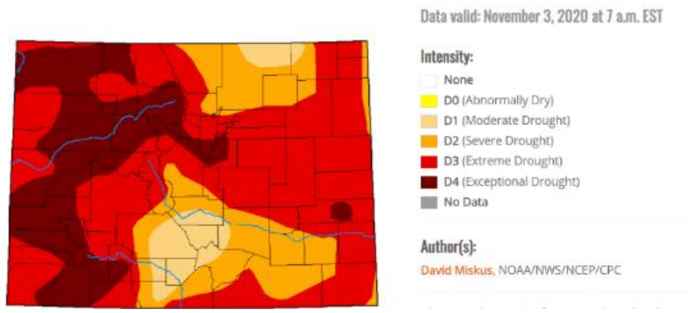
Source: University of Nevada Cooperative Extension 2020

Extent

The severity of a drought depends on the degree of moisture deficiency, the duration of the event, and the size and location of the affected area. The longer the duration of the drought and the larger the area impacted, the more severe the potential impacts. Douglas County has the potential to experience the entire range of effects, from extreme drought to extremely moist conditions, as described in the Palmer Drought Severity Index (PDSI).

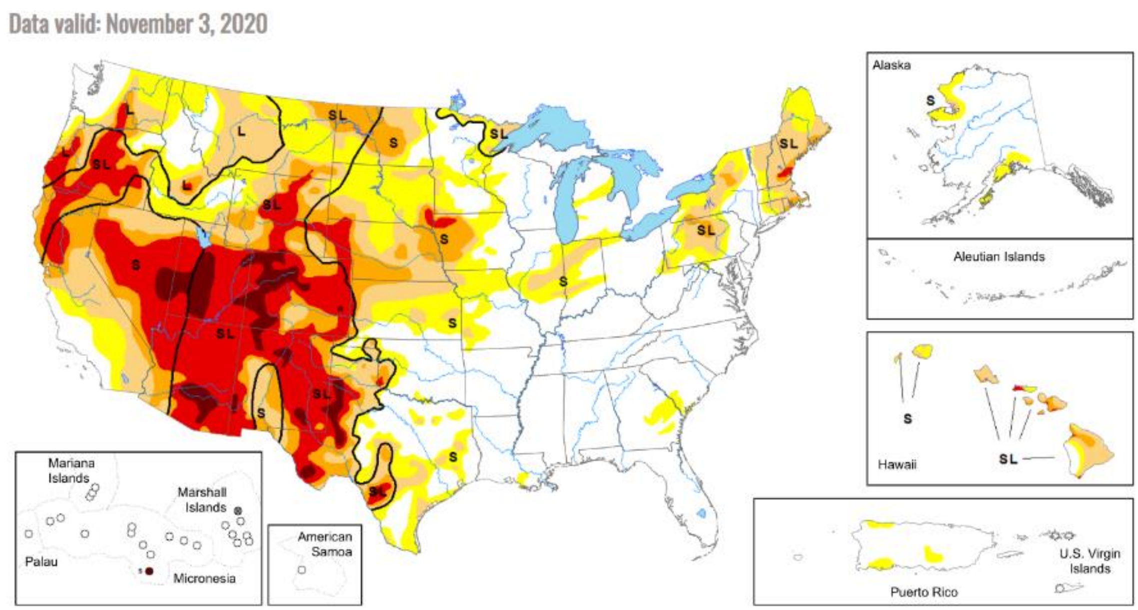
U.S. Drought Monitor

Figure 5-3 Drought Map for November 3, 2020



The U.S. Drought Monitor (USDM) is a map that shows the location and intensity of drought across the United States. The data is updated every Tuesday and the map is released on Thursdays. The USDM uses a five-category system, labeled Abnormally Dry or D0, (a precursor to drought, not actually drought), and Moderate (D1), Severe (D2), Extreme (D3) and Exceptional (D4) Drought. Drought categories show experts' assessments of conditions related to dryness and drought including observations of how much water is available in streams, lakes, and soils compared to usual for the same time of year. USDM data goes back to 2000 (National Integrated Drought Information System 2020). Figure 5-4 shows the USDM for November 3, 2020. The figure shows that Douglas County was in a period of Exceptional Drought (D4) in the western portion of the County and Extreme Drought (D3) in the eastern portion of the County.

Figure 5-4. U.S. Drought Monitor for November 3, 2020



Palmer Drought Severity Index

The Palmer Drought Severity Index (PDSI) is primarily based on soil conditions. Soil with decreased moisture content is the first indicator of an overall moisture deficit. Table 5-14 lists the PDSI classifications. At the one end of the spectrum, 0 is used as normal and drought is indicated by negative numbers. For example, -2 is moderate drought, -3 is severe drought, and -4 is extreme drought. The PDSI can reflect excess precipitation using positive numbers; however, this is not shown in Table 5-14. The PDSI is commonly converted to the Palmer Drought Category (National Drought Mitigation Center [NDMC] 2013).

Table 5-14. Palmer Drought Category and Palmer Drought Index Descriptions

Category	Description	Possible Impacts (for Colorado)	Palmer Drought Index
D0	Abnormally Dry	• Producers begin supplemental feeding for livestock • Planting is postponed; forage germination is stunted; hay cutting is reduced • Grass fires increase • Surface water levels decline	-1.0 to -1.99
D1	Moderate drought	• Dryland crops are stunted • Early cattle sales begin • Wildfire frequency increases • Stock tanks, creeks, streams are low; voluntary water restrictions are requested	-2.0 to -2.99
D2	Severe drought	• Pasture conditions are very poor • Soil is hard, hindering planting; crop yields decrease • Wildfire danger is severe; burn bans are implemented • Wildlife moves into populated areas • Hydroelectric power is compromised; well water use increases; mandatory water restrictions are implemented	-3.0 to -3.99
D3	Extreme drought	• Soil has large cracks; soil moisture is very low; dust and sandstorms occur • Row and forage crops fail to germinate; decreased yields for irrigated crops and very large yield reduction for dryland crops are reported • Need for supplemental feed, nutrients, protein, and water for livestock increases; herds are sold • Increased risk of large wildfires is noted • Many sectors experience financial burden • Severe fish, plant, and wildlife loss reported • Water sanitation is a concern; reservoir levels drop significantly; surface water is nearly dry; river flow is very low; salinity increases in bays and estuaries	-4.0 to -4.99
D4	Exceptional drought	• Exceptional and widespread crop loss is reported; rangeland is dead; producers are not planting fields • Culling continues; producers wean calves early and liquidate herds due to importation of hay and water expenses • Seafood, forestry, tourism, and agriculture sectors report significant financial loss • Extreme sensitivity to fire danger; firework restrictions are implemented • Widespread tree mortality is reported; most wildlife species' health and population are suffering • Devastating algae blooms occur; water quality is very poor • Exceptional water shortages are noted across surface water sources; water table is declining • Boat ramps are closed; obstacles are exposed in water bodies; water levels are at or near historic lows	-5.0 or less

Source: NDMC 2013 and 2020

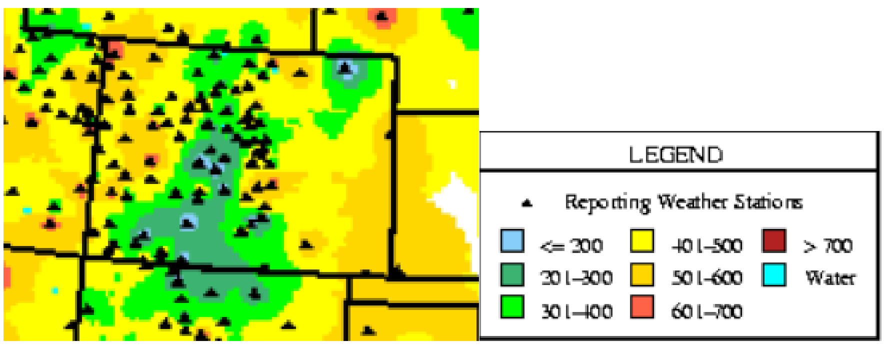
Keetch-Byram Drought Index (KBDI)

KBDI Value	Description
0 to 200	Soil moisture and large class fuel moistures are high and do not contribute much to fire intensity. Typical of spring dormant season following winter precipitation
200 to 400	Typical of late spring, early growing season. Lower litter and duff layers are

	drying and beginning to contribute to fire intensity
400 to 600	Typical of late summer, early fall. Lower litter and duff layers actively contribute to fire intensity and will burn actively.
600 to 800	Often associated with more severe drought with increased wildfire occurrence. Intense, deep burning fires with significant downwind spotting can be expected. Live fuels can also be expected to burn actively at these levels.

The KBDI is an index used in determining forest fire potential. The drought index is based on a daily water balance, where a drought factor is balanced with precipitation and soil moisture (assumed to have a maximum storage capacity of eight-inches) and is expressed in hundredths of an inch of soil moisture depletion. The index ranges from 0 to 800, where a drought index of 0 represents no moisture depletion, while an index of 800 represents absolutely dry conditions (Wildland Fire Assessment System 2020). This index is derived from weather station latitude, maximum dry bulb temperature, mean annual precipitation, and the previous 24 hours of rainfall. Figure 5-5 shows the KBDI for Douglas County for November 9, 2020. The figure shows KBDI value of 200-300 for Douglas County.

Figure 5-5. KBDI for the State of Colorado, November 9, 2020



Location

A drought occurs on a regional scale; therefore, all of Douglas County is vulnerable and at risk. Droughts can occur at any time and have the potential to impact every person directly or indirectly in the County, as well as the local economy.

Previous Occurrences and Losses

Between 1953 and 2020, there was one Federal Emergency Management Agency (FEMA)-declared major disaster (DR) or emergency (EM) in the State of Colorado. Generally, drought-related disasters affect a wide region of the state and can impact many counties. Douglas County was included in the disaster declaration.

Table 5-15 FEMA Disaster Declarations for Douglas County

Designation Number	Incident Date(s)	Description of Disaster
EM-3025	January 29, 1977	Drought

The U.S. Department of Agriculture (USDA) keeps records of agricultural disasters. Between 2013 and 2020, Douglas County was included in eight declarations related to drought. Crop losses due to drought in Douglas County were reported in 2018.

Table 5-16. USDA Disaster Declarations for Douglas County, CO between 2013 and 2020

Designation Number	Begin Date	End Date	Description of Disaster	Damages
S3627	11/1/2013	12/26/2013	Drought	N/A
S4145	11/15/2016	N/A	Drought	N/A
S4331	4/3/2018	N/A	Drought	N/A
S4334	4/10/2018	N/A	Drought	N/A
S4468	11/1/2018	N/A	Drought	N/A
S4703	6/16/2020	N/A	Drought	N/A
S4798	7/21/2020	N/A	Drought	N/A
S4848	8/25/2020	N/A	Drought	N/A

Source: USDA Risk Management Agency 2020; USDA Farm Service Agency 2020

Based on available historical records, Douglas County has experienced to drought events, of all magnitudes. Table 5-11 lists known drought events between 2014 and 2020 that have occurred in Douglas County, as reported by NCEI, USDA, and U.S. Drought Monitor. Historical drought information shows drought activity across the County.

Table 5-17. Drought Events in Douglas County, CO between 2014 and 2020

Dates of Event	Duration	Event Details*
September 27, 2016--May 9, 2017	32 weeks/7.5 months	Nearly all of Douglas County was impacted by Moderate Drought conditions. In mid-March through early April 2017, portions of the County experienced a Severe Drought.
January 9, 2018 – August 14, 2018	31 weeks/7 months	Moderate Drought conditions
January 8, 2019 – March 12, 2019	9 weeks/2 months	Moderate Drought conditions
October 1, 2019 – November 5, 2019	5 weeks/1 month	Moderate Drought conditions for up to 10% of County residents.
May 19, 2020 – Present	26 weeks/6 months	A severe drought persisted from September 2020 through early October and impacted up to 41% of the County's population. In October, the drought was classified as an exceptional drought. As of January 12, 2021, more than half of the County is in exceptional drought conditions.

Sources: USDA 2020; U.S. Drought Monitor 2020

* *Many sources were consulted to provide an update of previous occurrences and losses; event details and loss/impact information may vary and has been summarized in the above table.*

Climate Change Projections

Climate is defined not simply as average temperature and precipitation but also by the type, frequency and intensity of weather events. Both globally and at the local scale, climate change has the potential to alter the prevalence and severity of extremes such as droughts. While predicting changes of drought events under a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating future climate change impacts on human health, society and the environment (U.S. Environmental Protection Agency [EPA], 2006).

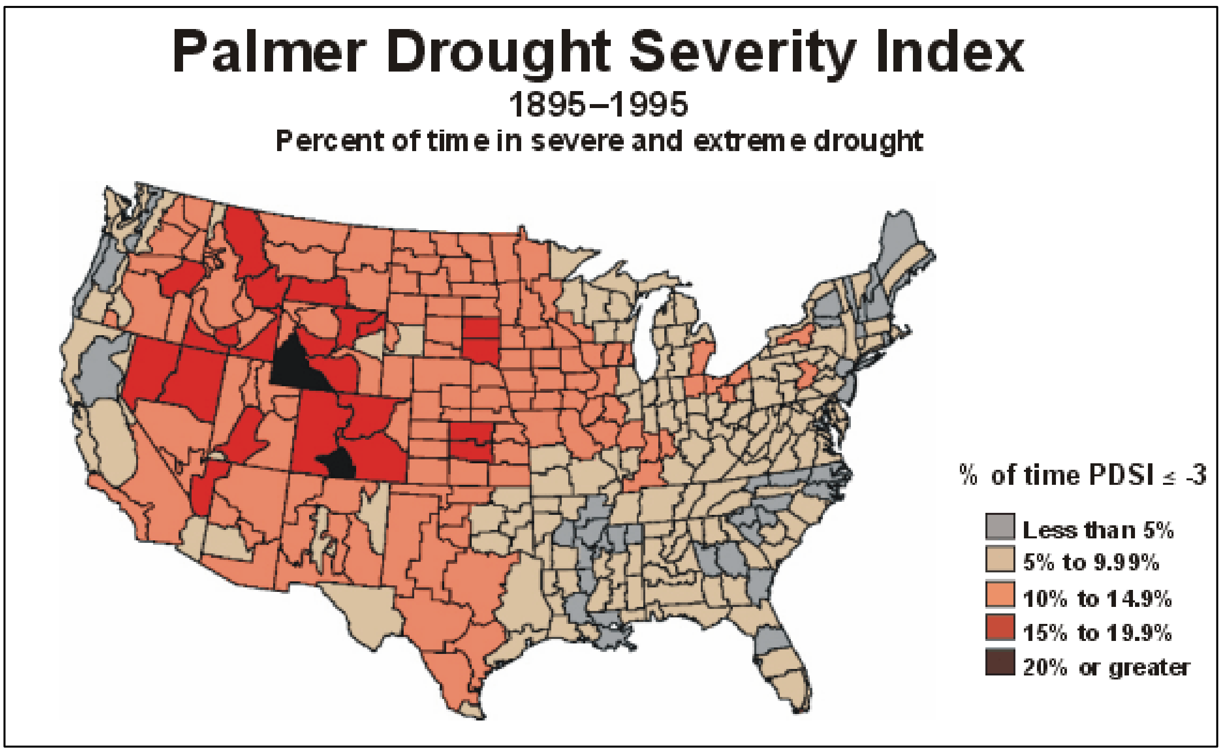
In Colorado, predictions for future precipitation change are divergent. Projections under different emissions scenarios show annual changes between -5% and +6% by 2050 under RCP 4.5m and between -3% and +8% under RCP 8.5 by 2050. Projections also anticipate increased winter precipitation by 2050, but less precipitation falling during the May-September growing season. Projections indicate that average annual streamflow for most Colorado river basins will decrease by up to 30% due to the impacts of warmer temperatures upon streamflow. However, some projections show increases in precipitations that may compensate for the impact of warming and thus lead to an increase of runoff. It is anticipated that droughts in the future will have more significant impacts than historic droughts due to lower streamflows resulting from warmer temperatures. Increasing temperatures will also cause winter precipitation to fall as rain rather than snow and decrease overall snowpack. This will affect water availability and seasonality.

With a warmer climate, droughts can become more frequent, more severe, and longer-lasting. According to the National Climate Assessment, variable precipitation and rising temperatures are intensifying droughts, increasing heavy downpours, reducing snowpack, and causing declines in water survey quality. Future warming will add to the stress on water supplies and impact the availability of water supply (U.S. Global Change Research Program 2018).

Probability of Future Occurrences

The frequency of droughts is difficult to forecast as drought occurrences are cyclical in nature and will occur in the future. Based on national annual data from 1895 to 1995, Douglas County underwent severe or extreme conditions approximately 15 to 19.9% of the time (illustrated in Figure 5-6).

Figure 5-6 Palmer Drought Severity Index (1895 to 1995)



Source: National Drought Mitigation Center 2020

For the 2021 HMP update, the most up-to-date data was collected to calculate the probability of future occurrence of drought events, of all magnitudes, for Douglas County. Information from NOAA-NCEI storm events database, the 2018 State of Colorado HMP, the 2015 Douglas County HMP, and the Drought Monitor were used to identify the number of drought events that occurred between 2000 and 2020. Using these sources ensures the most accurate probability estimates possible. Table 5-18 presents the probability of future occurrence of drought events in Douglas County.

Table 5-18. Probability of Future Drought Events in Douglas County

Hazard Type	Number of Occurrences Between 2000 and 2020	Percent chance of occurrence in any given year
Drought	15	71%

Sources: NOAA NCEI 2020, State of Colorado 2018, Douglas County 2015, Drought Monitor
Note: Occurrences include all calendar years for which a portion of the County was designated D2 (Moderate Drought).

Based on the 15 recorded drought events over 20 years, Douglas County typically experiences a drought in a given year. Some drought events have lasted multiple years. A drought event has a 71% chance of occurring in any given year in Douglas County. Based on the history of events and input from the Core Planning Team, the probability for drought occurring in the County is considered *frequent* (hazard event is likely to occur within 25 year). Refer to Sections 5.1 and 5.3 for additional information on the hazard ranking methodology and probability criteria.

Vulnerability Assessment

To understand risk, a community must evaluate assets exposed to and vulnerable to the identified hazard. The entire Douglas County is exposed to the drought hazard; therefore, all assets within the County (population, structures, critical facilities, and lifelines), as described in Section 4 (County Profile), are potentially vulnerable to a drought event. The following text evaluates and estimates the potential impact of the drought hazard in the County.

Impact on Life, Health, and Safety

The entire population of Douglas County is vulnerable to drought events (2018 American Community Survey 5-Year Estimate: 328,614 people). Drought conditions can affect public health and safety, including reduced local firefighting capabilities, health problems related to low water flows and poor water quality, and health problems related to dust. If droughts are severe enough, these health problems can lead to loss of human life.

Other possible impacts include recreational risks; effects on air quality; diminished living conditions related to energy, air quality, and sanitation and hygiene; compromised food and nutrition; and increased incidence of illness and disease. Due to their age, health conditions, and limited ability to mobilize to shelters, cooling, and medical resources, the infirm, young, and elderly are particularly susceptible to drought and extreme temperatures, sometimes associated with drought conditions. Some drought-related health effects are short term, while others can be long term (CDC 2012).

Impact on General Building Stock

A drought event is not expected to directly affect any structures; however, a secondary hazard most commonly associated with drought is wildfire. Prolonged lack of precipitation dries out vegetation, which becomes increasingly susceptible to ignition as the duration of the drought extends. Though some structures can become vulnerable to wildfire that are within or near the wildfire urban interface, this is more likely following long periods of drought. Refer to Section 5.4.17 of the HMP for additional discussion of the wildfire hazard in Douglas County.

Impact on Critical Facilities

Water supply facilities may be affected by drought events. However, a majority of the critical facilities defined for this plan will continue to be operational during a drought.

Impact on the Economy

Drought causes the most significant economic impacts on industries that use water or depend on water for their business, most notably agriculture and related sectors (forestry, fisheries, and waterborne activities), power plants, and oil refineries. In addition to losses in yields in crop and livestock production, drought is associated with increased insect infestations, plant diseases, and wind erosion. Drought can lead to other losses because so many sectors are affected—losses that include reduced income for farmers and reduced business for retailers and others who provide goods and services to farmers. This leads to unemployment, increased credit risk for financial institutions, capital shortfalls, and loss of tax revenue. Prices for food, energy, and other products may also increase as supplies decrease.

Future Changes that May Impact Vulnerability

Understanding future changes that impact vulnerability in the County can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development.
- Projected changes in population.
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development

Any areas of growth could be potentially impacted by the drought hazard because the entire County is exposed and vulnerable to droughts. Future growth and development could impact the amount of potable water available due to a drain on the available water resources. An increased drain on water resources would not only impact the county's population, but it would also exacerbate impacts to other areas of the county as discussed above, including agriculture and recreational facilities.

Projected Changes in Population

The County has experienced an increase in population between the 2010 Census (285, 465) and the estimated 2018 American Community Survey estimated population of 328,614. The population of the County is expected to increase over the next few years. With an increase in population, the demand for water supply will increase. During a drought, the amount of water needed might not be available. This might require reallocation of water resources to meet demands during a drought. If needed, the County can pass special ordinances regulating the amount of water consumed and used during periods of drought to conserve water.

Climate Change

As discussed earlier, climate change has the potential to impact the number of and the severity of droughts. In Colorado, the variability of precipitation changes and the nature of precipitation changes poses a serious threat for Douglas County. An increased incidence of drought might impact availability of water supplies, primarily placing an increased stress on the population. It is unlikely that structure exposure and vulnerability would increase as a direct result of drought, although secondary impacts of drought, such as wildfire, could increase and threaten structures. If a wildfire were to occur during a drought, emergency services might face complications from a water shortage depending on their water source, and critical water-related service sectors might need to adjust management practices and actively manage resources. Increased incidence of drought increases the potential for impacts on the local economy, including the production of agricultural products.

Change of Vulnerability since the 2015 HMP

The 2015 HMP provided a summary of historic loss information and qualitative assessment for the drought hazard. For this HMP Update, a qualitative assessment was conducted for population, buildings and critical facilities. According to the U.S. Census Bureau 2018 Population Estimates, the population of Douglas County has increased since the 2010 Census; therefore, the number of people exposed to the drought hazard has increased. Overall, the County will continue to be exposed and vulnerable to drought events.

Issues Identified

The following have been identified as drought-related issues:

- The County's agricultural economy may face continued losses due to drought.
- The probability of drought frequencies and durations may increase due to climate change.
- The promotion of active water conservation even during non-drought periods should be encouraged.
- With the possibility of climate change, drought may become a larger issue due to warming trends and wider fluctuations in rainfall patterns that reduce snowpack.

5.4.4 Earthquake

This section provides a profile and vulnerability assessment for the earthquake hazard for Douglas County.

Hazard Profile

Description

An earthquake is the sudden movement of the Earth's surface caused by the release of stress accumulated within or along the edge of the Earth's tectonic plates, a volcanic eruption, or by a manmade explosion (Federal Emergency Management Agency [FEMA] 2001, Shedlock and Pakiser 1995). Most earthquakes occur at the boundaries where the Earth's tectonic plates meet (faults); less than 10 percent of earthquakes occur within plate interiors. As plates continue to move and plate boundaries change geologically over time, weakened boundary regions become part of the interiors of the plates. These zones of weakness within the continents can cause earthquakes in response to stresses that originate at the edges of the plate or in the deeper crust (Shedlock and Pakiser 1995).

The location of an earthquake is commonly described by its focal depth and the geographic position of its epicenter. Focal depth of an earthquake is depth from earth's surface to the region where an earthquake's energy originates (the focus or hypocenter). The epicenter of an earthquake is the point on the earth's surface directly above the hypocenter (Shedlock and Pakiser 1997). Earthquakes usually occur without warning, and their effects can impact areas a great distance from the epicenter (FEMA 2001).

According to the U.S. Geological Society (USGS) Earthquake Hazards Program, an earthquake hazard is any disruption associated with an earthquake that may affect residents' normal activities. This includes surface faulting, ground shaking, landslides, liquefaction, tectonic deformation, tsunamis, and seiches; each of these terms is defined below:

- *Surface faulting*: Displacement that reaches the earth's surface during a slip along a fault. Commonly occurs with shallow earthquakes—those with an epicenter less than 20 kilometers.
- *Ground motion (shaking):* The movement of the earth's surface from earthquakes or explosions. Ground motion or shaking is produced by waves that are generated by a sudden slip on a fault or sudden pressure at the explosive source and travel through the Earth and along its surface.
- *Landslide*: A movement of surface material down a slope.
- *Liquefaction*: A process by which water-saturated sediment temporarily loses strength and acts as a fluid, like the wet sand near the water at the beach. Earthquake shaking can cause this effect. Liquefaction susceptibility is determined by the geological history, depositional setting, and topographic position of the soil. Liquefaction effects may occur along the shorelines of the ocean, rivers, and lakes and they can also happen in low-lying areas away from water bodies in locations where the ground water is near the earth's surface.
- *Tectonic Deformation*: A change in the original shape of a material caused by stress and strain.
- *Tsunami*: A sea wave of local or distant origin that results from large-scale seafloor displacements associated with large earthquakes, major sub-marine slides, or exploding volcanic islands.
- *Seiche*: The sloshing of a closed body of water, such as a lake or bay, from earthquake shaking (USGS 2012).

Extent

An earthquake's magnitude and intensity are used to describe the size and severity of the event. Magnitude describes the size at the focus of an earthquake and intensity describes the overall felt severity of shaking during the event. The earthquake's magnitude is a measure of the energy released at the source of the earthquake. Magnitude was formerly expressed by ratings on the Richter scale but is now most commonly expressed using the moment magnitude (Mw) scale. This scale is based on the total moment release of the earthquake (the product of the distance a fault moved, and the force required to move it). The scale is as follows:

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

The most commonly used intensity scale is the modified Mercalli intensity scale. Ratings of the scale, as well as the perceived shaking and damage potential for structures, are shown in Table 5-19 The modified Mercalli intensity scale is generally represented visually using shake maps, which show the expected ground shaking at any given location produced by an earthquake with a specified magnitude and epicenter. An earthquake has only one magnitude and one epicenter, but it produces a range of ground shaking at sites throughout the region. This shaking depends on the distance from the earthquake, the rock and soil conditions at sites, and variations in the propagation of seismic waves from the earthquake due to complexities in the structure of the earth's crust. A USGS shake map shows the variation of ground shaking in a region immediately following significant earthquakes. Table 5-19 displays the MMI scale and its relationship to the areas peak ground acceleration.

Table 5-19 Modified Mercalli Intensity Scale

Mercalli Intensity	Shaking	Description
I	Not Felt	Not felt except by a very few under especially favorable conditions.
II	Weak	Felt only by a few persons at rest, especially on upper floors of buildings.
III	Weak	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV	Light	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Moderate	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Strong	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Very Strong	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Severe	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Violent	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Extreme	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

Source: USGS 2016c

Table 5-20. Modified Mercalli Intensity and PGA Equivalents

Modified Mercalli Intensity	Acceleration (%g) (PGA)	Perceived Shaking	Potential Damage
I	< 0.17	Not Felt	None
II	0.17–1.4	Weak	None
III	0.17–1.4	Weak	None
IV	1.4–3.9	Light	None
V	3.9–9.2	Moderate	Very Light
VI	9.2–18	Strong	Light
VII	18–34	Very Strong	Moderate
VIII	34–65	Severe	Moderate to Heavy
IX	65–124	Violent	Heavy
X	>124	Extreme	Very Heavy

Source: Freeman et al. (Purdue University) 2004
Note: PGA Peak Ground Acceleration

The ground experiences acceleration as it shakes during an earthquake. The peak ground acceleration (PGA) is a measure of how hard the earth shakes in a given geographic area. It is expressed as a percentage of the acceleration due to gravity (percent g). Horizontal and vertical PGA varies with soil or rock type. Earthquake hazard assessment involves estimating the annual probability that certain ground accelerations will be exceeded, and then summing the annual probabilities over a period of interest. Damage levels experienced in an earthquake vary with the intensity of ground shaking and with the seismic capacity of structures, as noted in Table 5-21.

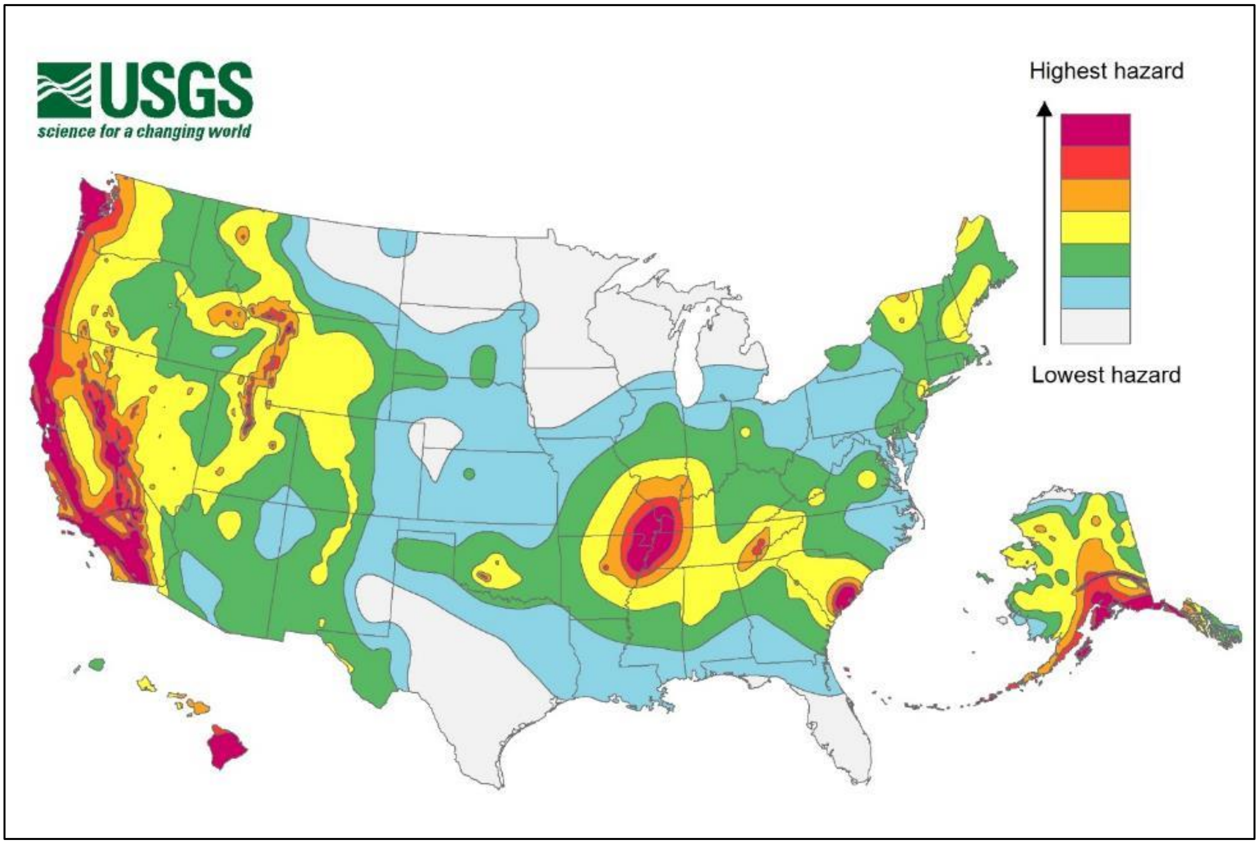
Table 5-21. Damage Levels Experienced in Earthquakes

Ground Motion Percentage	Explanation of Damages
1-2%g	Motions are widely felt by people; hanging plants and lamps swing strongly, but damage levels, if any, are usually very low.
Below 10%g	Usually causes only slight damage, except in unusually vulnerable facilities.
10 - 20%g	May cause minor-to-moderate damage in well-designed buildings, with higher levels of damage in poorly designed buildings. At this level of ground shaking, only unusually poor buildings would be subject to potential collapse.
20 - 50%g	May cause significant damage in some modern buildings and very high levels of damage (including collapse) in poorly designed buildings.
≥50%g	May causes higher levels of damage in many buildings, even those designed to resist seismic forces.

Source: NJOEM 2014
Note: %g Peak Ground Acceleration

National maps of earthquake shaking hazards provide information for creating and updating seismic design requirements for building codes, insurance rate structures, earthquake loss studies, retrofit priorities, and land use planning. After thorough review of the studies, professional organizations of engineers update the seismic-risk maps and seismic design requirements contained in building codes (Brown et al. 2001). The USGS updated the National Seismic Hazard Maps in 2018. New seismic, geologic, and geodetic information on earthquake rates and associated ground shaking were incorporated into these revised maps. The 2018 map represents the best available data, as determined by the USGS (see Figure 5-7). The figure shows that Douglas County has a moderate earthquake hazard relative to the Country.

Figure 5-7. Peak Ground Accelerations Map, 2% PGA in 50 Years



Source: USGS 2020

The Hazus earthquake model was run for two mean return period (MRP) events in Douglas County to provide a range of potential scenarios and associated impacts—the 500-year MRP event and the 2,500-year MRP event. Figure 5-8 and Figure 5-9 illustrate geographic distributions of the Modified Mercalli Scale based on PGAs (*g*) across Douglas County at the census-tract level for these two events. A 500-year MRP event is an earthquake with a 0.4 percent chance that mapped ground motion levels (PGA) will be exceeded in any given year. Douglas County is estimated to experience not felt shaking during a 500-year event. A 2,500-year MRP is an earthquake with 0.1 percent chance that mapped PGAs will be exceeded in any given year. Hazus estimates Douglas County will experience not felt and weak shaking during the 2,500-year event with moderate shaking and light damage.

Figure 5-8 Peak Ground Acceleration 500-Year Mean Return Period for Douglas County

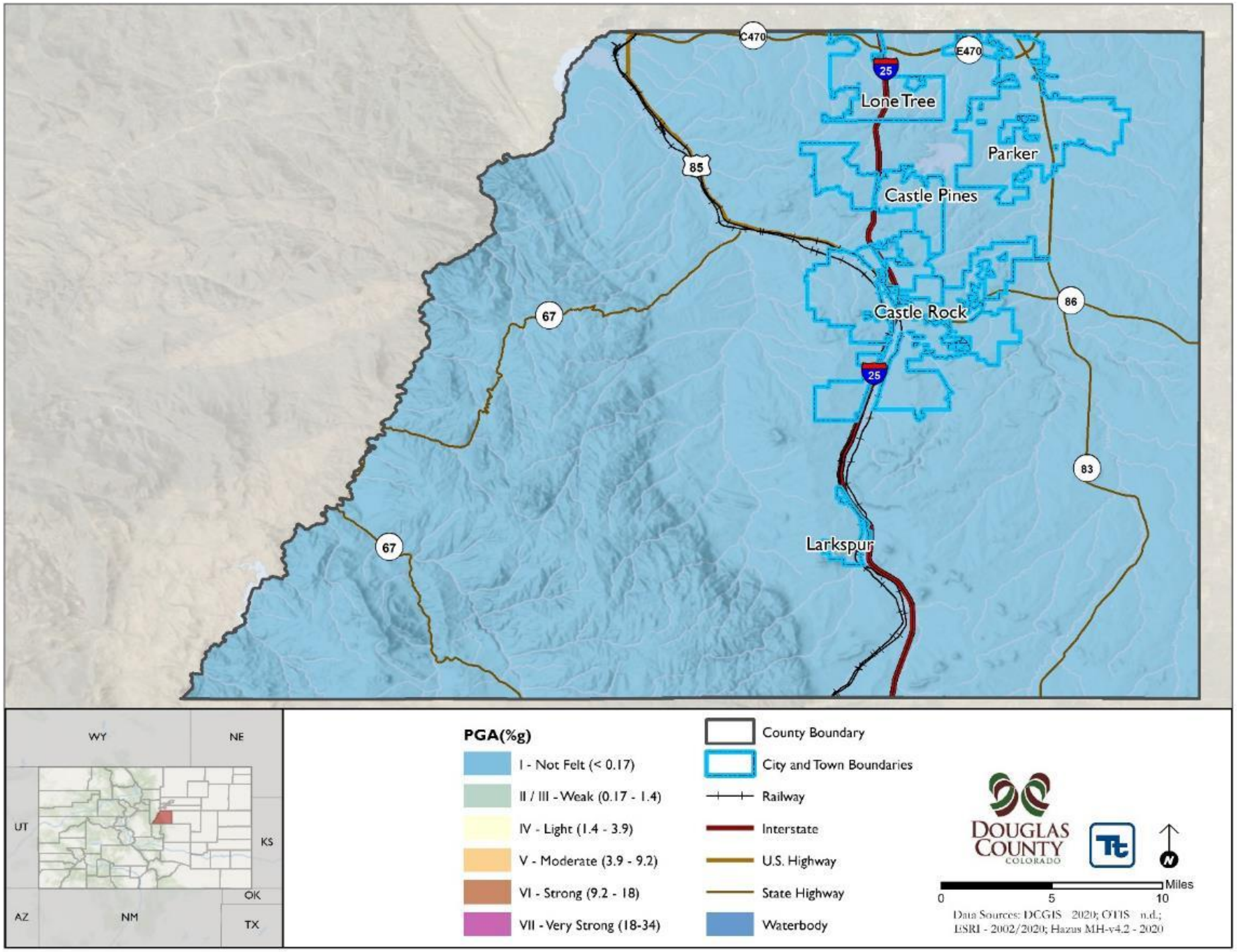
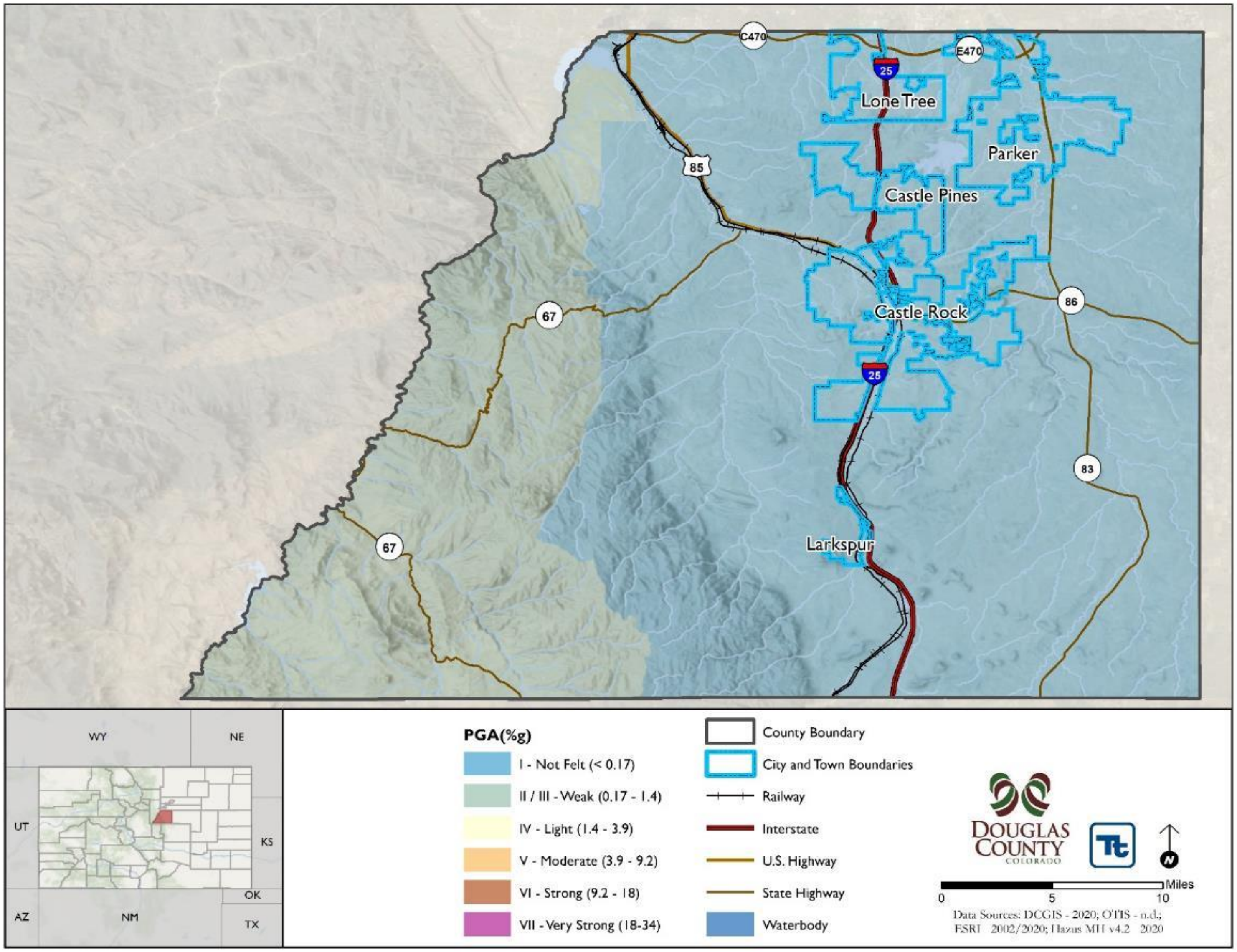


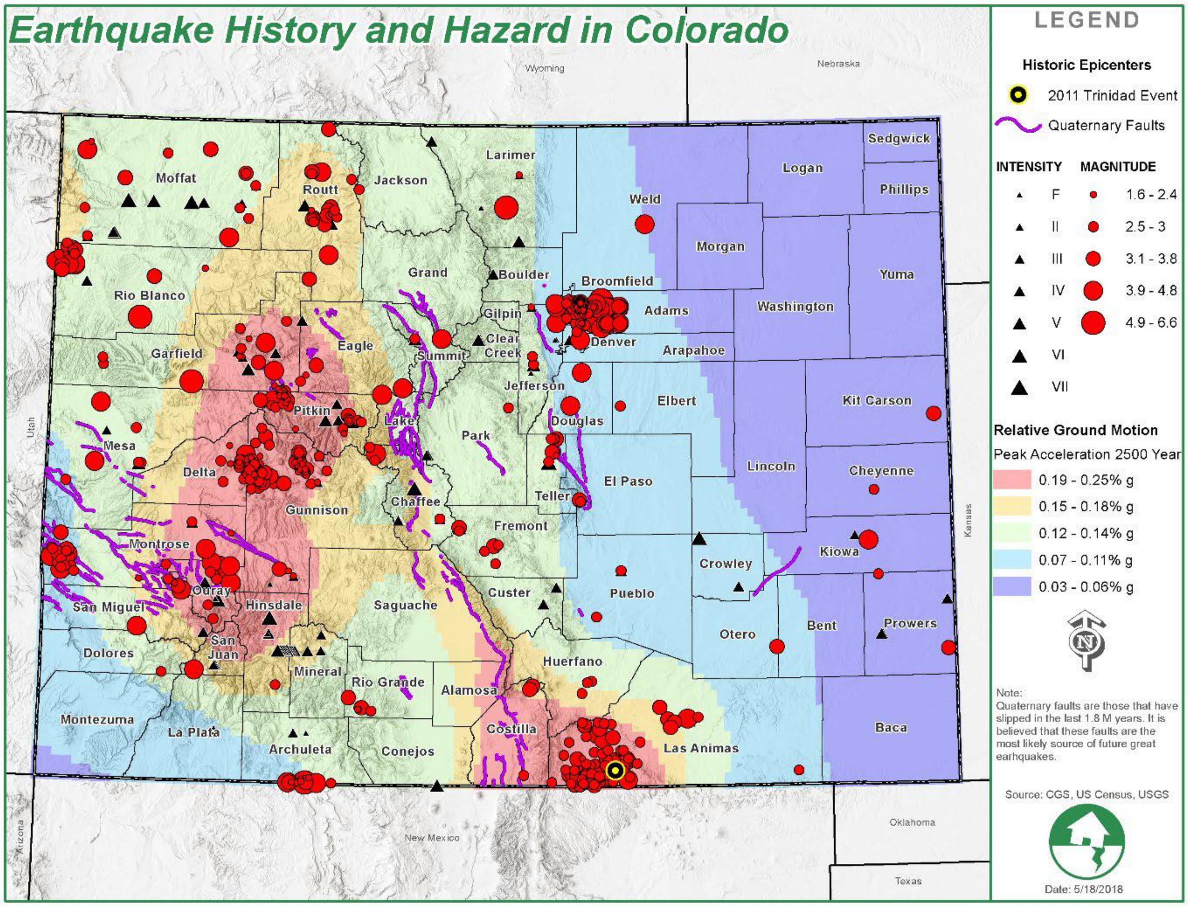
Figure 5-9 Peak Ground Acceleration 2,500-Year Mean Return Period for Douglas County



Location

In Colorado, the regions at greatest risk to earthquakes are in the western section of the State. However, earthquake hotspots exist throughout the State. Douglas County is located in central Colorado, where there has been relatively less earthquake activity and occurrences are rare. Some earthquake clusters are induced by human activities, such as fossil fuel extractions or underground injections.

Figure 5-10. Earthquake History in Colorado



Source: State of Colorado HMP

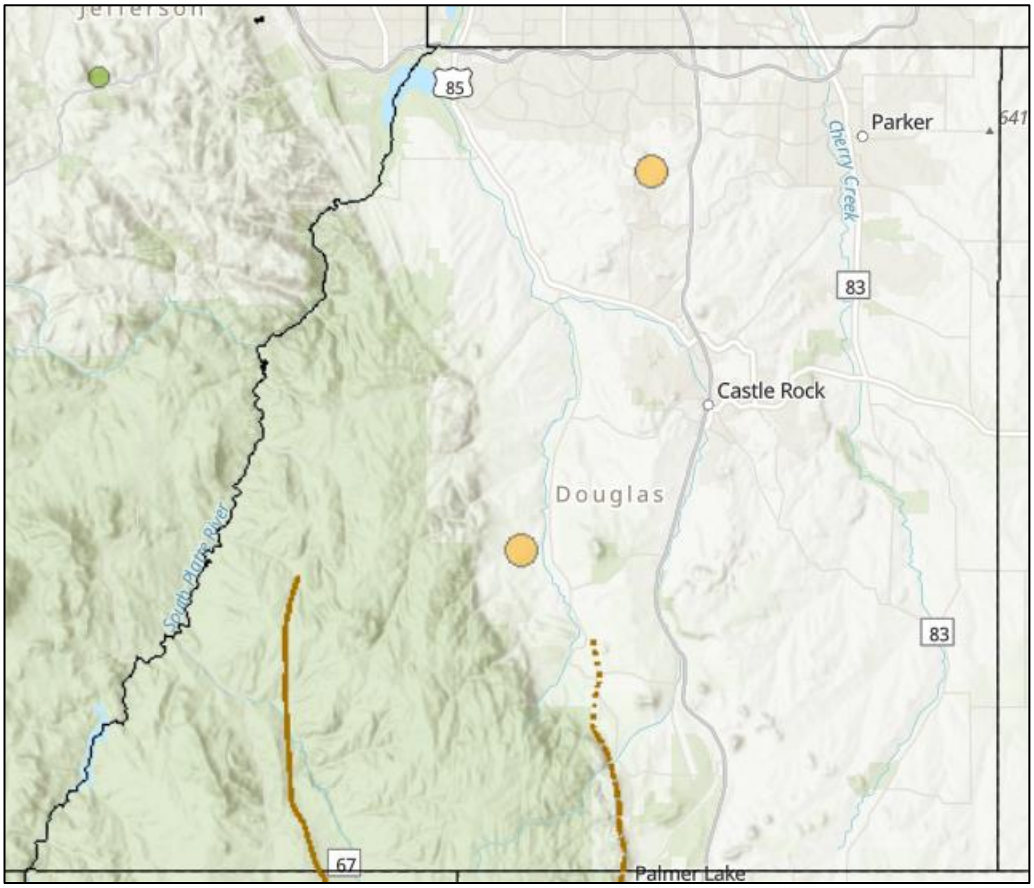
In Douglas County, the Rampart fault and the Ute fault are of concern. According to the US Geological Survey, the Rampart Range fault forms the east flank of the Rampart Range between Larkspur and Colorado Springs (USGS 1997).

The Advanced National Seismic System (ANSS) is run by USGS. When earthquakes strike, ANSS delivers real-time information, providing situational awareness for emergency-response personnel. In regions with sufficient seismic stations, that information includes –within minutes–a ShakeMap showing the distribution of potentially damaging ground shaking, information used to target post-earthquake response efforts. ANSS stations are situated in two locations in the State of Colorado, with one located just northwest of Douglas County in Idaho Springs (USGS 2020).

Previous Occurrences and Losses

According to the US Geological Survey and Colorado Geological Survey, there have been two earthquakes recorded in Douglas County. Figure 5-11 shows the earthquake history in Douglas County.

Figure 5-11: Earthquakes in Douglas County



Source: Colorado School of Mines

Douglas County has experienced two earthquakes since 1900. On September 9th, 1965 a M 4.8 earthquake was recorded with an epicenter located between Wildcat Mountain and Coyote Ridge Park in Castle Pines (Colorado School of Mines 2020). On Christmas Day in 1994, another earthquake occurred and was recorded at a magnitude of M 4.0. The earthquake's epicenter was located six miles northeast of Larkspur in a sparsely-populated portion of Unincorporated Douglas County. The 1994 earthquake did not result in major damage (NWS 2018). No damage records for the 1965 earthquake were found as part of the HMP update.

It has been hypothesized that the 1965 earthquake – alongside a number of earthquakes observed in the Denver area during that time – was caused due to injection of chemical-waste fluids into an underground reservoir at the Rocky Mountain Arsenal approximately 23 miles to the northeast (Healy et al., 1968).

Climate Change Projections

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

Secondary impacts of earthquakes could be magnified by climate change. Soils saturated by repetitive storms could experience liquefaction during seismic activity due to the increased saturation. Dams storing increased volumes of water due to changes in the hydrograph could fail during seismic events. There are currently no models available to estimate these impacts.

Probability of Future Events

Two reports of earthquakes have been recorded in Douglas County. Based on the lack of historical occurrences, the probability of a future event is considered *occasional* (hazard event is likely to occur within 100 years). However, the likelihood of a damaging earthquake to occur is very low. Refer to Sections 5.1 and 5.3 for additional information on the hazard ranking methodology and probability criteria.

Vulnerability Assessment

A probabilistic assessment was conducted for the 500-year and the 2,500-year MRPs through a Level 2 analysis in Hazus to analyze the earthquake hazard and provide a range of loss estimates. Figure 5-8 and Figure 5-9 shows the geographic distribution of the PGA in the County for the 500- and 2,500 year MRP events. Refer to Section 5.1 (Methodology and Tools) for additional details on the methodology used to assess earthquake risk.

Impact on Life, Health and Safety

Although the entire County may experience an earthquake, the degree of impact is dependent on many factors including the age and type of construction people live in, the soil types their homes are located on, and the intensity of the earthquake. NEHRP soil classes D and E can amplify ground shaking to damaging levels even during a moderate earthquake, and thus increase risk to the population. A NEHRP soil inventory was not available for Douglas County, therefore the floodplain boundary was used to assess softer soil classes in the Hazus earthquake analysis which are more at risk for ground shaking.

Whether directly or indirectly impacted, residents could be faced with business closures, road closures that could isolate populations, and loss of function of critical facilities and utilities. There is a higher risk to public safety for those inside buildings due to structural damage or people walking below building ornamentations and chimneys that may be shaken loose and fall because of an earthquake.

Populations considered most vulnerable are those located in/near the built environment, particularly those near unreinforced masonry structures. Of these most vulnerable populations, socially vulnerable populations, including the elderly (persons over age 65) and individuals living below the census poverty threshold, are most susceptible. Factors leading to this higher susceptibility include decreased mobility and financial ability to react or respond during a hazard, and the location and construction quality of their housing. There are 35,801 persons over the age of 65 and 11,333 persons living in poverty in Douglas County. The distribution of these vulnerable populations can be found in Section 4 (County Profile).

Residents may be displaced or require temporary to long-term sheltering due to an earthquake event. The number of people requiring shelter is generally less than the number displaced as some displaced persons use hotels or stay with family or friends following a disaster event. Table 5-22 summarizes the households Hazus v4.2 estimates will be displaced and population that may require short-term sheltering as a result of the 500- and the 2,500-year MRP earthquake events.

Table 5-22 Summary of Estimated Sheltering Needs for Douglas County

Scenario	Displaced Households	Persons Seeking Short-term Shelter
500-Year Earthquake	1	0
2500-Year Earthquake	31	14

Source: Hazus v4.2, Census 2010

A strong correlation exists between structural building damage and number of injuries and casualties from an earthquake event. Factors such as building material type, geographic location, and climate zone, and available resources could impact the ability to rescue and provide medical treatment (USGS, 2009). Further, time of day also exposes different sectors of the community to the hazard. For example, Hazus v4.2 considers residential occupancy at its maximum at 2:00 AM, whereas educational, commercial, and industrial sectors are at their maximum at 2:00 PM, and peak commute time is at 5:00 PM. Whether directly impacted or indirectly impacted, the entire population will be affected to some degree. Business interruption could prevent people from working, road closures could isolate populations, and loss of utilities could impact populations that suffered no direct damage from an event.

Table 5-23 and Table 5-24 summarize the County-wide injuries and casualties estimated for the 500- and 2,500-year MRP earthquake events.

Table 5-23 Estimated Number of Injuries and Casualties from the 500-Year MRP Earthquake Event

Level of Severity	Time of Day		
	2:00 AM	2:00 PM	5:00 PM
Injuries	3	5	4
Hospitalization	0	0	0
Casualties	0	0	0

Table 5-24 Estimated Number of Injuries and Casualties from the 2,500-Year MRP Earthquake Event

Level of Severity	Time of Day		
	2:00 AM	2:00 PM	5:00 PM
Injuries	29	46	37
Hospitalization	2	4	3
Casualties	0	0	0

Impact on General Building Stock

The entire County's general building stock is considered at risk and exposed to this hazard. There is a strong correlation between PGA and damage a building might undergo (USGS n.d.). The Hazus model is based on best available earthquake science and aligns with these statements. The Hazus probabilistic earthquake model was applied to analyze effects from the earthquake hazard on general building stock in

Douglas County. See Figure 5-8 and Figure 5-9 earlier in this profile which illustrates the geographic distribution of PGA (g) across the County for the 500-year and 2,500-year MRP events at the Census-tract level.

A building's construction determines how well it can withstand the force of an earthquake. The Colorado State Hazard Mitigation Plan indicated that although earthquakes are not frequent within the area, they could have greater losses due to non-reinforced structures (Colorado HMP, 2018). A building's construction determines how well it can withstand the force of an earthquake. The 2009 FEMA Unreinforced Masonry Buildings and Earthquakes report indicates that unreinforced masonry buildings are most at risk during an earthquake because the walls are prone to collapse outward, whereas steel and wood buildings absorb more of the earthquake's energy (FEMA 2009). Certain attributes can affect a building's capability to withstand an earthquake's force include its age, number of stories, and quality of construction. Hazus v4.2 considers building construction and age of building as part of the analysis. Because a custom general building stock was used for this Hazus analysis, the building ages and building types from the inventory were incorporated into the Hazus model.

Potential building damage was evaluated using Hazus v4.2 across the following damage categories: none, slight, moderate, extensive, and complete. Table 5-25 provides definitions of these five categories of damage to a light wood-framed building; definitions of categories of damage to other building types appear in Hazus technical manual documentation.

Table 5-25 Example of Structural Damage State Definitions for a Light Wood-Framed Building

Damage Category	Description
Slight	Small plaster or gypsum-board cracks at corners of door and window openings and wall-ceiling intersections; small cracks in masonry chimneys and masonry veneer.
Moderate	Large plaster or gypsum-board cracks at corners of door and window openings; small diagonal cracks across shear wall panels exhibited by small cracks in stucco and gypsum wall panels; large cracks in brick chimneys; toppling of tall masonry chimneys.
Extensive	Large diagonal cracks across shear wall panels or large cracks at plywood joints; permanent lateral movement of floors and roof; toppling of most brick chimneys; cracks in foundations; splitting of wood sill plates and/or slippage of structure over foundations; partial collapse of room-over-garage or other soft-story configurations.
Complete	Structure may have large permanent lateral displacement, may collapse, or be in imminent danger of collapse due to cripple wall failure or the failure of the lateral load resisting system; some structures may slip and fall off the foundations; large foundation cracks.

Source: Hazus Technical Manual

Building damage as a result of the 500- and 2,500-year MRP earthquake events was estimated using Hazus v4.2. Damage loss estimates include structural and non-structural damage to the building and loss of contents. Table 5-26 and Table 5-27 summarizes the estimated damages for the County by building type for the 500-year and 2,500-year MRP earthquake events. Hazus estimates that 18 structures in the County will face extensive damages due to a 500-year earthquake event and 247 structures will face extensive damage due to a 2,500-year earthquake event. The majority of these structures are reinforced masonry and wood building types. Hazus estimates that 246 structures will be moderately damaged in a 500-year earthquake event, and majority of the buildings are reinforced masonry (i.e., 95 total), followed by wood building types (i.e., 88 total). Hazus v4.2 also summarizes damage state estimates for buildings by general occupancy class. Table 5-28, Table 5-29, Table 5-30 and Table 5-31 and summarize the estimated structural and content damages for buildings categorized by general building stock for the 500-year and the 2,500-

year MRP earthquake events. Furthermore, Table 5-32 and Table 5-33 lists the severity of damage state structures will experience by the 500-year and the 2,500-year MRP earthquake event by general occupancy class.

Table 5-26 Estimated Number of Buildings Damaged by Building Type for 500-year MRP Earthquake Event

Building Category	Expected Number of Buildings Within Damage State Categories by Building Type 500-Year MRP				
	None	Slight	Moderate	Extensive	Complete
Wood	118,669	1,231	88	0	0
Steel	105	0	0	0	0
Concrete	1,598	27	5	0	0
Precast	975	20	12	2	0
Reinforced Masonry	9,963	206	95	10	0
Un-reinforced Masonry	1,279	92	39	6	1
Manufactured housing	703	20	7	0	0

Source: Hazus v4.2

Table 5-27 Estimated Number of Buildings Damaged by Building Type for 2,500-year MRP Earthquake Event

Building Category	Expected Number of Buildings Within Damage State Categories by Building Type 2,500-Year MRP				
	None	Slight	Moderate	Extensive	Complete
Wood	108,763	9,768	1,385	74	0
Steel	98	5	2	0	0
Concrete	1,415	153	58	4	0
Precast	831	87	72	19	0
Reinforced Masonry	8,869	747	552	105	1
Un-reinforced Masonry	985	236	149	40	7
Manufactured housing	577	98	51	5	0

Source: Hazus v4.2

Table 5-28 Estimated County-Wide Building Damage Severity by General Occupancy Class for the 500-year MRP Earthquake Event

Occupancy Class	Total Number of Buildings in Occupancy	Severity of Expected Damage	Earthquake 500-Year	
			Building Count	Percent Buildings in Occupancy Class
Residential Exposure (Single and Multi-Family Dwellings)	125,826	None	124,121	98.6%
		Minor	1,472	1.2%
		Moderate	216	0.2%
		Severe	16	<0.1%
		Complete Destruction	1	<0.1%

Occupancy Class	Total Number of Buildings in Occupancy	Severity of Expected Damage	Earthquake 500-Year	
			Building Count	Percent Buildings in Occupancy Class
Commercial Buildings	4,218	None	4,137	98.1%
		Minor	61	1.4%
		Moderate	18	0.4%
		Severe	2	<0.1%
		Complete Destruction	0	0.0%
Industrial Buildings	422	None	408	96.8%
		Minor	8	1.9%
		Moderate	5	1.1%
		Severe	1	0.2%
		Complete Destruction	0	0.0%
Government, Religion, Agricultural, and Education Buildings	4,690	None	4,626	98.6%
		Minor	56	1.2%
		Moderate	8	0.2%
		Severe	0	0.0%
		Complete Destruction	0	0.0%

Source: Hazus v4.2

Table 5-29 Estimated County-Wide Building Damage Severity by General Occupancy Class for the 2,500-year MRP Earthquake Event

Occupancy Class	Total Number of Buildings in Occupancy	Severity of Expected Damage	Earthquake 2,500-Year	
			Building Count	Percent Buildings in Occupancy Class
Residential Exposure (Single and Multi-Family Dwellings)	125,826	None	113,264	90.0%
		Minor	10,328	8.2%
		Moderate	2,015	1.6%
		Severe	212	0.2%
		Complete Destruction	7	0.0%
Commercial Buildings	4,218	None	3,723	88.3%
		Minor	340	8.1%
		Moderate	133	3.1%
		Severe	23	0.5%
		Complete Destruction	0	0.0%
Industrial Buildings	422	None	350	82.9%
		Minor	35	8.4%
		Moderate	29	6.9%
		Severe	8	1.8%
		Complete Destruction	0	0.0%
Government, Religion, Agricultural, and	4,690	None	4,201	89.6%
		Minor	389	8.3%
		Moderate	92	2.0%

Occupancy Class	Total Number of Buildings in Occupancy	Severity of Expected Damage	Earthquake 2,500-Year	
			Building Count	Percent Buildings in Occupancy Class
Education Buildings		Severe	7	0.2%
		Complete Destruction	0	0.0%

Source: Hazus v4.2

Table 5-30 Estimated Building Value (Building and Contents) By General Occupancy Classes and Estimated Damage in the 500-Year MRP Earthquake Event

Jurisdiction	Replacement Cost Value (RCV)	Estimated Losses to the 500 Year Earthquake Mean Return Period Event				
		Estimated Total Damage	Percent of Total Building and Contents Replacement Cost Value	Estimated Residential Damage	Estimated Commercial Damage	Estimated Damages for All Other Occupancies
Castle Pines (C)	$4,995,772,208	$2,957,011	0.1%	$2,691,498	$210,935	$54,578
Castle Rock (T)	$28,003,310,038	$11,167,058	<0.1%	$8,881,615	$1,300,777	$984,665
Larkspur (T)	$135,724,576	$185,228	0.1%	$142,427	$10,691	$32,111
Lone Tree (C)	$23,664,803,217	$6,418,385	<0.1%	$4,122,630	$2,209,903	$85,851
Parker (T)	$23,597,914,712	$8,742,465	<0.1%	$6,386,929	$1,499,228	$856,307
Unincorporated Douglas County	$102,018,837,713	$48,083,389	<0.1%	$36,988,295	$7,214,823	$3,880,272
Douglas County (Total)	**$182,416,362,464**	**$77,553,535**	**<0.1%**	**$59,213,395**	**$12,446,357**	**$5,893,784**

Source: Hazus v4.2
Notes: C = City; T= Town

Table 5-31 Estimated Building Value (Building and Contents) By General Occupancy Classes and Estimated Damage in the 2,500-Year MRP Earthquake Event

Jurisdiction	Replacement Cost Value (RCV)	Estimated Losses to the 2,500 Year Earthquake Mean Return Period Event				
		Estimated Total Damage	Percent of Total Building and Contents Replacement Cost Value	Estimated Residential Damage	Estimated Commercial Damage	Estimated Damages for All Other Occupancies
Castle Pines (C)	$4,995,772,208	$38,523,969	0.8%	$33,590,402	$4,125,486	$808,081
Castle Rock (T)	$28,003,310,038	$157,493,971	0.6%	$123,161,288	$20,023,880	$14,308,802
Larkspur (T)	$135,724,576	$2,487,575	1.8%	$1,862,521	$137,612	$487,443
Lone Tree (C)	$23,664,803,217	$95,591,770	0.4%	$54,568,517	$39,828,675	$1,194,578
Parker (T)	$23,597,914,712	$125,235,331	0.5%	$90,219,485	$22,784,345	$12,231,501
Unincorporated Douglas County	$102,018,837,713	$668,576,839	0.7%	$494,051,184	$118,585,206	$55,940,448
Douglas County (Total)	**$182,416,362,464**	**$1,087,909,454**	**0.6%**	**$797,453,397**	**$205,485,204**	**$84,970,854**

Source: Hazus v4.2
Notes: C = City; T= Town

Hazus v4.2 estimates approximately $77.6 million of damage as a result of the 500-year MRP event and $1.1 billion as a results of the 2,500-year MRP event. These damages account for less than 0.1-percent of total replacement cost value in Douglas County for the 500-year MRP event and approximately 0.6-percent for the 2,500-year MRP event. The sum of damages calculated in Hazus v4.2 include structural damage, non-structural damage, and loss of contents. Residential buildings account for majority of the building replacement cost damages.

Impacts on Critical Facilities

All critical facilities in Douglas County are considered exposed and vulnerable to the earthquake hazard. Refer to Section 4.6 (Critical Facilities) in the County Profile for a complete inventory of critical facilities in Douglas County.

The Hazus v4.2 earthquake model was used to assign a probability of each damage state category defined in Table 5-32 and Table 5-33 to every critical facility in the planning area for the 500-year and the 2,500-year MRP event, which was then averaged across the facility category. In addition, Hazus estimates the time to restore critical facilities to fully functional use. Results are presented as the probability of being functional at specified time increments (days after the event). For example, Hazus v4.2 might estimate that a facility has a 5-percent chance of being fully functional at Day 3, and a 95-percent chance of being fully functional at Day 90. For percent probability of sustaining damage, the minimum and maximum damage estimated value for that facility type is presented. As a result of a 500-year MRP event, Hazus v4.2 estimates that critical facilities will be nearly 100-percent functional with negligible damages. Their risk for extensive damage is predicted to be range 0.2-percent and 0.5-percent to police stations and fire stations. During a 2,500-year earthquake event, there is an overall increased probability of potential damage thus lowering percent functionality. At Day 1 there are several critical facilities such as medical facilities, police facilities, fire facilities, and school facilities that predicted to have under 90-percent functionality at Day 1. Additionally, extensive damage could range from 1.5-percent to 4.5-percent to many critical facilities. There is minimal change of damage for utilities and transportation facilities during both the 500-year and 2,500-year MRP events.

Table 5-32 Damage State for Critical Facilities During a 500-Year MRP Earthquake Event

Name	Percent Probability of Sustaining Damage					Percent Functionality			
	None	Slight	Moderate	Extensive	Complete	Day 1	Day 7	Day 30	Day 90
Critical Facilities									
Medical	98.2%-99.1%	0.9%-1.6%	<0.1%	0.0%	0.0%	98.1%-99.1%	99.9%	99.9%	99.9%
Police	93.7%-97.3%	1.6%-3.5%	0.9%-2.3%	0.2%-0.5%	0.0%	93.7%-97.3%	97.1%-98.8%	99.7%	99.8%
Fire	94.6%97.4%	1.5%-3.0%	0.9%-2.0%	0.2%-0.4%	0.0%	94.5%-97.4%	97.5%-98.9%	99.7%	99.8%
EOC	99.0%	0.9%	<0.1%	0.0%	0.0%	99.0%	99.8%	99.9%	99.9%
School	97.7%-98.3%	1.4%	0.5%	<0.1%	0.0%	97.6%-98.2%	99.2%-99.4%	99.9%	99.9%
Utilities									
Potable	94.6%-97.5%	1.5%-3.5%	0.8%-2.0%	0.2%	0.0%	96.1%-99.0%	99.6%-99.8%	99.9%	99.9%
Wastewater	96.6%	1.9%	1.2%	0.2%	0.0%	97.4%	99.6%	99.8%	99.9%
Transportation									
Airports	98.8%	1.1%	<0.1%	0.0%	0.0%	99.9%	99.9%	99.9%	99.9%
Bus	98.6%-99.0%	0.9%-1.2%	<0.1%	0.0%	0.0%	99.9%	99.9%	99.9%	99.9%
Bridges	100.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%	100.0%
Light Rail	98.9%	1.0%	<0.1%	0.0%	0.0%	99.9%	99.9%	99.9%	99.9%

Source: Hazus v4.2
Notes: EOC = Emergency Operation Center

Table 5-33 Damage State for Critical Facilities During a 2,500-Year MRP Earthquake Event

Name	Percent Probability of Sustaining Damage					Percent Functionality			
	None	Slight	Moderate	Extensive	Complete	Day 1	Day 7	Day 30	Day 90
	Critical Facilities								
Medical	85.3%-92.0%	7.4%-13.0%	0.6%-1.7%	<0.1%	<0.1%	85.2%-92.0%	97.9%-99.1%	99.9%	99.9%
Police	69.2%-85.0%	7.5%-13.2%	6.0%-13%	1.5%-4.5%	<0.1%	69.2%-84.9%	82.1%-92.3%	95.4%-98.4%	97.6%-99.2%
Fire	73.6%-85.5%	7.3%-11.8%	5.8%-11%	1.4%-3.5%	<0.1%	73.6%-85.5%	85.1%-92.3%	96.4%-98.5%	98.1%-99.2%
EOC	90.8%-91.9%	7.0%-7.8%	1.2%	<0.1%	0.0%	90.8%-91.9%	98.5%	99.9%	99.9%
School	87.4%-90.7%	5.5%-7.0%	3.4%-4.8%	<0.1%	<0.1%	87.4%-90.1%	94.2%-96%	99.2%-99.5%	99.7%
	Utilities								
Potable	73.6%-85.97%	7.1%-12.1%	5.5%-11.0%	1.4%-3.5%	<0.1%	82.4%-92.6%	97.1%-99.0%	98.4%-99.9%	98.9%-99.9%
Wastewater	81.1%-82.9%	83.9%-91.0%	6.7%-7.7%	1.8%-2.1%	<0.1%	85.0%-86.4%	97.2%-98.3%	98.1%-99.5%	99.8%
	Transportation								
Airports	90.3%	8.8%	8.2%	<0.1%	0.0%	99.4%	99.9%	99.9%	99.9%
Bus	90.2%-91.5%	7.8%-8.9%	<0.1%	0.0%	0.0%	99.4%	99.9%	99.9%	99.9%
Bridges	99.9%	<0.1%	<0.1%	<0.1%	0.0%	99.9%	99.9%	99.9%	99.9%
Light Rail	90.1%	8.3%	7.41%	<0.1%	0.0%	99.4%	99.9%	99.9%	99.9%

Source: Hazus v4.2
Notes: EOC = Emergency Operation Center

Impact on Economy

Earthquakes also impact the economy, including loss of business function, damage to inventory (buildings, transportation, and utility systems), relocation costs, wage loss, and rental loss due to repair and replacement of buildings. Hazus v4.2 estimates building-related economic losses, including income losses (wage, rental, relocation, and capital-related losses) and capital stock losses (structural, non-structural, content, and inventory losses). Economic losses estimated by Hazus v4.2 are summarized in Table.

Table 5-34 Building-Related Economic Losses from the 500- and 2,500-Year MRP Earthquake Events

Mean Return Period (MRP)	Inventory Loss	Relocation Loss	Building and Content Losses	Wages Losses	Rental Losses	Capital-Related Loss
500-year MRP	$118,200	$4,888,400	$77,552,400	$1,422,500	$2,314,000	$1,019,400
2,500-year MRP	$2,205,200	$50,945,000	$1,087,908,800	$18,102,700	$22,921,700	$11,374,100

Source: Hazus v4.2

Although the Hazus v4.2 analysis did not compute damage estimates for individual roadway segments and railroad tracks, assumedly these features would undergo damage due to ground failure resulting in interruptions of regional transportation and of distribution of materials. Losses to the community that would result from damage to lifelines could exceed costs of repair. Earthquake events can significantly affect road bridges, many of which provide the only access to certain neighborhoods. Because softer soils generally follow floodplain boundaries, bridges that cross watercourses should be considered vulnerable. Another key factor in degree of vulnerability is age of facilities and infrastructure, which correlates with standards in place at time of construction.

Additionally, Hazus v4.2 estimates volume of debris that may be generated as a result of an earthquake event to enable the study region to prepare for and rapidly and efficiently manage debris removal and disposal. Debris estimates were divided into two categories: (1) reinforced concrete and steel that require special equipment to break up before transport can occur, and (2) brick, wood, and other debris that can be loaded directly onto trucks by use of bulldozers (Hazus Earthquake User's Manual).

Hazus v4.2 estimated the generation of over 15,285 tons of debris during the 500-year MRP event and 123,076 tons of total debris during the 2,500-year MRP event, and 37 below lists estimated debris generated by these events.

Table 5-35 Estimated Debris Generated by the 500- and 2,500-year MRP Earthquake Event

Jurisdiction	500-Year		2,500-Year	
	Brick/Wood (tons)	Concrete/Steel (tons)	Brick/Wood (tons)	Concrete/Steel (tons)
Castle Pines (C)	557	365	3,221	3,594
Castle Rock (T)	1,340	740	9,163	7,521
Larkspur (T)	28	23	181	212
Lone Tree (C)	840	567	5,166	6,139
Parker (T)	738	579	5,722	5,473
Unincorporated Douglas County	5,611	3,897	37,729	39,029
Douglas County (Total)	**9,115**	**6,170**	**61,183**	**61,968**

Source: Hazus v4.2

Impact on the Environment

According to USGS, earthquakes can cause damage to the surface of the Earth in various forms depending on the magnitude and distribution of the event (USGS 2020). Surface faulting is one of the major seismic components to earthquakes that can create wide ruptures in the ground. Ruptures can have a direct impact on the landscape and natural environment because it can disconnect habitats for miles isolating animal species or tear apart plant roots.

Furthermore, ground failure as a result of soil liquefaction can have an impact on soil pores and retention of water resources (USGS 2020). The greater the seismic activity and liquefaction properties of the soil, the more likely drainage of groundwater can occur which depletes groundwater resources. In areas where there is higher pressure of groundwater retention, the pores can build up more pressure and make soil behave more like a fluid rather than a solid increasing risk of localized flooding and deposition or accumulation of silt.

Cascading Impacts to Other Hazards

The Global Geoengineering Research Group in USGS has been investigating the relationship earthquakes have with ground deformation, ground failure, and coastal erosion (USGS 2019). As mentioned in earlier sections, soft and loose soils are more susceptible to earthquake events. Ground failure can become exacerbated due to earthquake events, causing landsliding and erosion. Areas of steep slopes are at greater risk of ground failure and potential erosion during earthquakes (USGS 2019).

Further, residual impacts from earthquakes could alter the floodplain extent for the County if ground failure and erosion occur. Damage to infrastructure controlling flood waters or waterbody sources may become breached as a result of an earthquake event, which could create flooding in the impacted areas.

Future Changes That May Impact Vulnerability

Understanding future changes that effect vulnerability in the County can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change

Projected Development

As discussed and illustrated in Section 4 (County Profile), areas targeted for future growth and development have been identified across the County. Development built in areas with softer NEHRP soil classes, liquefaction, and landslide-susceptible areas may experience shifting or cracking in the foundation during earthquakes because of the loose soil characteristics of these soil classes. However, current building codes require seismic provisions that should render new construction less vulnerable to seismic impacts than older, existing construction that may have been built to lower construction standards. Refer to Section 4 and 9 for more information about the potential new development in Douglas County.

Projected Changes in Population

According to the State of Colorado Department of Local Affairs, the population in Douglas County has increased by approximately 2.07-percent or 6,946 persons between 2017 and 2018 (SOC DLA 2019). The increase in population will expose more people to the earthquake hazard. Persons that move into older structures in the County are at greater risk of being impacted by earthquake events because older structures are more vulnerable to ground shaking. As noted earlier, if moving into new construction, current building codes require seismic provisions that should render new construction less vulnerable to seismic impacts. Refer to Section 4 (County Profile), which includes a more thorough discussion about population trends for the County.

Climate Change

Because the impacts of climate change on earthquakes are not well understood, a change in the County's vulnerability as the climate continues to change is difficult to determine. However, climate change has the potential to magnify secondary impacts of earthquakes. As a result of the climate change projections discussed above, the County's assets located on areas of saturated soils and on or at the base of steep slopes, are at a relatively higher risk of landslides/mudslides because of seismic activity.

Changes in Vulnerability Since the 2015 HMP

Since the 2015 analysis, population statistics have been updated using the 5-Year 2014-2018 American Community Survey Population Estimates. A custom structure inventory was created using tax assessor information, building footprints, and parcel data provided by the County. In addition, a critical facility inventory was generated and reviewed the planning partnerships. These inventories were imported into Hazus v4.2 to complete an earthquake model analysis. The NEHRP data was created using the Special Flood Hazard Area boundary and imported into Hazus as floodplain soils tend to be softer and have a greater potential of ground failure.

Overall, this vulnerability assessment uses a more accurate and updated building inventory which provides more accurate estimated exposure and potential losses for Douglas County.

Issues Identified

Important issues associated with an earthquake in Douglas County include the following:

- Critical facility/lifeline owners should be encouraged to create or enhance a continuity of operations plan using the information on risk and vulnerability contained in this plan update.
- Identifying assets built prior to the uniform application of seismic provisions in the state will provide a basis to better understand the vulnerability of building stock in the County.
- Earthquakes could trigger other natural hazard events, such as levee/dam failures and slope failures which could impact Douglas County, its municipalities, and districts.

5.4.5 Extreme Temperature

The following section provides the hazard profile and vulnerability assessment for the extreme temperature hazard in Douglas County.

Profile

Hazard Description

Extreme temperature includes both heat and cold events, which can have a significant impact to human health, commercial/agricultural businesses and primary and secondary effects on infrastructure (e.g., burst pipes and power failure). What constitutes *extreme cold* or *extreme heat* can vary across different areas of the country, based upon what the population is accustomed.

Extreme Heat

Extreme heat is defined as temperatures which hover 10 degrees or more above the average high temperature for a region. Because some areas are hotter than others, extreme heat temperatures vary based on regional averages and locations (CDC 2017). A heat wave is an extended period of extreme heat of two or more consecutive days is typically called a heat wave and is often accompanied by high humidity (NWS 2009). Extreme heat during the summer months is a common occurrence in the State of Colorado, including Douglas County.

Extreme Cold

Extreme cold events are when temperatures drop well below normal in an area. What constitutes as extreme cold varies in different parts of the country. In the southern United States, near freezing temperatures are considered extreme cold. Freezing temperatures can cause severe damage to citrus fruit crops and other vegetation. Pipes may freeze and burst in homes that are poorly insulated or without heat (NWS 2017). Douglas County typically does not experience extreme cold; however, the County does have a history of occurrence for extreme cold temperatures.

Extent

Extreme Heat

The extent of extreme heat temperatures generally is measured through the Heat Index, identified in Figure 5-12. Created by the NWS, the Heat Index is a chart that accurately measures apparent temperature of the air as it increases with the relative humidity. To determine the Heat Index, the temperature and relative humidity are needed. Once both values are identified, the Heat Index is the corresponding number of both the values. This provides a measure of how temperatures feel; however, the values are devised for shady, light wind conditions. Exposure to full sun can increase the index by up to 15 degrees.

> Relative humidity is the amount of moisture in the air at a certain temperature compared to what the air can "hold" at that temperature…it is measured as a percentage or ratio of the amount of water vapor in a volume of air RELATIVE to a given temperature and the amount it can hold at that given temperature. Warm air can hold more moisture than cold air.

Figure 5-12. Heat Index Chart

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Source: NWS 2016

The NWS provides alerts when Heat Indices approach hazardous levels. Table 5-36 explains these alerts.

Table 5-36 National Weather Service Alerts for Excessive Heat

Alert	Criteria
Excessive Heat Outlook	The Excessive Heat Outlook is issued when the potential exists for an excessive heat event in the next 3-7 days. An Outlook provides information to Heat Index forecast map for the contiguous United States for those who need considerable lead time to prepare or the event, such as public utilities, emergency management and public health officials.
Excessive Heat Watch	The Excessive Heat Watch is issued when conditions are favorable for an excessive heat event in the next 12 to 48 hours. A Watch is used when the risk of a heat wave has increased, but its occurrence and timing is still uncertain. A Watch provides enough lead time so those who need to prepare can do so, such as cities that have excessive heat event mitigation plans.

Alert	Criteria
Excessive Heat Warning/Advisory	The Excessive Heat Warning/Advisory is issued when an excessive heat event is expected in the next 36 hours. These products are issued when an excessive heat event is occurring, is imminent, or has a very high probability of occurring. The warning is used for conditions posing a threat to life or property. An advisory is for less serious conditions that cause significant discomfort or inconvenience and, if caution is not taken, could lead to a threat to life and/or property.

Source: Douglas County 2015

Extreme Cold

The extent (severity or magnitude) of extreme cold temperatures generally are measured through the Wind Chill Temperature (WCT) Index. The WCT Index uses advances in science, technology, and computer modeling to provide an accurate, understandable, and useful formula for calculating the dangers from wind chill. For details regarding the WCT Index, refer to: http://www.nws.noaa.gov/om/winter/windchill.shtml

Figure 5-13. NWS WCT Index

Temperature (°F)

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

Frostbite Times: 30 minutes; 10 minutes; 5 minutes

Source: NWS 2020

The NWS provides alerts when Wind Chill indices approach hazardous levels. Table 5-37 explains these alerts.

Table 5-37 National Weather Service Alerts for Extreme Cold

Alert	Criteria
Freeze Watch	A freeze warning is issued during the growing season when widespread temperatures are expected to drop to below 32 degrees.
Freeze Warning	A freeze warning is issued during the growing season when widespread temperatures are expected to drop to below 32 degrees.
Wind Chill Advisory	A wind chill advisory is issued on the plains when wind and temperature combine to produce wind chill values of minus 18 degrees to minus 25 degrees. A wind chill advisory is issued for the mountains and foothills when wind and temperature combine to produce wind chill values of minus 25 degrees.

Alert	Criteria
Wind Chill Watch	A wind chill watch is issued when wind chill warning criteria are possible in the next 12 to 36 hours.
Wind Chill Warning	A wind chill warning is issued for wind chills of at least minus 25 degrees on the plains, and minus 35 degrees in the mountains and foothills.

Source: NWS 2020

Location

Extreme temperature events can occur in any area of Douglas County. Metropolitan areas could experience more extreme heat events due to urban heat islands. Heat island describes built up areas that are hotter than nearby rural areas. According to the U.S. EPA, the annual mean air temperature of a city with 1 million people or more can be 1.8–5.4°F (1–3°C) warmer than its surroundings. In the evening, the difference can be as high as 22°F (12°C). Heat islands can affect communities by increasing summertime peak energy demand, air conditioning costs, air pollution and greenhouse gas emissions, heat-related illness and mortality, and water pollution (U.S. EPA 2020).

Previous Occurrences and Losses

Many sources have provided historical information regarding previous occurrences and losses associated with extreme temperatures in Douglas County. According to the NOAA-NCEI Storm Events Database, Douglas County has not been impacted by extreme temperature events between 2014 and 2020. Between 2014 and 2020, the State of Colorado was not included in extreme temperature-related disaster declarations related to extreme temperatures (FEMA 2020).

Douglas Colorado has been subject to one agricultural disaster declarations since 2014 related to extreme temperatures. The event occurred in 2014 and entailed excessive heat/high temperature (S3627) (USDA 2020).

In April 2020, coniferous trees throughout the County were damaged by a cold snap and temperature fluctuations. A warm winter caused the ponderosa pines and spruce trees to not enter dormancy before freezing occurred.

According to the National Center for Environmental Information, the mean number of days between 1948 and 2018 with a daily maximum temperature equal to or greater than 90°F was 36 days for Denver, Colorado. The greatest number of days which the County experienced extreme heat is 73 in 2020, while the highest temperature recorded was 100°F, recorded on June 27th, 2012 and July 2-3, 2012. Table 5-38 shows the number of days with a maximum temperature of 90°F for the Castle Rock station (USC00051401). 2020 featured the highest number of days since 2000 with a temperature above 90°F (73 days) followed by 2012 (40 days). 2004 and 2009 were years with the lowest number of days with a maximum temperature of 90°F (seven and nine days, respectively).

Table 5-38 Monthly Number of Days with Maximum Temperature ≥ 90°F

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2000	0	0	0	0	1	7	8	8	1	0	0	0	25
2001	0	0	0	0	0	6	13	0	0	0	0	0	19
2002	0	0	0	0	1	11	15	7	1	0	0	0	35
2003	0	0	0	0	1	0	22	9	0	0	0	0	32
2004	0	0	0	0	0	2	3	2	0	0	0	0	7

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2005	0	0	0	0	0	0	17	3	0	0	0	0	20
2006	0	0	0	0	0	9	10	0	0	0	0	0	19
2007	0	0	0	0	0	7	14	3	0	0	0	0	24
2008	0	0	0	0	0	0	18	5	0	0	0	0	23
2009	0	0	0	0	0	0	1	2	0	0	0	0	3
2010	0	0	0	0	0	5	9	5	3	0	0	0	22
2011	0	0	0	0	0	3	11	9	2	0	0	0	25
2012	0	0	0	0	1	11	20	6	2	0	0	0	40
2013	0	0	0	0	0	9	9	7	4	0	0	0	29
2014	0	0	0	0	0	0	7	0	2	0	0	0	9
2015	0	0	0	0	0	3	3	10	0	0	0	0	16
2016	0	0	0	0	0	2	11	6	0	0	0	0	19
2017	0	0	0	0	0	3	13	4	1	0	0	0	21
2018	0	0	0	0	0	10	14	2	5	0	0	0	31
2019	0	0	0	0	0	3	12	16	5	0	0	0	36
2020	0	0	0	0	4	17	21	22	9	0	0	0	73

Source: Midwest Regional Climate Center 2020
Notes:
- = indicates that there is no available data
** = indicates that the data are not complete*
*** = indicates that the value is being computed using only the years with complete data*

Table 5-39 shows the number of days with maximum temperatures less than 32°F recorded at the Castle Rock weather station. 2020 had the lowest number of days with a temperature below 32°F (10 days), followed by 2000 (11 days). In 2007, there were 29 days when the temperature was less than 32°F – the highest amount in a year since 2000.

Table 5-39 Monthly Number of Days with Maximum Temperature ≤ 32°F

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2000	5	1	1	0	0	0	0	0	0	0	2	2	11
2001	3	3	2	1	0	0	0	0	0	0	2	1	12
2002	5	2	3	1	0	0	0	0	0	3	2	1	17
2003	0	6	2	0	0	0	0	0	0	1	2	2	13
2004	2	5	0	0	0	0	0	0	0	0	3	2	12
2005	3	3	2	1	0	0	0	0	0	0	1	9	19
2006	2	6	3	0	0	0	0	0	0	0	0	6	17
2007	7	5	3	2	0	0	0	0	0	0	3	9	29
2008	8	4	2	0	0	0	0	0	0	0	0	8	22
2009	4	0	2	2	0	0	0	0	0	2	0	12	22
2010	3	9	2	0	0	0	0	0	0	0	3	2	19
2011	4	6	1	0	0	0	0	0	0	1	0	5	17
2012	4	6	2	0	0	0	0	0	0	0	0	4	16
2013	5	3	5	0	0	0	0	0	0	0	1	6	20
2014	5	5	1	0	0	0	0	0	0	0	5	3	19
2015	4	4	4	0	0	0	0	0	0	0	0	0	12
2016	0	4	3	2	0	0	0	0	0	0	0	5	14

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2017	8	3	0	1	0	0	0	0	0	2	1	3	18
2018	3	5	0	0	0	0	0	0	0	1	2	4	15
2019	3	7	5	0	0	0	0	0	0	3	2	2	22
2020	0	4	0	1	0	0	0	0	0	0	2	3	10

Source: Midwest Regional Climate Center 2020
Notes:
- = indicates that there is no available data
** = indicates that the data are not complete*
*** = indicates that the value is being computed using only the years with complete data*

Climate Change Projections

Colorado's climate is changing and is warming. Much of Colorado has already warmed by between one and two degrees Fahrenheit within the last century (EPA 2017). The State is anticipated to warm between 2.5°F and 5°F by 2050 relative to a 1971-2000 baseline. In a higher emissions scenario (RCP 8.5), warming in Colorado could reach 6.5°F by 2050. A 2.5°F to 5°F warming would render the climate of the Douglas County region more similar to Pueblo in the southern part of the State, whereas a 6.5°F would render the County's temperatures more similar to those found in Albuquerque, New Mexico (Climate.gov 2014). Warming is anticipated to result in impacts to the State's hydrology and water sources, impacting the timing of snowmelt and runoff. Rising temperatures are also anticipated to result in heat waves, wildfires, and droughts that are increased in frequency and severity.

Probability of Future Occurrences

It is anticipated that Douglas County will experience extreme temperature events each year, with a majority of the days being extreme heat days. The probability of future occurrences for extreme temperatures can be determined by assessing historical averages. Based on the information provided by the Midwest Regional Climate Center for the years between 2000 and 2020, the County can expect, on average, approximately 25 days a year with temperatures greater than or equal to 90°F. Additionally, the County can expect, on average, approximately 17 days each year with temperatures less than or equal to 32°F.

Table 5-40 Probability of Occurrences of Extreme Temperature Events

Hazard Type	Number of Occurrences Between 2000 and 2020	% chance of occurrence in any given year
Temperature ≥ 90°F	528	100%
Temperature ≤ 32°F	356	100%
Total	**884**	100%

Source: *Midwestern Regional Climate Center 2020*
Note: Probability was calculated using the available data provided in the Midwest Regional Climate Center data for the Castle Rock station

Based on historical records and input from the Planning Committee, the probability of occurrence for extreme temperatures in Douglas County is considered *frequent* (hazard event is likely to occur within 25 years).

Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed and vulnerable. For the extreme temperature hazard, the entire County has been identified as exposed; therefore, all assets are potentially vulnerable. The following text estimated potential impacts of extreme temperatures on Douglas County.

Impact on Life, Health and Safety

The entire population (328,614) of Douglas County is exposed to the extreme temperature hazard. Extreme temperature events have potential health impacts including injury and death. According to the Centers for Disease Control and Prevention, populations most at risk to extreme cold and heat events include the following: 1) the elderly, who are less able to withstand temperatures extremes due to their age, health conditions, and limited mobility to access shelters; 2) infants and children up to four years of age; 3) individuals with chronic medical conditions (e.g., heart disease, high blood pressure), 4) low-income persons that cannot afford proper heating and cooling; and 5) the general public who may overexert during work or exercise during extreme heat events or experience hypothermia during extreme cold events (CDC 2017a).

Table 5-41 Vulnerable Populations in Douglas County

Jurisdiction	Population Over 65	Population Under 5	Population Below Poverty Threshold
Douglas County	35,801	19,924	11,333

Source: 2018 American Community Survey 5-Year Estimate

Exposure to excessive heat can pose a number of health risks to individuals. Table 5-42 and Table 5-43 identify different health hazards related to extreme temperature conditions.

Table 5-42 Health Effects of Extreme Cold

Health Hazard	Symptoms
Wind Chill	Wind chill is not the actual temperature but rather how wind and cold feel on exposed skin. As the wind increases, heat is carried away from the body at an accelerated rate, driving down the body temperature. Animals are also affected by wind chill; however, cars, plants and other objects are not.
Frostbite	Frostbite is damage to body tissue caused by extreme cold. A wind chill of -20°F will cause frostbite in just 30 minutes. Frostbite causes a loss of feeling and a white or pale appearance in extremities, such as fingers, toes, ear lobes or the tip of the nose. If symptoms are detected, get medical help immediately! If you must wait for help, slowly re-warm affected areas. However, if the person is also showing signs of hypothermia, warm the body core before the extremities.
Hypothermia	Hypothermia is a condition brought on when the body temperature drops to less than 95°F. It can kill. For those who survive, there are likely to be lasting kidney, liver and pancreas problems. Warning signs include uncontrollable shivering, memory loss, disorientation, incoherence, slurred speech, drowsiness and apparent exhaustion.

Source: CDC 2020

Table 5-43 Health Effects of Extreme Heat

Health Hazard	Symptoms
Sunburn	Redness and pain. In severe cases: swelling of skin, blisters, fevers, and headaches
Dehydration	Excessive thirst, dry lips, and slightly dry mucous membranes
Heat Cramps	Painful spasms, usually in muscles of legs and abdomen, and possible heavy sweating
Heat Exhaustion	Heavy sweating; weakness; cold, pale and clammy skin; weak pulse; possible fainting and vomiting

Health Hazard	Symptoms
Heat Stroke	High body temperature (104ºF or higher), hot and dry skin, rapid and strong pulse, and possible coma

Source: CDC 2020

Meteorologists can accurately forecast extreme heat and cold event development and the severity of the associated conditions with several days of lead time. These forecasts provide an opportunity for public health and other officials to notify vulnerable populations, implement short-term emergency response actions, and focus on surveillance and relief efforts on those at greatest risk. Adhering to extreme temperature warnings can significantly reduce the risk of temperature-related deaths.

Impact on General Building Stock

All the building stock in the County is exposed to the extreme temperature hazard. Extreme heat generally does not impact buildings; however, elevated summer temperatures increase the energy demand for cooling. Losses can be associated with the overheating of heating, ventilation, and air conditioning (HVAC) systems. Extreme cold temperature events can damage buildings through freezing/bursting pipes and freeze/thaw cycles, as well as increasing vulnerability to home fires. Additionally, manufactured homes (mobile homes) and antiquated or poorly constructed facilities can have inadequate capabilities to withstand extreme temperatures.

Impact on Critical Facilities

All critical facilities in the County are exposed to the extreme temperature hazard. Impacts to critical facilities are the same as described for general building stock. Additionally, it is essential that critical facilities remain operational during natural hazard events. Extreme heat events can sometimes cause short periods of utility failures, commonly referred to as *brown-outs*, due to increased usage from air conditioners and other energy-intensive appliances. Similarly, heavy snowfall and ice storms, associated with extreme cold temperature events, can cause power interruption. Backup power is recommended for critical facilities and infrastructure.

Impact on Economy

Extreme temperature events also have impacts on the economy, including loss of business function and damage to and loss of inventory. Business-owners can be faced with increased financial burdens due to unexpected repairs caused to the building (e.g., pipes bursting), higher than normal utility bills, or business interruption due to power failure (i.e., loss of electricity, telecommunications).

Impact on the Environment

Extreme temperature events can have a major impact on the environment. For example, freezing and warming weather patterns create changes in natural processes. An excess amount of snowfall and earlier warming periods may affect natural processes such as flow within water resources (USGS 2020).

Cascading Impacts to Other Hazards

Extreme temperature events can exacerbate the drought hazard, increase the potential risk of wildfires, and escalate severe storm and severe winter weather events for the County. For example, extreme heat events may accelerate evaporation rates, drying out the air and soils. Extreme heat can also dry out terrestrial species, making them more susceptible to catching fire. Extreme variation in temperatures could create ideal atmospheric conditions for severe storms or worsen the outcome of severe winter weather during freezing and thawing periods. Refer to Section 5.4.3 (Drought), Section 5.4.9-5.4.11 (Severe Storm), Section 5.4.12 (Severe Winter Storm), and Section 5.4.17 (Wildfire) for more information about these hazards of concern.

Future Changes that May Impact Vulnerability

Understanding future changes that impact vulnerability in the County can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development.
- Projected changes in population.
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development and Change in Population

The ability of new development to withstand extreme temperature impacts lies in sound land use practices and consistent enforcement of codes and regulations for new construction. New development will change the landscape where buildings, roads, and other infrastructure potentially replace open land and vegetation. Surfaces that were once permeable and moist are now impermeable and dry. These changes cause urban areas to become warmer than the surrounding areas forming an *island* of higher temperatures (EPA 2009).

Climate Change

As the climate warms, extreme cold events might decrease in frequency, while extreme heat events might increase in frequency; the shift in temperatures could also result in hotter extreme heat events. With increased temperatures, vulnerable populations could face increased vulnerability to extreme heat and its associated illnesses, such as heatstroke and cardiovascular and kidney disease. Additionally, as temperatures rise, more buildings, facilities, and infrastructure systems may exceed their ability to cope with the heat.

Change of Vulnerability Since the 2015 HMP

Overall, the entire County remains vulnerable to extreme temperatures. As existing development and infrastructure continue to age they can be at increased risk to failed utility systems (e.g., HVAC) if they are not properly maintained. Similarly, an increase in the elderly population remaining in the County increases the vulnerable population.

Issues Identified

The potential issues identified with extreme temperature events include:

- Extreme temperature events can damage aging infrastructure and buildings as highways and roads are damaged by excessive heat as the asphalt softens, and roadways can be damaged from extreme cold temperatures causing frost heaving of road infrastructure.
- The aging population of the County may result in an increase of residents vulnerable to extreme temperature events as the senior population is less able to withstand extreme temperatures due to age and health conditions.

- Prolonged extreme heat events can lead to drought conditions and impact the drinking water supply for residents and result in more frequent and intense wildfires.

5.4.6 Flood

The following section provides the hazard profile and vulnerability assessment for the flood hazard in Douglas County

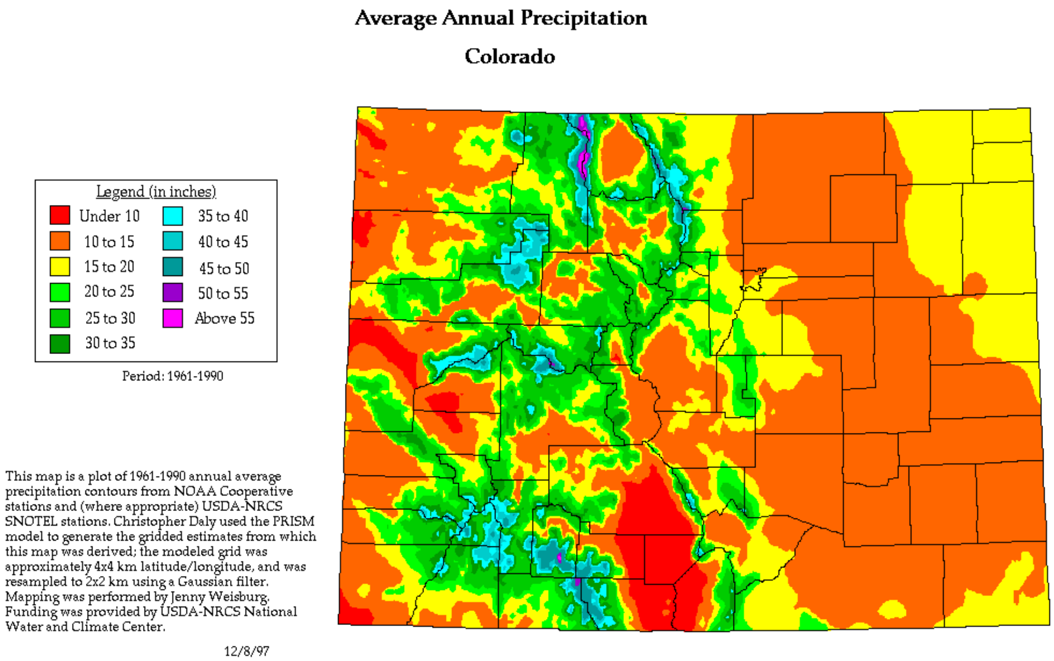
Profile

Hazard Description

Floods are one of the most common natural hazards in the U.S. They can develop slowly over a period of days or develop quickly, with disastrous effects that can be local (impacting a neighborhood or community) or regional (affecting entire river basins, coastlines and multiple counties or states) (FEMA 2007). As defined in the State of Colorado HMP, flooding is the general and temporary condition of partial or complete inundation of typically dry areas. This can result from overflow of stream banks, rapid accumulation of surface water runoff, or mudflows from the sudden collapse of a shoreline (State of Colorado HMP 2018).

In hydrologic analysis, runoff is that portion of rainfall which, in combination with other factors, contributes to the stream flow of any surface drainage way. When runoff exceeds the carrying capacity of the stream or drainage, flooding occurs. Runoff is a product of two major groups of factors, climate and physiographic. Climatic factors may include precipitation, evaporation, transpiration and interception. Physiographic factors would include the characteristics of the watershed such as size, shape and slope of the basin's drainage area, the general land use within the basin. With river networks spanning most of Colorado, runoff from snowmelt yields a high chance of flooding quite evenly throughout the State (State of Colorado HMP 2018). Figure 5-14 illustrates the annual average precipitation across the State. In Douglas County, the average precipitation is between 15 and 20 inches and up to 35 inches in the mountain region in the southern portion of the County.

Figure 5-14. Annual Average Runoff from Precipitation, in Inches (1961-1990)



Source: Boulder Area Sustainability Information Network

Colorado is vulnerable to flooding resulting from snow runoff and precipitation. Snowmelt in the Front Range is carried by the South Platte River to Douglas County and beyond. If the local basin drainage area is relatively flat, shallow, slow-moving floodwater can last for days. In drainage areas with substantial slope, or the channel is narrow and confined, rapidly moving and extreme high water conditions, called a flash flood, can occur (Colorado State HMP 2018).

Types of Flooding

Flooding generally takes one of the following forms:

- **Riverine Flooding—**Riverine flooding occurs when rivers overflow their banks in response to excessive precipitation levels and water runoff volumes within the watershed. Riverine floodplains may be broad, as when a river crosses an extensive flat landscape, or narrow, as when a river is confined in a canyon.
- **Coastal Flooding—**Coastal flooding is primarily caused by storm surge, a cascading effect of hurricanes and coastal storms that pushes water toward the shore. The result can be waves that extend further inland, causing damage to development that would not normally be subject to wave action. Storm surge heights, and associated waves, are dependent upon the local width of the continental shelf and the depth of the ocean bottom. A narrow shelf, or one that drops steeply from the shoreline and subsequently produces deep water close to the shoreline, tends to produce a lower surge but higher and more powerful storm waves. Due to the high risk and vulnerability to this flood specific hazard, it was analyzed independently in this chapter rather than as a cascading effect of hurricanes.

- **Flash Flooding—**Most flash flooding is caused by slow-moving thunderstorms in a local area or by heavy rains associated with hurricanes and tropical storms. However, flash flooding events can also occur from accelerated snow melt due to heavy rains, a dam or levee failure within minutes or hours of heavy amounts of rainfall, or from a sudden release of water held by an ice jam. Although flash flooding occurs often along mountain streams, it is also common in urbanized areas where much of the ground is covered by impervious surfaces. Flash flood waters move at very high speeds, uprooting trees, destroying buildings, and obliterating bridges and roads.
- **Urban Flooding—**Urban flooding occurs when development has obstructed the natural flow of water and decreased the ability of natural groundcover to absorb and retain surface water runoff.

For the purpose of this HMP and as deemed appropriate by Core Planning Team, riverine, flash, and urban flooding are the main flood types of concern for the County.

Extent

The severity of a flood event is typically determined by a combination of several factors including stream and river basin topography and physiography; precipitation and weather patterns; recent soil moisture conditions; and degree of vegetative clearing and impervious surface. Generally, floods are long-term events that may last for several days. Regarding the riverine flood hazard, once a river reaches flood stage, flood extent or severity categories used by the NWS include minor flooding, moderate flooding, and major flooding. Each category is defined as follows, based on property damage and level of public threat:

- Minor Flooding – minimal or no property damage, but possibly some public threat or inconvenience.
- Moderate Flooding – some inundation of structures and roads near streams. Some evacuations of people and/or transfer of property to higher elevations are necessary.
- Major Flooding – extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations (NWS 2011).

USGS uses stream gages to determine the severity of flood at different points along a body of water. There are a number of gages in the County that actively monitor water levels and have had determined flood stages. The County relies on the gages to determine the height of the river during heavy rain events and to determine whether or not residents need to evacuate. Table 5-44 shows the two gages in the area of the County with their determined flood stage and their record flood event. The USGS website provides details about each of the gages (https://waterwatch.usgs.gov/index.php) and the gage heights of flooding events. The NWS provides the different flood stages for the gages (https://water.weather.gov/ahps/).

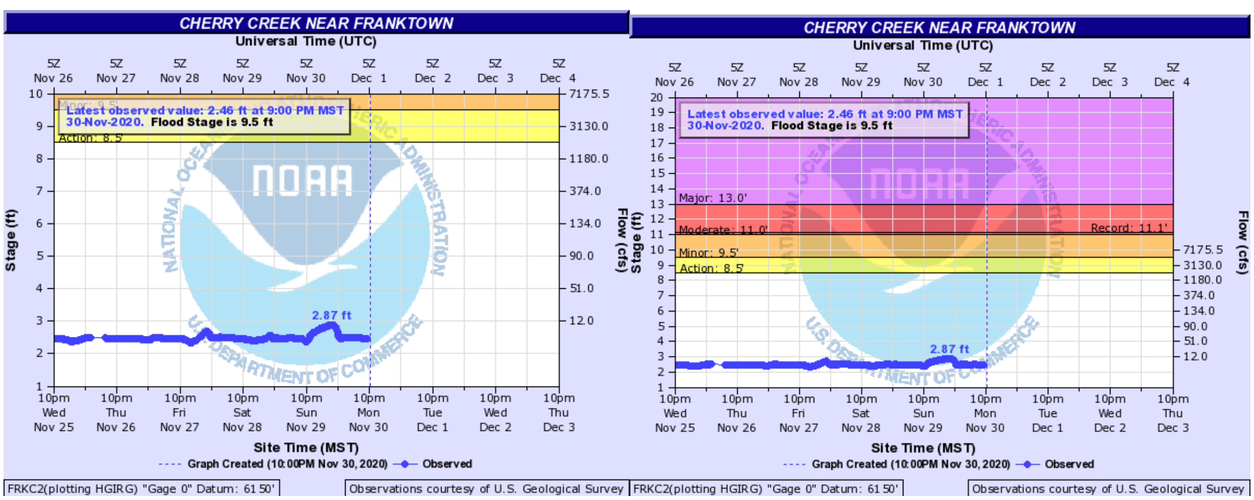
Table 5-44 Stream Gage Statistics for the Vicinity of Douglas County

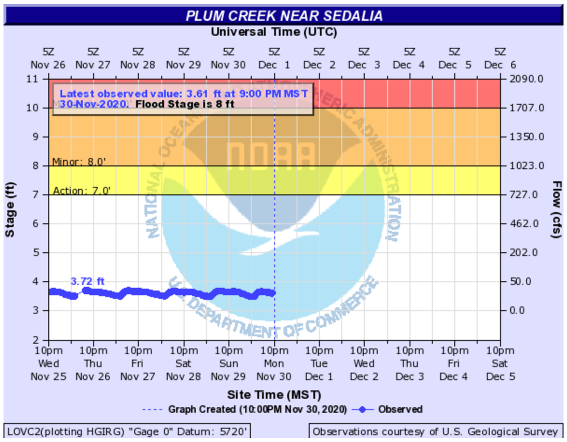
Gage Site Number	Site Name	Action Stage (feet)	Flood Stage (feet)	Moderate Flood Stage (feet)	Major Flood Stage (feet)	Record Flood
06712000	Cherry Creek at Franktown	8.5	9.95	11	13	11.13 feet (July 2nd, 2006)
06709000	Plum Creek near Sedalia, CO	7	8	10	12	22.4 feet (June 16th, 1965)
	West Plum Creek at Pine Cliff above Sedalia, CO	5	6.8	11	11.6	

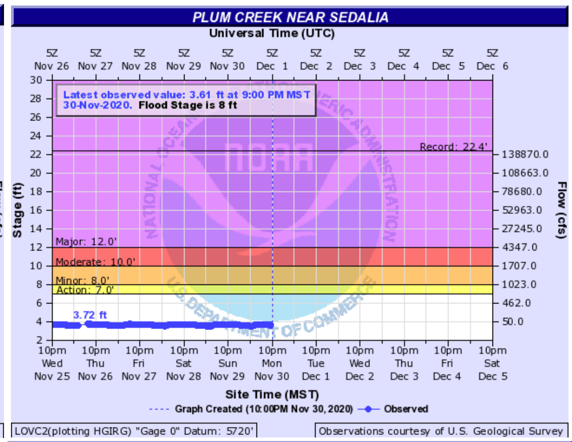
Gage Site Number	Site Name	Action Stage (feet)	Flood Stage (feet)	Moderate Flood Stage (feet)	Major Flood Stage (feet)	Record Flood
06709530	Plum Creek at Titan Road near Louviers, CO	N/A	N/A	N/A	N/A	11.45 feet (June 12, 2015)
393109104464500	Cherry Creek near Parker	7.5	8.5	10	12	12.29 feet (June 6, 2012)
06708800	East Plum Creek above Haskins Gulch near Castle Rock, CO	8.5	10	N/A	N/A	N/A
	East Plum Creek above Castle Rock	95.5	96.5	97.5	98.5	N/A
	South Platte River at Chatfield Reservoir	5,440				5,448.48 feet (June 19th, 2015)
	South Platte River at South Platte	6	7	8.5	9.5	11.2 feet (July 12, 1996)
	South Platte River below Cheesman Reservoir	5	7	9	11	N/A

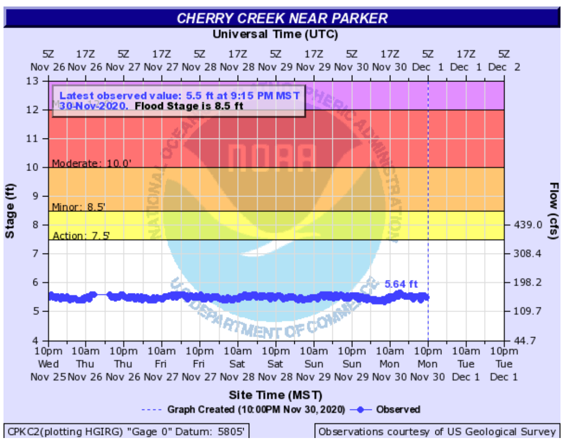
Source: USGS 2020; NWS 2020

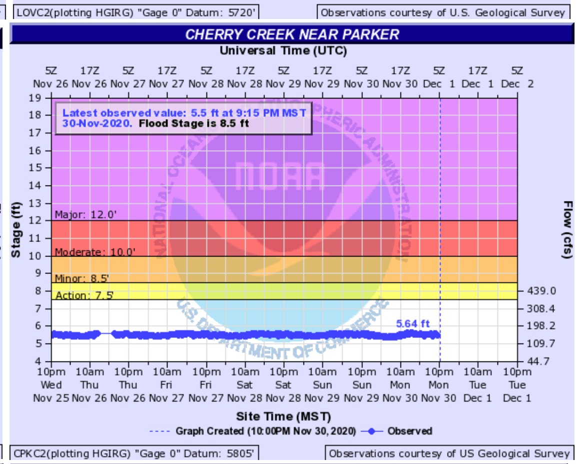
Figure 5-15. Flood Hydrographs for the Gages in the Vicinity of Douglas County

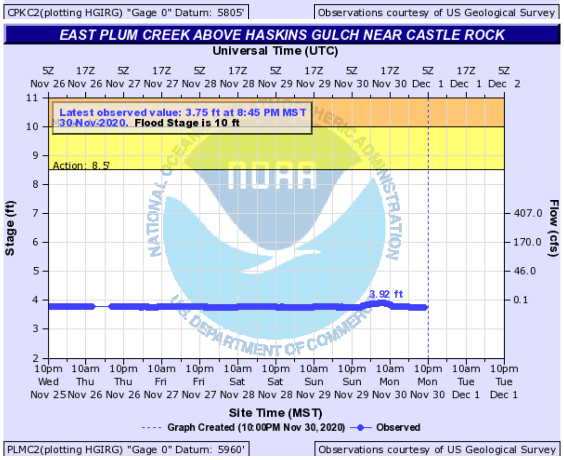


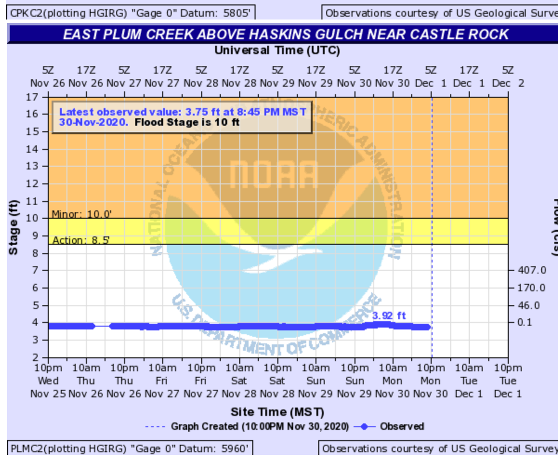

PLUM CREEK NEAR SEDALIA
Universal Time (UTC)
Latest observed value: 3.61 ft at 9:00 PM MST 30-Nov-2020. Flood Stage is 8 ft
Minor: 8.0'
Action: 7.0'
3.72 ft
Stage (ft)
Flow (cfs)
Site Time (MST)
Graph Created (10:00PM Nov 30, 2020)
Observed
LOVC2(plotting HGIRG) "Gage 0" Datum: 5720'
Observations courtesy of U.S. Geological Survey

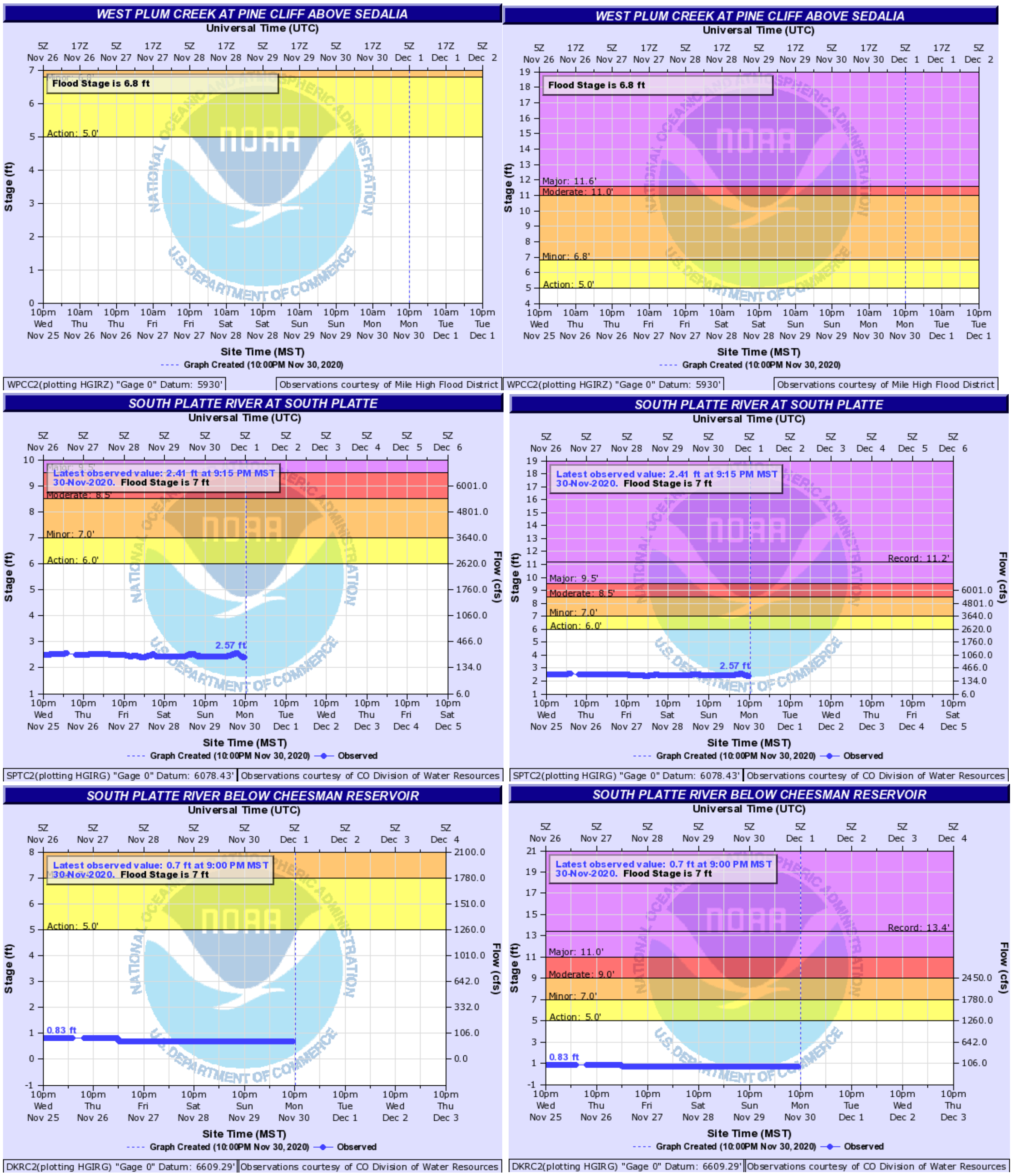

PLUM CREEK NEAR SEDALIA
Universal Time (UTC)
Latest observed value: 3.61 ft at 9:00 PM MST 30-Nov-2020. Flood Stage is 8 ft
Record: 22.4'
Major: 12.0'
Moderate: 10.0'
Minor: 8.0'
Action: 7.0'
3.72 ft
Stage (ft)
Flow (cfs)
Site Time (MST)
Graph Created (10:00PM Nov 30, 2020)
Observed
LOVC2(plotting HGIRG) "Gage 0" Datum: 5720'
Observations courtesy of U.S. Geological Survey


CHERRY CREEK NEAR PARKER
Universal Time (UTC)
Latest observed value: 5.5 ft at 9:15 PM MST 30-Nov-2020. Flood Stage is 8.5 ft
Moderate: 10.0'
Minor: 8.5'
Action: 7.5'
5.64 ft
Stage (ft)
Flow (cfs)
Site Time (MST)
Graph Created (10:00PM Nov 30, 2020)
Observed
CPKC2(plotting HGIRG) "Gage 0" Datum: 5805'
Observations courtesy of US Geological Survey


CHERRY CREEK NEAR PARKER
Universal Time (UTC)
Latest observed value: 5.5 ft at 9:15 PM MST 30-Nov-2020. Flood Stage is 8.5 ft
Major: 12.0'
Moderate: 10.0'
Minor: 8.5'
Action: 7.5'
5.64 ft
Stage (ft)
Flow (cfs)
Site Time (MST)
Graph Created (10:00PM Nov 30, 2020)
Observed
CPKC2(plotting HGIRG) "Gage 0" Datum: 5805'
Observations courtesy of US Geological Survey


EAST PLUM CREEK ABOVE HASKINS GULCH NEAR CASTLE ROCK
Universal Time (UTC)
Latest observed value: 3.75 ft at 8:45 PM MST 30-Nov-2020. Flood Stage is 10 ft
Action: 8.5'
3.92 ft
Stage (ft)
Flow (cfs)
Site Time (MST)
Graph Created (10:00PM Nov 30, 2020)
Observed
PLMC2(plotting HGIRG) "Gage 0" Datum: 5960'
Observations courtesy of US Geological Survey


EAST PLUM CREEK ABOVE HASKINS GULCH NEAR CASTLE ROCK
Universal Time (UTC)
Latest observed value: 3.75 ft at 8:45 PM MST 30-Nov-2020. Flood Stage is 10 ft
Minor: 10.0'
Action: 8.5'
3.92 ft
Stage (ft)
Flow (cfs)
Site Time (MST)
Graph Created (10:00PM Nov 30, 2020)
Observed
PLMC2(plotting HGIRG) "Gage 0" Datum: 5960'
Observations courtesy of US Geological Survey



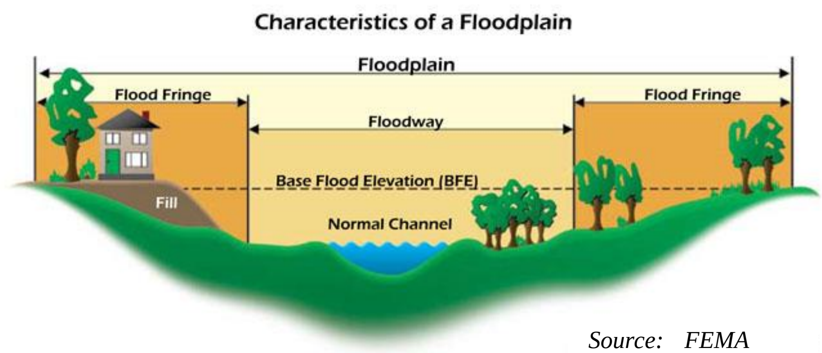
Source: NWS 2020

Location

Flooding potential is influenced by climatology, meteorology, and topography (elevations, latitude, and water bodies and waterways). Flooding potential for each type of flooding that affects the County is described in the subsections below.

Floodplains

A floodplain is defined as the land adjoining the channel of a river, stream, ocean, lake, or other watercourse or water body that becomes inundated with water during a flood. In Douglas County, floodplains line the rivers and streams of the County. The boundaries of the floodplains are altered as a result of changes in land use, the amount of impervious surface, placement of obstructing structures in floodways, changes in precipitation and runoff patterns, improvements in technology for measuring topographic features, and utilization of different hydrologic modeling techniques.



Source: FEMA 2009

Flood Map Terms

- Flood hazard areas identified on the Flood Insurance Rate Map are identified as a Special Flood Hazard Area (SFHA).
- SFHA = the area that will be inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year.
- 1-percent annual chance flood = the base flood or 100-year flood.
- SFHAs are labeled as Zone A, Zone AO, Zone AH, Zones A1-A30, Zone AE, Zone A99, Zone AR, Zone AR/AE, Zone AR/AO, Zone AR/A1-A30, Zone AR/A, Zone V, Zone VE, and Zones V1-V30.
- Zone B or Zone X (shaded) = Moderate flood hazard areas and are the areas between the limits of the base flood and the 0.2-percent-annual-chance (or 500-year) flood.
- Zone C or Zone X (unshaded) = Areas of minimal flood hazard, which are the areas outside the SFHA and higher than the elevation of the 0.2-percent-annual-chance flood, are labeled Zone C or Zone X (unshaded).

Source: FEMA, 2018

Flood hazard areas are identified as Special Flood Hazard Area (SFHA). SFHA are defined as the area that will be inundated by the flood event having a 1 percent chance of being equaled to or exceeded in any given year. The 1 percent annual chance flood is also referred to as the base flood or 100-year flood. A 100-year floodplain is not a flood that will occur once every 100 years; the designation indicates a flood that has a 1-percent chance of being equaled or exceeded each year. Thus, the 100-year flood could occur more than once in a relatively short period of time. Similarly, the moderate flood hazard area (500-year floodplain) will not occur every 500 years but is an event with a 0.2-percent chance of being equaled or exceeded each year (FEMA 2018). The 1-percent annual chance floodplain establishes the area that has flood insurance and floodplain management requirements.

Locations of flood zones in the County as depicted on the FEMA preliminary Digital Flood Insurance Rate Map (DFIRM) are illustrated in Figure 5-16 through Figure 5-20 and Table 5-45 summarizes the total land area in the floodplain, inclusive of waterbodies. Douglas County is located in three watersheds that cause flooding in the County: Upper South Platte, Middle South Platte, and Fountain. The South Fork of the South Platte is the major river in the County (Douglas County 2015).

The Digital Flood Insurance Rate Map (DFIRM) data provided by FEMA for the County show the following flood hazard areas:

- 1-Percent Annual Chance Flood Hazard: Areas subject to inundation by the 1-percent-annual-chance flood event. This includes Zone A, Zone AE, and Zone AO. Mandatory flood insurance requirements and floodplain management standards apply. Base flood elevations are provided in Zone AE. Zone AO has associated flood depths derived from detailed hydraulic analyses. Zone A has no determined flood depths.

- 0.2-Percent Annual Chance Flood Hazard: Area of minimal flood hazard, usually depicted on FIRMs as the 500-year flood level or Shaded X Zone.

Table 5-45 Total Land Area in the 1-Percent and 0.2-Percent Annual Chance Flood Zones (Acres)

Municipality	Total Area (acres)	1% Flood Event Hazard Area		0.2% Flood Event Hazard Area	
		Area (acres)	Percent (%) of Total	Area (acres)	Percent of Total
Castle Pines (C)	6,131	54	0.9%	54	0.9%
Castle Rock (T)	22,025	685	3.1%	937	4.3%
Larkspur (T)	1,013	118	11.6%	135	13.4%
Lone Tree (C)	6,280	124	2.0%	131	2.1%
Parker (T)	14,294	1,225	8.6%	2,010	14.1%
Unincorporated Douglas County	489,919	11,167	2.3%	12,208	2.5%
Douglas County (Total)	539,663	13,371	2.5%	15,475	2.9%

Source: FEMA 2020
Note: The area presented includes the area of waterways.

Flood Insurance in Douglas County

National Flood Insurance Program

Douglas County participates in the NFIP and has been in the program since 1987. All municipalities and the County with the exception of the City of Castle Pines participate in the National Flood Insurance Program. There are 385 policies in the County, with the vast majority of policies being in an unknown jurisdiction. Nearly $118 million in property is covered, with over $505,000 in losses paid.

Table 5-46 NFIP Status

Municipality	NFIP Status	Regular Program Entry Date	FIRM Effective Date
Castle Pines (C)	Not Participating	-	9/4/2020
Castle Rock (T)	Participating	8/15/1978	3/16/2016
Larkspur (T)	Participating	9/30/1987	9/30/2005
Lone Tree (C)	Participating	9/30/1980	9/4/2020
Parker (T)	Participating	9/30/1987	9/4/2020
Unincorporated Douglas County	Participating	9/30/1987	9/4/2020

Table 5-47 NFIP Statistics for Douglas County

Municipality	Total Premium	Total Policies	Value of Coverage	Total Losses	Losses Paid	RL	SRL
Castle Pines (C)	$0	0	$0	0	$0	0	0
Castle Rock (T)	$39,372	75	$21,752,400	5	$4,573	0	0
Larkspur (T)	$7,131	2	$732,000	0	$0	0	0
Lone Tree (C)	$11,425	20	$6,140,000	4	$4,105	0	0
Parker (T)	$28,723	58	$21,964,000	1	$0	0	0
Unincorporated Douglas County	$0	0	$0	1	$3,245	0	0
Unknown	$125,305	230	$67,339,800	43	$493,120	0	0
Douglas County (Total)	**$211,956**	**385**	**$117,928,200**	**54**	**$505,043**	**0**	**0**

Properties constructed after a FIRM has been adopted are eligible for reduced flood insurance rates. Such structures are less vulnerable to flooding since they were constructed after regulations and codes were adopted to decrease vulnerability. Properties built before a FIRM is adopted are more vulnerable to flooding because they do not meet code or are located in hazardous areas. The first FIRMs in Douglas County became available in 1977. New FIRM panels became effective in 1980, 1987, 1993, 1996, 2005, 2016, and 2017.

Community Rating System

The CRS is a voluntary program within the NFIP that encourages floodplain management activities that exceed the minimum NFIP requirements. Flood insurance premiums are discounted to reflect the reduced flood risk resulting from community actions meeting the following three goals of the CRS:

- Reduce flood losses.
- Facilitate accurate insurance rating.
- Promote awareness of flood insurance.

For participating communities, flood insurance premium rates are discounted in increments of 5 percent. For example, a Class 1 community would receive a 45 percent premium discount, and a Class 9 community would receive a 5 percent discount. (Class 10 communities are those that do not participate in the CRS; they receive no discount.) The discount partially depends on location of the property. Properties outside the SFHA receive smaller discounts: a 10-percent discount if the community is at Class 1 to 6 and a 5-percent discount if the community is at Class 7 to 9. The CRS classes for local communities are based on 18 creditable activities in the following categories:

- Public information
- Mapping and regulations
- Flood damage reduction
- Flood preparedness

CRS activities can help to save lives and reduce property damage. Communities participating in the CRS represent a significant portion of the nation's flood risk; over 66 percent of the NFIP's policy base is located in these communities. Communities receiving premium discounts through the CRS range from small to large and represent a broad mixture of flood risks, including both coastal and riverine flood risks.

Multiple jurisdictions in Douglas County participate in the CRS program.

- Douglas County entered the CRS program on October 1, 1996 and is currently ranked as a Class 5 community. This provides residents within the SFHA, who have NFIP-backed flood insurance, a 25% discount on their flood insurance premiums.
- The Town of Parker entered the CRS program on October 1, 1992 and is currently ranked as a Class 5 community. This provides residents within the SFHA, who have NFIP-backed flood insurance, a 25% discount on their flood insurance premiums (FEMA 2020).

Figure 5-16. FEMA DFIRM Flood Hazard Areas in Douglas County

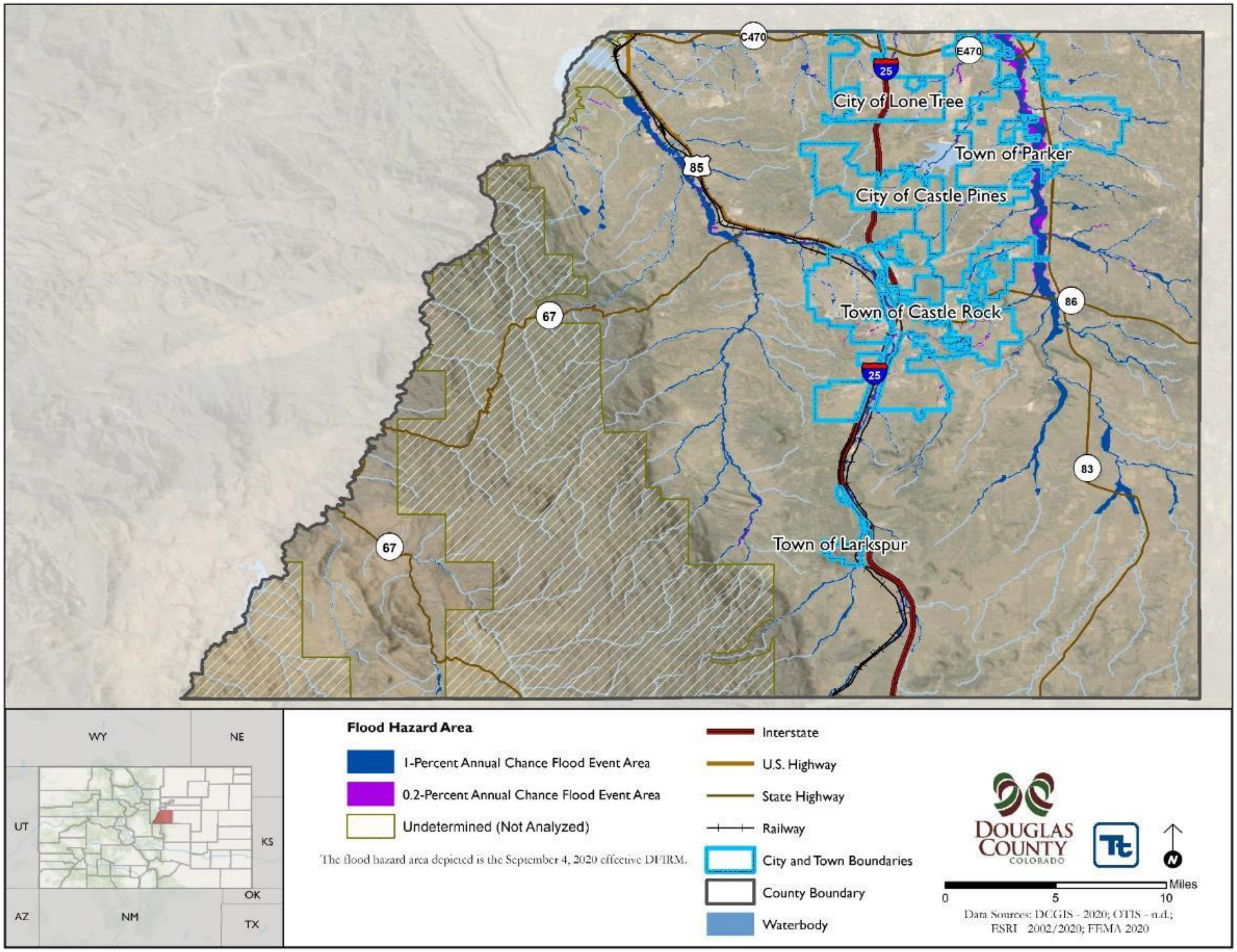


Figure 5-17. FEMA DFIRM Flood Hazard Areas in Douglas County (Northeast)

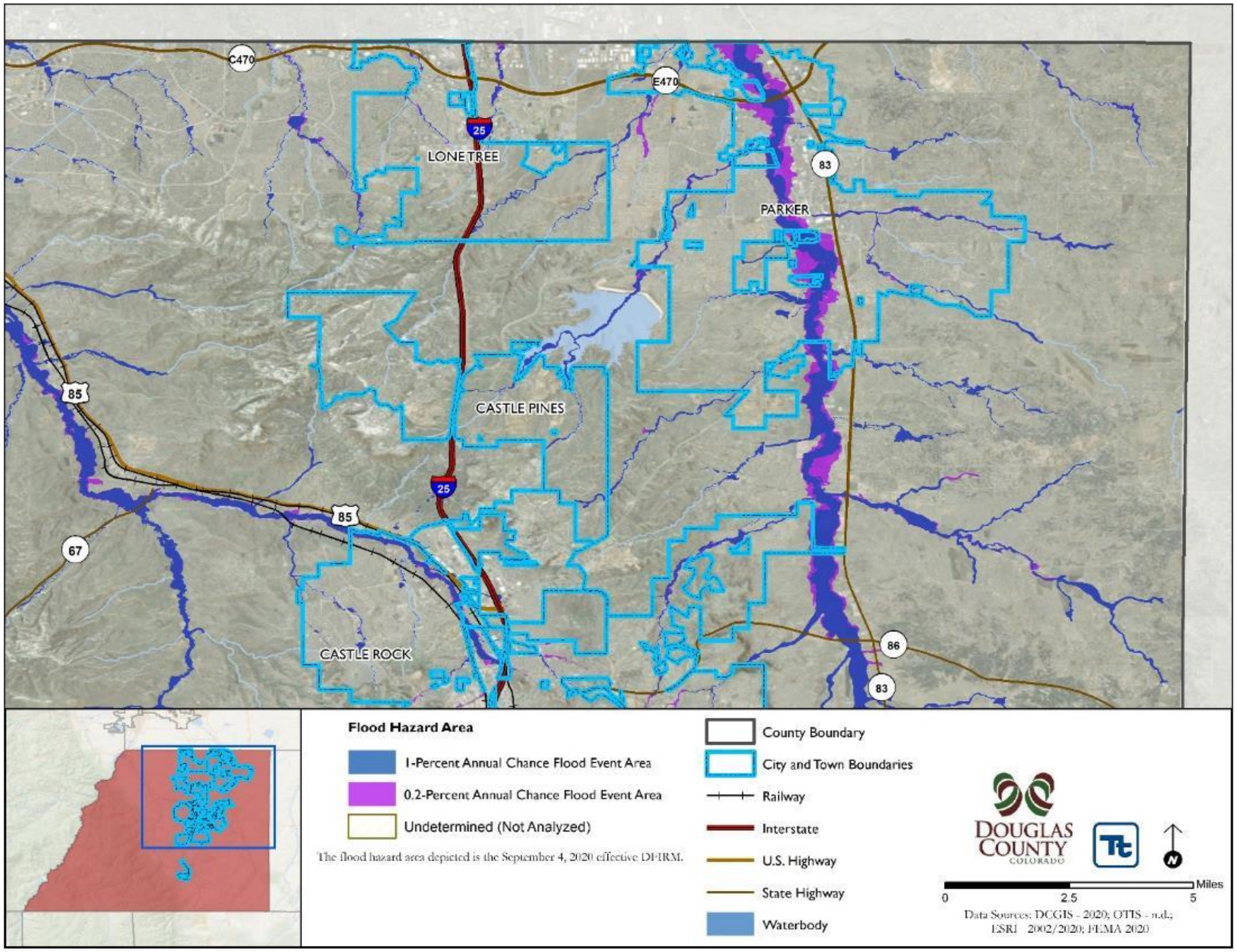


Figure 5-18. FEMA DFIRM Flood Hazard Areas in Douglas County (Northwest)

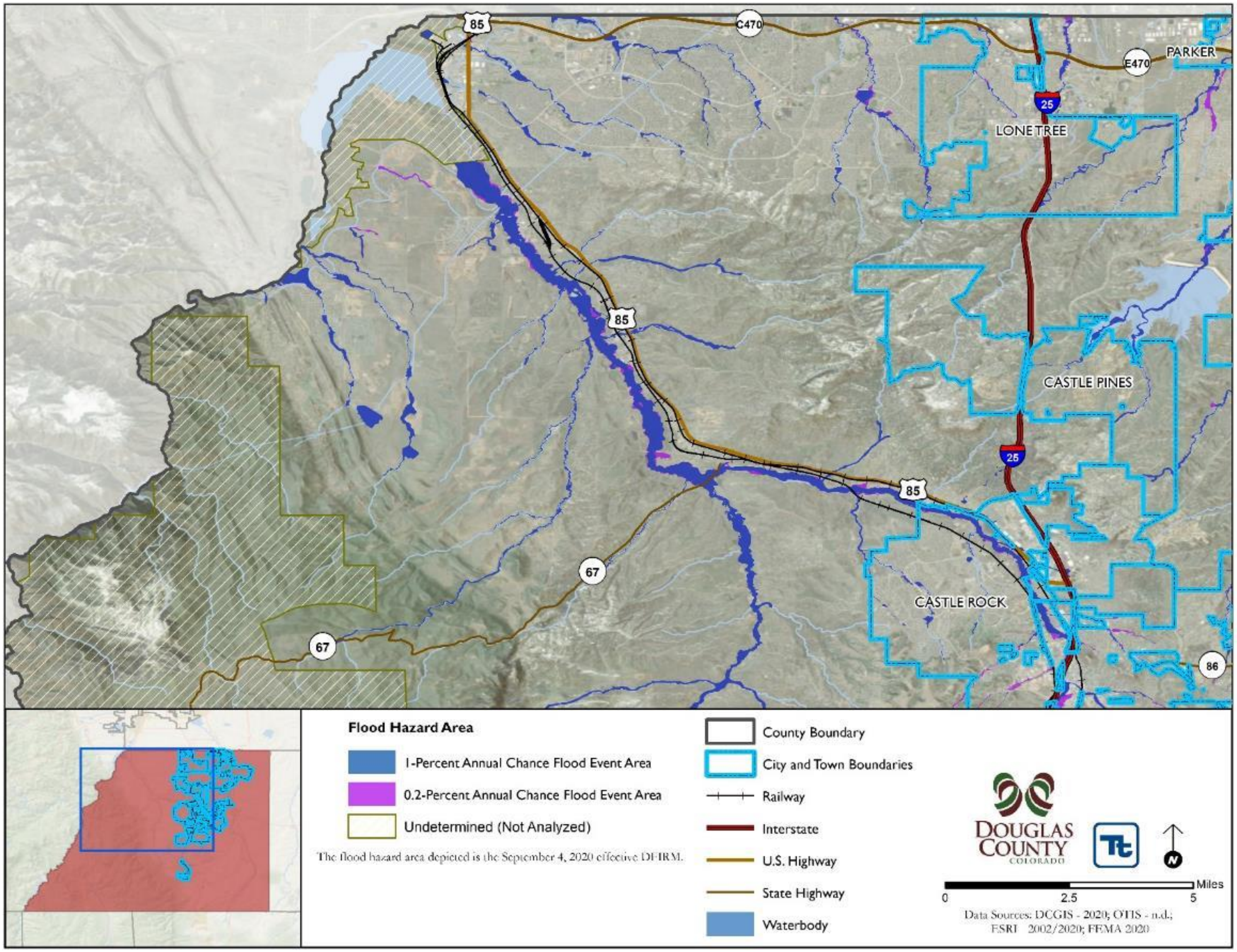


Figure 5-19. FEMA DFIRM Flood Hazard Areas in Douglas County (Southeast)

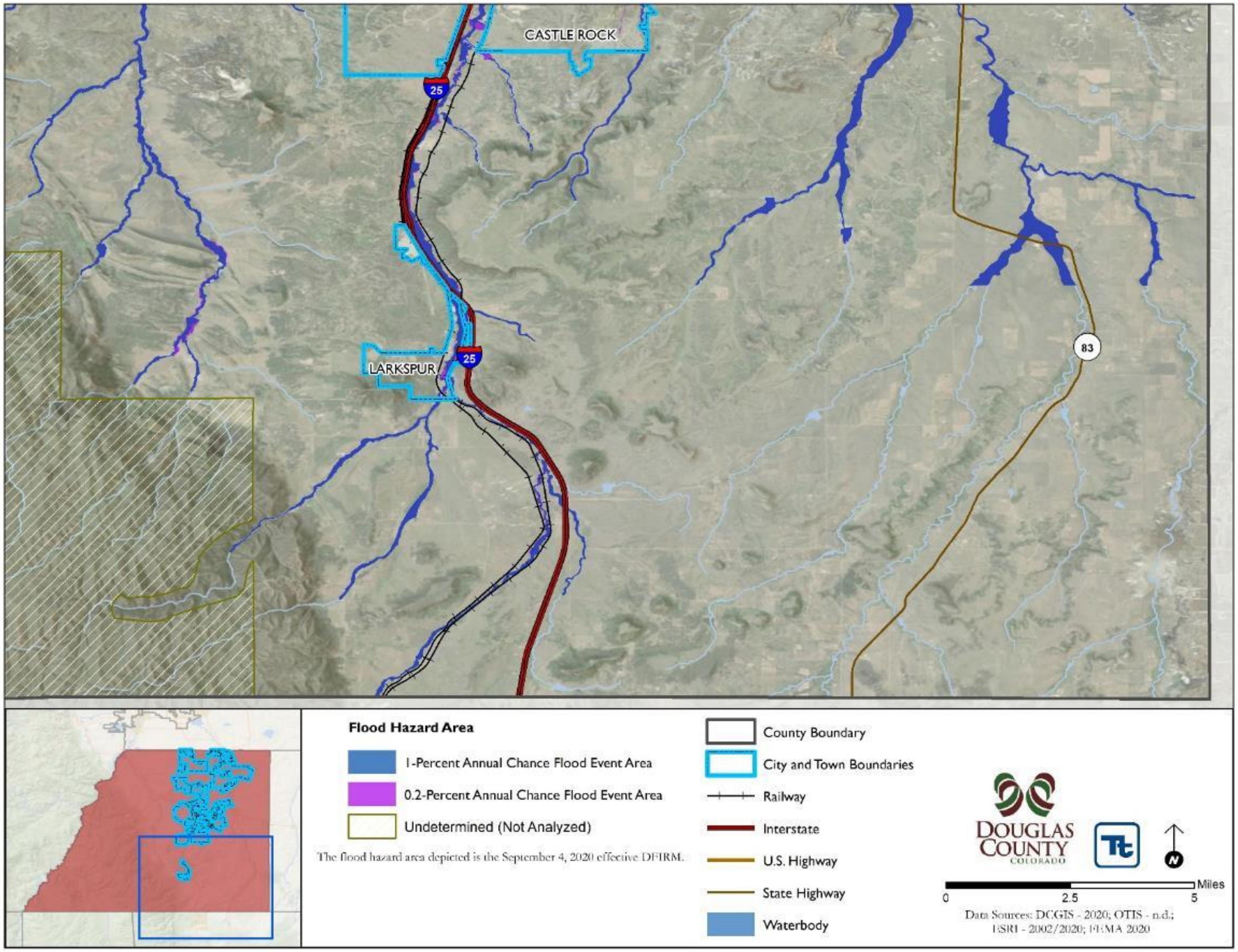
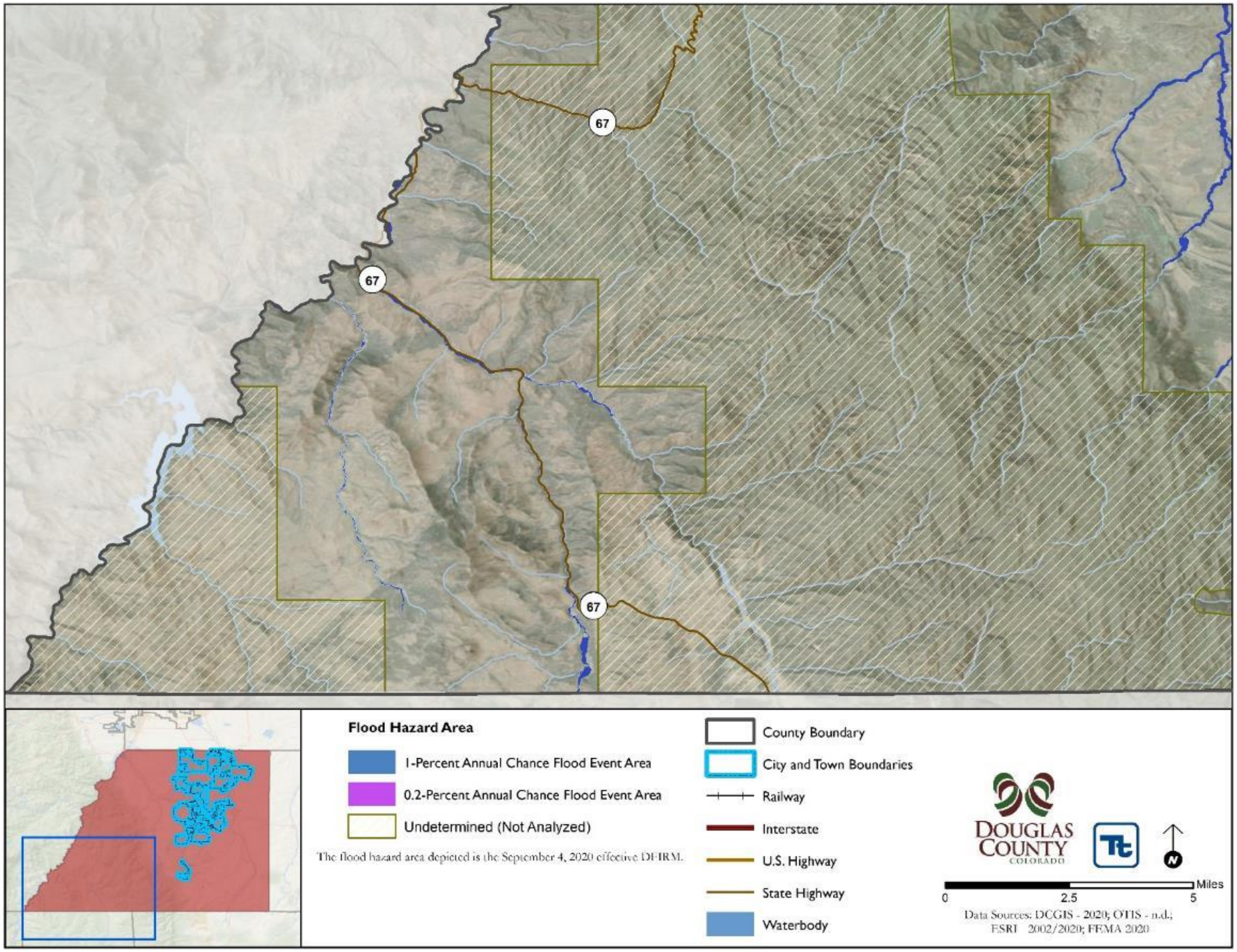


Figure 5-20. FEMA DFIRM Flood Hazard Areas in Douglas County (Southwest)



Previous Occurrences and Losses

Many sources have provided historical information regarding previous occurrences and losses associated with floods in Douglas County. According to the NOAA-NCEI Storm Events Database, Douglas County has been impacted by four flood events between 2014 and 2020 that caused $60,000 in property damage (refer to Table 5-48).

Table 5-48 Flood Events in Douglas County, 2014-2020

Hazard Type	Number of Occurrences Between 2014 and 2020	Total Fatalities	Total Injuries	Total Property Damage ($)	Total Crop Damage ($)
Flash Flood	2	0	0	$30,000	$10,000
Flood	2	0	0	$30,000	$10,000
TOTAL	**4**	**0**	**0**	$60,000	$20,000

Source: NOAA-NCEI 2020

Between 1953 and 2020, FEMA included the State of Colorado in 13 flood-related major disaster (DR) or emergency (EM) declarations. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. Douglas County was included in two of these flood-related declarations; refer to Table 5-49 .

Table 5-49 Flood-Related FEMA Declarations for Douglas County, 1953 to 2020

FEMA Declaration Number	Date(s) of Event	Incident Type	Incident Title
DR-261	May 19, 1969	Flood	Severe Storms and Flooding
DR-385	May 23, 1973	Flood	Heavy Rains, Snowmelt, and Flooding

Source: FEMA 2020

This HMP update includes known flood events that have impacted Douglas County between 2014 and 2020. These events are shown in Table 5-50 . The events listed in Table 5-50 represent only those that were reported to the NOAA-NCEI Storm Events Database and/or resulted in a FEMA disaster declaration; therefore, the table may not represent all flood events that have occurred since 2014.

Table 5-50 Flood Events in Douglas County, 2014 to 2020

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Fatalities	Injuries	Damages	Event Details*
July 12, 2014	Flash Flood	N/A	N/A	0	0	$15,000 in property damage, $10,000 in crop damage	Douglas County experienced flash flooding, where heavy rain pushed mud and debris across US 85 near Airport Road. Floodwaters on Moore and Titan Roads were 6 to 8 inches deep.
June 11, 2015	Flash Flood	N/A	N/A	0	0	$15,000 in property damage	Flash flooding in Douglas County resulted from thunderstorms producing heavy rainfall.
June 12, 2015	Flood	N/A	N/A	0	0	$15,000 in property damage	The following day after flash flooding, Douglas County experienced flooding. The flooding closed four trails in Castle Rock. The flooding resulted from thunderstorms producing heavy rainfall.
June 14-June 22, 2015	Flood	N/A	N/A	0	0	$15,000 in property damage, $10,000 in crop damage	Douglas County and Jefferson County experienced flooding after thunderstorms produced heavy rain and hail, leading to snowmelt. This caused a prolonged period of flooding, with southwestern Douglas County being impacted the most. Various roads were closed, including Trumbull Bridge and South West Platte River Road, were damaged and remained closed. The South Platte River's use was restricted while the river was swollen.

Sources: NOAA-NCEI 2020; FEMA 2020; Douglas County Sheriff

** Many sources were consulted to provide an update of previous occurrences and losses; event details and loss/impact information may vary and has been summarized in the above table*

- Not available/not recorded
FEMA Federal Emergency Management Agency
NCEI National Centers for Environmental Information
NOAA National Oceanic and Atmospheric Administration
NWS National Weather Service

Climate Change Projections

The climate of Colorado is changing. Most of the State has warmed between one to two degree Fahrenheit in the past century. In the eastern two-thirds of the State, average annual rainfall is increasing; however, the soil is becoming drier. Rainstorms are more frequent and intense, with precipitation increasingly falling as rain rather than snow. In the coming decades, storms are likely to become more severe in Colorado (EPA 2016). Major clusters of summertime thunderstorms in North America will grow larger, more intense, and more frequent later this century in a changing climate, leading to increased rainfall and posing a greater threat of flooding across wide areas (University Corporation for Atmospheric Research [UCAR] 2017).

Probability of Future Occurrences

Based on the historic and more recent flood events in Douglas County, and the future climate projections for this region, the County has a moderate probability of future flooding. It is anticipated that Douglas County will continue to experience direct and indirect impacts of flooding events annually that may induce secondary hazards such as infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays, accidents and inconveniences. Additionally, climate change is expected to increase the severity and frequency of heavy rain events in Douglas County. This is likely to lead to an increase in flooding events and dam failure events.

As defined by FEMA, Douglas County's 1-percent annual chance flood area is estimated to have a one-percent chance of flooding in any given year. A structure located within a 1-percent annual chance flood area has a 26-percent chance of suffering flood damage during the term of a 30-year mortgage. Similarly, the 0.2-percent annual chance flood has a 6-percent chance of occurring during a 30-year time period.

Table 5-51 calculates the probability of future flood events for Douglas County. Using FEMA disaster declarations and NOAA-NCEI storm events database, 46 flood events have impacted Douglas County between 1954 and 2020.

Table 5-51 Probability of Future Occurrence of Flood Events

Hazard Type	Number of Occurrences Between 1954 and 2020	% chance of occurrence in any given year
Flood	6	8.9%
Flash Flood	40	59.7%

Source: NOAA-NCEI 2020; FEMA 2020
Note: This calculation does not include all flood events that occurred in this time period due to data limitations. The numbers presented here are presented as low estimates.

Based on historical records and input from the Core Planning Team, the probability of occurrence for flood events in the County is considered *high* (likely to occur within 25 years). Refer to Sections 5.1 and 5.3 for additional information on the hazard ranking methodology and probability criteria.

Vulnerability Assessment

To assess Douglas County's risk to the flood hazard, a spatial analysis was conducted using the best available spatially-delineated flood hazard areas. The 1-percent annual chance flood event was examined to determine the assets located in the hazard areas and to estimate potential loss using the FEMA Hazus v4.2 riverine model and an exposure analysis was conducted on both the 1- and 0.2-percent annual chance flood event. These results are summarized below. Refer to Section 5.1 (Methodology) for additional details on the methodology used to assess flood risk.

Impact on Life, Health and Safety

The impact of flooding on life, health and safety is dependent upon several factors including the severity of the event and whether adequate warning time is provided to residents. Exposure represents the population living in or near floodplain areas that could be impacted should a flood event occur. However, exposure is not limited to persons who reside in a defined hazard zone, but includes all individuals who may be affected by the effects of a hazard event (e.g., people are at risk while traveling in flooded areas, or their access to emergency services is compromised during an event). The degree of that impact will vary and is not strictly measurable.

Based on the spatial analysis, there are an estimated 595 people living in the 1-percent annual chance flood event hazard area and 4,775 people living in the 0.2-percent annual chance flood event area (refer to Table 5-52). These residents may be displaced due to their homes flooding, requiring them to seek temporary shelter with friends and family or in emergency shelters.

The Town of Larkspur has the greatest percentage of its population located in the 1-percent annual chance flood event hazard area; approximately 5.8-percent or 257 persons. Douglas County unincorporated area has the greatest number of residents located in the 1- and the 0.2-percent annual chance flood event hazard area; approximately 540 persons and 1,581 persons, respectively. Overall, 1.5-percent of the Douglas County's residence live in the 0.2-percent annual chance flood event hazard area. For this project, the potential population exposed is used as a guide for planning purposes.

Table 5-52 Estimated Population Exposed to the 1-Percent and 0.2-Percent Annual Chance Flood Event Hazard Areas

Jurisdiction	American Community Survey (2014-2018) Population	Estimated Population Exposed to the Flood Hazard Areas			
		1-percent Annual Chance Flood Hazard Event Area		0.2-percent Annual Chance Flood Hazard Event Area	
		Number of People	Percent of Total	Number of People	Percent of Total
Castle Pines (C)	10,573	0	0.0%	0	0.0%
Castle Rock (T)	59,680	3	<0.1%	122	0.2%
Larkspur (T)	257	15	5.8%	20	7.9%
Lone Tree (C)	14,209	0	0.0%	0	0.0%
Parker (T)	52,563	38	0.1%	3,052	5.8%
Unincorporated Douglas County	191,332	540	0.3%	1,581	0.8%
Douglas County (Total)	**328,614**	**595**	**0.2%**	**4,775**	**1.5%**

Sources: FEMA DFIRM 2020; American Community Survey 2018 (ACS 2014-2018)
Note: C= City; T= Town

Research has shown that some populations, while they may not have more hazard exposure, may experience exacerbated impacts and prolonged recovery if/when impacted. This is due to many factors including their physical and financial ability to react or respond during a hazard. Of the population exposed, the most vulnerable include the economically disadvantaged and the population over age 65. Economically disadvantaged populations may be more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on net economic impacts on their families. The population over age 65 is also more vulnerable because they are more likely to seek or need medical attention that may not be available due to isolation during a flood event, and they may have more difficulty evacuating.

Within Douglas County, there are approximately 35,801 people over the age of 65 and 11,333 people below the poverty level (American Community Survey 2018).

The Centers for Disease Control and Prevention (CDC) 2016 Social Vulnerability Index (SVI) ranks U.S. Census tracts on socioeconomic status, household composition and disability, minority status and language, and housing and transportation. Douglas County's overall score is 0.0175, indicating that its communities have a relatively low social vulnerability (CDC 2016). However, portions of the Town of Castle Rock have scores of 0.6058, indicating these communities have a relatively high social vulnerability (CDC 2016). These scores indicate that some County residents may not have enough resources to respond to flood events.

Using 2010 U.S. Census data, Hazus v4.2 estimates the potential sheltering needs as a result of a 1-percent annual chance flood event. For the 1-percent flood event, Hazus v4.2 estimates 2,552 persons will be displaced, and 67 people will seek short-term sheltering. These statistics are presented in Table 5-53 by jurisdiction. The estimated displaced population and number of persons seeking short-term sheltering differs from the number of persons exposed to the 1-percent annual chance flood because the displaced population numbers take into consideration that not all residents will be significantly impacted enough to be displaced or to require short-term sheltering during a flood event. Displaced population accounts for households in the inundation area that would be displaced due to evacuations or restricted access due to flooded roadways.

Table 5-53 Estimated Population Displaced or Seeking Short-Term Shelter from the 1-Percent Annual Chance Flood Event Hazard Area

Municipality	American Community Survey (2014-2018) Population	1-Percent Annual Chance Flood Event Area	
		Displaced Population	Persons Seeking Short-Term Sheltering
Castle Pines (C)	10,573	0	0
Castle Rock (T)	59,680	322	7
Larkspur (T)	257	4	0
Lone Tree (C)	14,209	20	0
Parker (T)	52,563	1,033	49
Unincorporated Douglas County	191,332	1,173	11
Douglas County (Total)	**328,614**	**2,552**	**67**

Sources: Hazus v4.2; FEMA 2020; American Community Survey 2018 (ACS 2014-2018)
Note: C= City; V= Village
*Population results generated by Hazus-MH v4.2 are using 2010 Census population statistics and may be underestimated

Injuries and Casualties

Total number of injuries and casualties resulting from typical riverine flooding are generally limited based on advance weather forecasting, blockades, and warnings. Injuries and deaths generally are not anticipated if proper warning and precautions occur. In contrast, warning time for flash flooding, ice jam, and dam failure is limited. These events are frequently associated with other natural hazard events such as earthquakes, landslides, or severe weather, which limits their predictability and compounds the hazard. Populations without adequate warning of the event are highly vulnerable to this hazard.

Public Health Impacts

Cascading impacts of flooding may also include exposure to pathogens such as mold. After flood events, excess moisture and standing water contribute to the growth of mold in buildings. Mold may present a health risk to building occupants, especially those with already compromised immune systems such as infants, children, the elderly and pregnant women. The degree of impact will vary and is not strictly measurable. Mold spores can grow in as short a period as 24-48 hours in wet and damaged areas of buildings that have not been properly cleaned. Very small mold spores can easily be inhaled, creating the potential for allergic reactions, asthma episodes, and other respiratory problems. Buildings should be properly cleaned and dried out to safely prevent mold growth (CDC 2015).

Molds and mildews are not the only public health risk associated with flooding. Floodwaters can be contaminated by pollutants such as sewage, human and animal feces, pesticides, fertilizers, oil, asbestos, and rusting building materials. Common public health risks associated with flood events also include:

- Unsafe food
- Contaminated drinking and washing water and poor sanitation
- Mosquitos and animals
- Carbon monoxide poisoning
- Secondary hazards associated with re-entering/cleaning flooded structures
- Mental stress and fatigue

Current loss estimation models such as Hazus are not equipped to measure public health impacts. The best level of mitigation for these impacts is to be aware that they can occur, educate the public on prevention, and be prepared to deal with these vulnerabilities in responding to flood events.

Impact on General Building Stock

Exposure to the flood hazard includes those buildings located in the flood zone or those that are built downstream in other flood inundation areas such as dam failure inundation areas. Potential damage is the modeled loss that could occur to the exposed inventory measured by the structural and content replacement cost value.

There are an estimated 458 buildings located in the 1-percent annual chance flood event hazard area with a value of approximately $301 million of building and contents (based on replacement cost value). This represents approximately 0.2-percent of the County's total general building stock inventory replacement cost value (approximately $182 billion). The Town of Larkspur has the greatest percentage of its buildings located in the floodplain; 6.9-percent or 27 buildings of its total building stock. Unincorporated areas in Douglas County have an estimated 392 buildings located in the 1-percent annual chance flood event area and 894 buildings located in the 0.2-percent annual chance flood event area. The Town of Parker has the largest number of buildings in the 0.2-percent annual chance flood event area (6.3-percent), 1,129 buildings and 7.1-percent of the total building stock ($1.68 billion). Table 5-54 presents a summary of 1- and 0.2 percent flood inundation area exposure results by jurisdiction. Table 5-55 and Table 5-56 break down the 1-percent and 0.2-percent annual chance flood event exposure results for residential structures and commercial structures, respectively.

Furthermore, Hazus v4.2 estimates approximately $25.6 million in building and content damage as a result of the 1-percent annual chance flood event (or less than 0.1-percent of the total building stock replacement cost value). Of the $25.6 million in potential loss, approximately $15.2 million losses (59.4-percent) are estimated to occur to residential structures. Refer to Table 5-57 for the potential losses from the 1-percent annual chance flood event for all occupancies estimated by jurisdiction. Table 5-58, Table 5-59, and Table 5-60 summarize Hazus v4.2 estimated damages for residential, commercial occupancy classes, and all other occupancies, respectively.

Table 5-54 Estimated General Building Stock Exposure to the 1-Percent and 0.2-Percent Annual Chance Flood Events

Jurisdiction	Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Exposed to the Flood Hazard Areas (All Occupancies)							
			1-percent Annual Chance Flood Hazard Event Area				0.2-percent Annual Chance Flood Hazard Event Area			
			Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total	Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total
Castle Pines (C)	3,701	$4,995,772,208	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Castle Rock (T)	24,262	$28,003,310,038	6	<0.1%	$8,839,879	<0.1%	82	0.3%	$649,788,001	2.3%
Larkspur (T)	394	$135,724,576	27	6.9%	$18,668,924	13.8%	38	9.6%	$25,039,714	18.4%
Lone Tree (C)	4,190	$23,664,803,217	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Parker (T)	17,864	$23,597,914,712	33	0.2%	$19,612,863	0.1%	1,129	6.3%	$1,679,537,656	7.1%
Unincorporated Douglas County	84,745	$102,018,837,713	392	0.5%	$253,956,677	0.2%	894	1.1%	$761,156,674	0.7%
Douglas County (Total)	**135,156**	**$182,416,362,464**	**458**	**0.3%**	**$301,078,343**	**0.2%**	**2143**	**1.6%**	**$3,115,522,044**	**1.7%**

Sources: FEMA 2020, Douglas County GIS 2020; RS Means 2020
Note: C= City; T = Town

Table 5-55 Estimated General Building Stock Exposure to the 1-percent and 0.2- Percent Annual Chance Flood Events – Residential Occupancy Class

Jurisdiction	Number of Buildings	Total Replacement Cost Value (RCV) - Residential Occupancy	Estimated Building Stock Exposed to the Flood Hazard Areas (Residential Occupancy)							
			1-percent Annual Chance Flood Hazard Event Area				0.2-percent Annual Chance Flood Hazard Event Area			
			Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total	Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total
Castle Pines (C)	3,610	$4,678,591,960	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Castle Rock (T)	22,939	$22,069,828,170	1	<0.1%	$1,707,902	<0.1%	47	0.2%	$384,606,851	1.7%
Larkspur (T)	330	$61,629,261	19	5.8%	$6,734,550	10.9%	26	7.9%	$8,915,380	14.5%
Lone Tree (C)	3,835	$9,414,618,130	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Parker (T)	16,792	$17,580,831,920	12	0.1%	$9,576,206	0.1%	975	5.8%	$1,234,815,224	7.0%
Unincorporated Douglas County	78,320	$77,647,371,278	224	0.3%	$118,537,327	0.2%	647	0.8%	$404,058,305	0.5%
Douglas County (Total)	**125,826**	**$131,452,870,718**	**256**	**0.2%**	**$136,555,984**	**0.1%**	**1,695**	**1.3%**	**$2,032,395,760**	**1.5%**

Sources: FEMA 2020, Douglas County GIS 2020; RS Means 2020
Note: C= City; T = Town

Table 5-56 Estimated General Building Stock Exposure to the 1-percent and 0.2- Percent Annual Chance Flood Events – Commercial Occupancy Class

Jurisdiction	Number of Buildings	Total Replacement Cost Value (RCV) - Commercial Occupancy	Estimated Building Stock Exposed to the Flood Hazard Areas (Commercial Occupancy)							
			1-percent Annual Chance Flood Hazard Event Area				0.2-percent Annual Chance Flood Hazard Event Area			
			Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total	Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total
Castle Pines (C)	49	$117,118,414	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Castle Rock (T)	936	$3,742,436,370	2	0.2%	$3,418,167	0.1%	30	3.2%	$218,900,743	5.8%
Larkspur (T)	32	$26,178,377	4	12.5%	$2,076,344	7.9%	6	18.8%	$3,533,938	13.5%
Lone Tree (C)	289	$13,868,238,675	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Parker (T)	697	$4,279,983,009	8	1.1%	$5,937,509	0.1%	83	11.9%	$269,373,365	6.3%
Unincorporated Douglas County	2,215	$16,865,120,359	37	1.7%	$29,136,715	0.2%	66	3.0%	$79,279,881	0.5%
Douglas County (Total)	**4,218**	**$38,899,075,203**	**51**	**1.2%**	**$40,568,734**	**0.1%**	**185**	**4.4%**	**$571,087,928**	**1.5%**

Sources: FEMA 2020, Douglas County GIS 2020; RS Means 2020
Note: C= City; T = Town

Table 5-57 Estimated General Building Stock Potential Loss to the 1-Percent Annual Chance Flood Event – All Occupancies

Jurisdiction	Total Replacement Cost Value	All Occupancies	
		Estimated Loss	Percent of Total
Castle Pines (C)	$4,995,772,208	$0	0.0%
Castle Rock (T)	$28,003,310,038	$246,320	0.0%
Larkspur (T)	$135,724,576	$103,107	0.1%
Lone Tree (C)	$23,664,803,217	$0	0.0%
Parker (T)	$23,597,914,712	$2,316,932	<0.1%
Unincorporated Douglas County	$102,018,837,713	$22,914,069	<0.1%
Douglas County (Total)	**$182,416,362,464**	**$25,580,429**	**<0.1%**

Sources: Hazus v4.2; FEMA 2020, Douglas County GIS 2020; RS Means 2020
Note: C= City, T = Town

Table 5-58 Estimated General Building Stock Potential Loss to the 1-Percent Annual Chance Flood Event – Residential Occupancy Class

Jurisdiction	Total Replacement Cost Value	Residential		
		Total Replacement Cost Value (Residential Occupancy Class)	Estimated Loss	Percent of Total
Castle Pines (C)	$4,995,772,208	$4,678,591,960	$0	0.0%
Castle Rock (T)	$28,003,310,038	$22,069,828,170	$0	0.0%
Larkspur (T)	$135,724,576	$61,629,261	$103,107	0.2%
Lone Tree (C)	$23,664,803,217	$9,414,618,130	$0	0.0%
Parker (T)	$23,597,914,712	$17,580,831,920	$36,293	<0.1%
Unincorporated Douglas County	$102,018,837,713	$77,647,371,278	$15,058,753	<0.1%
Douglas County (Total)	**$182,416,362,464**	**$131,452,870,718**	**$15,198,153**	**<0.1%**

Sources: Hazus v4.2; FEMA 2020, Douglas County GIS 2020; RS Means 2020
Note: C= City, T = Town

Table 5-59 Estimated General Building Stock Potential Loss to the 1-Percent Annual Chance Flood Event – Commercial Occupancy Class

Jurisdiction	Total Replacement Cost Value	Commercial		
		Total Replacement Cost Value (Commercial Occupancy Class)	Estimated Loss	Percent of Total
Castle Pines (C)	$4,995,772,208	$117,118,414	$0	0.0%
Castle Rock (T)	$28,003,310,038	$3,742,436,370	$0	0.0%
Larkspur (T)	$135,724,576	$26,178,377	$0	0.0%
Lone Tree (C)	$23,664,803,217	$13,868,238,675	$0	0.0%
Parker (T)	$23,597,914,712	$4,279,983,009	$233,840	<0.1%
Unincorporated Douglas County	$102,018,837,713	$16,865,120,359	$585,469	<0.1%
Douglas County (Total)	**$182,416,362,464**	**$38,899,075,203**	**$819,309**	**<0.1%**

Sources: Hazus v4.2; FEMA 2020, Douglas County GIS 2020; RS Means 2020
Note: C= City, T = Town

Table 5-60 Estimated General Building Stock Potential Loss to the 1-Percent Annual Chance Flood Event – Agricultural, Industrial, Religious, Education, and Government Occupancies

Jurisdiction	Total Replacement Cost Value	Agricultural, Industrial, Religious, Education and Government		
		Total Replacement Cost Value (All Other Occupancy Classes)	Estimated Loss	Percent of Total
Castle Pines (C)	$4,995,772,208	200,061,834	$0	0.0%
Castle Rock (T)	$28,003,310,038	2,191,045,499	$246,320	<0.1%
Larkspur (T)	$135,724,576	47,916,938	$0	0.0%
Lone Tree (C)	$23,664,803,217	381,946,412	$0	0.0%
Parker (T)	$23,597,914,712	1,737,099,783	$2,046,799	0.1%
Unincorporated Douglas County	$102,018,837,713	7,506,346,076	$7,269,847	0.1%
Douglas County (Total)	**$182,416,362,464**	**12,064,416,543**	**$9,562,966**	**0.1%**

Sources: Hazus v4.2; FEMA 2020, Douglas County GIS 2020; RS Means 2020
Note: C= City, T = Town

NFIP Statistics

FEMA Region 8 provided a list of NFIP policies, past claims, and payments in Douglas County. According to FEMA, a RL property is a NFIP-insured structure that has had at least two paid flood losses of more than $1,000 in any 10-year period since 1978 (FEMA, 2005). A SRL property is a NFIP-insured structure that has had four or more separate claim payments made under a standard flood insurance policy, with the amount of each claim exceeding $5,000 and with the cumulative amount of such claims payments exceeding $20,000; or at least two separate claims payments made under a standard flood insurance policy with the cumulative amount of such claim payments exceed the fair market value of the insured building on the day before each loss. Table 5-61 shows that the number of claims compared to the number of policies in Douglas County. In some cases, the number of claims may exceed the number of policies. This is likely because multiple repetitive loss properties submitted more than one flood loss claim under their NFIP policies. Note that specific locations of repetitive loss properties were not made available for this Plan.

Table 5-61 NFIP Data for Douglas County

Jurisdiction	Number of NFIP Policies	Number of Write Your Own Policies	Total Number of Policies	Number of NFIP Claims	Number of Write Your Own Claims	Total Claims	Total NFIP Payments	Total Write Your Own Payments	Total Payments
Castle Pines (C)	0	0	0	0	0	0	$0	$0	$0
Castle Rock (T)	6	69	75	0	5	5	$0	$4,573	$4,573
Larkspur (T)	0	2	2	0	5	5	$0	$0	$0
Lone Tree (C)	2	18	2	0	4	4	$0	$4,105	$4,105
Parker (T)	7	51	58	0	1	1	$0	$0	$0
Unincorporated Douglas County	7	231	31	7	42	49	$33,000	$480,770	$513,770
Douglas County (Total)	**22**	**371**	**168**	**561**	**57**	**64**	**$33,000**	**$489,448**	**$522,448**

Source: FEMA Region 8, 2020
Note: NFIP = National Flood Insurance Program, C= City, T = Town

Impact on Land Uses

An exposure analysis was completed to determine the acres of developed residential land and developed non-residential land use types located in the 1-percent flood hazard area. To estimate exposure for developed residential and non-residential land use types to the 1-percent flood hazard area, the floodplain boundary was overlaid upon land use data. Refer to Table 5-62 for a complete summary of this analysis.

Table 5-62 Developed Residential and Non-Residential Land Use Exposed to 1-Percent and 0.2-Percent Annual Chance Flood Event Hazard Areas

Land Use Type	Total Acres for County	1-Percent Annual Chance Flood Hazard Event Area		0.2-Percent Annual Chance Flood Hazard Event Area	
		Acres	Percent of Total	Acres	Percent of Total
Residential Land	36,087	386	1.1%	919	2.5%
Non-Residential Land	501,498	12,644	2.5%	14,207	2.8%
Natural Land	254,730	6,443	2.5%	6,788	2.7%
Douglas County (Total Acres)	**537,585**	**13,029**	**2.4%**	**15,126**	**2.8%**

Sources: FEMA 2020, Douglas County GIS 2020; NLCD 2016
Notes: Land use areas do not include areas of water. Non-residential area = Agriculture, Barren, Developed – Open Space, Forest, Wetlands; This analysis does not incorporate areas delineated as water. Residential area = Developed – low intensity, Developed – medium intensity, and Developed – high intensity.

Impact on Critical Facilities

It is important to determine the critical facilities and infrastructure that may be at risk to flooding, and who may be impacted should damage occur. Critical services during and after a flood event may not be available if critical facilities are directly damaged or transportation routes to access these critical facilities are impacted. Roads that are blocked or damaged can isolate residents and can prevent access throughout the planning area to many service providers needing to reach vulnerable populations or to make repairs.

Critical facility exposure to the 1- and 0.2-percent annual chance flood hazard event boundary was examined. In addition, Hazus v4.2 was used to estimate the flood loss potential to critical facilities located in the FEMA mapped floodplains. Hazus results can be found in Section 9, Jurisdiction Annexes. Table 5-63 and Table 5-64 summarize the number of critical facilities exposed to the 1-percent and 0.2-percent flood inundation areas by jurisdiction. Table 5-65 and 68 provide the distribution of critical facilities in the 1-percent and 0.2-percent annual chance flood event boundary. Of the 75 critical facilities located in the 1-percent annual chance flood event boundary, 70 are considered lifelines for the County (Table 5-67). Table 5-67 summarizes the distribution of lifeline types and exposure to the 1-percent and 0.2-percent annual chance flood event. Overall, the majority of lifelines vulnerable to flood events are either for safety and security or for food, water, or shelter. Refer to Section 4 (County Profile) for more information about the critical facilities and lifelines in Douglas County.

Table 5-63 Number of Critical and Lifeline Facilities Located in the 1-Percent Annual Chance Flood Hazard Area

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Exposed to the 1-Percent Annual Chance Flood Event			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Castle Pines (C)	20	12	1	5.0%	1	8.3%
Castle Rock (T)	108	100	1	0.9%	1	1.0%
Larkspur (T)	15	9	2	13.3%	2	22.2%
Lone Tree (C)	54	42	1	1.9%	1	2.4%
Parker (T)	140	105	4	2.9%	1	1.0%
Unincorporated Douglas County	827	703	66	8.0%	64	9.1%
Douglas County (Total)	**1,164**	**971**	**75**	**6.4%**	**70**	**7.2%**

Sources: FEMA 2012, Douglas County GIS 2020
Notes: C= City; T= Town

Table 5-64 Number of Critical and Lifeline Facilities Located in the 0.2-Percent Annual Chance Flood Hazard Area

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Exposed to the 0.2-Percent Annual Chance Flood Event			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Castle Pines (C)	20	12	1	5.0%	1	8.3%
Castle Rock (T)	108	100	3	2.8%	3	3.0%
Larkspur (T)	15	9	6	40.0%	4	44.4%
Lone Tree (C)	54	42	2	3.7%	2	4.8%
Parker (T)	140	105	21	15.0%	9	8.6%
Unincorporated Douglas County	827	703	72	8.7%	69	9.8%
Douglas County (Total)	**1,164**	**971**	**105**	**9.0%**	**88**	**9.1%**

Sources: FEMA 2012, Douglas County GIS 2020
Notes: C= City; T= Town

Table 5-65 Distribution of Critical Facilities in the 1-Percent Annual Chance Flood Event Floodplain by Type and Jurisdiction

Jurisdiction	Critical Facilities Exposed to the 1-Percent Annual Chance Flood Hazard Event Area								
	Bridge	Dam	Fire Station	Government Building	Medical Care	Police Station	Potable Water Lift station	Potable Well	Recreation Site
Castle Pines (C)	0	0	0	0	0	0	1	0	0
Castle Rock (T)	0	0	0	1	0	0	0	0	0
Larkspur (T)	2	0	0	0	0	0	0	0	0
Lone Tree (C)	1	0	0	0	0	0	0	0	0
Parker (T)	0	1	0	0	0	0	0	0	3
Unincorporated Douglas County	32	12	1	0	1	1	0	17	2
Douglas County (Total)	**35**	**13**	**1**	**1**	**1**	**1**	**1**	**17**	**5**

Sources: FEMA 2012, Douglas County GIS 2020
Notes: C= City; T= Town

Table 5-66 Distribution of Critical Facilities in the 0.2-Percent Annual Chance Flood Event Floodplain by Type and Jurisdiction

Jurisdiction	Critical Facilities Exposed to the 0.2-Percent Annual Chance Flood Hazard Event Area																
	Bridge	Childcare	Dam	Fire Station	Food Distribution	Government Building	Libraries	Medical Care	Pharmacy	Police Station	Polling Sites	Potable Water Lift station	Potable Water Treatment Facility	Potable Well	Primary Education	Recreation Site	Urgent Care
Castle Pines (C)	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Castle Rock (T)	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1
Larkspur (T)	2	0	0	1	0	1	1	0	0	0	1	0	0	0	0	0	0
Lone Tree (C)	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parker (T)	0	1	1	0	1	0	0	1	1	0	0	2	2	0	1	11	0
Unincorporated Douglas County	33	0	12	2	0	0	0	1	0	1	0	1	0	19	0	3	0
Douglas County (Total)	**37**	**1**	**13**	**3**	**1**	**2**	**1**	**2**	**2**	**1**	**1**	**4**	**2**	**19**	**1**	**14**	**1**

Sources: FEMA 2012, Douglas County GIS 2020
Notes: C= City; T= Town

Table 5-67 Lifelines Exposed to the 1-Percent Annual Chance Flood Event Boundary

FEMA Lifeline Category	Number of Lifelines	Number of Lifelines Exposed to 1-Percent Annual Chance Flood Event Hazard	Number of Lifelines Exposed to 0.2-Percent Annual Chance Flood Event Hazard
Food, Water, Shelter	428	18	26
Hazardous Material	22	0	
Health and Medical	203	1	5
Safety and Security	239	16	20
Transportation	79	35	37
Douglas County (Total)	**971**	**70**	**88**

Sources: FEMA 2012, Douglas County GIS 2020
Notes: C= City; T= Town

Impact on the Economy

Flood events can significantly impact the local and regional economy. This includes but is not limited to general building stock damages and associated tax loss, impacts to utilities and infrastructure, business interruption, and impacts on tourism. In areas that are directly flooded, renovations of commercial and industrial buildings may be necessary, disrupting associated services. Refer to the 'Impact on Buildings' subsection earlier which discusses direct impacts to buildings in Douglas County.

Debris management may also be a large expense after a flood event. Hazus v4.2 estimates the amount of structural debris generated during a flood event. The model breaks down debris into three categories: (1) finishes (dry wall, insulation, etc.); (2) structural (wood, brick, etc.); and (3) foundations (concrete slab and block, rebar, etc.). These distinctions are necessary because of the different types of equipment needed to handle debris. Table 5-68 summarizes the Hazus v4.2 countywide debris estimates for the 1-percent annual chance flood event. This table only estimates structural debris generated by flooding and does not include non-structural debris or additional potential damage and debris possibly generated by wind that may be associated with a flood event or storm that causes flooding. Overall, Hazus estimates that there will be 2,272 tons of debris generated during the 1-percent annual chance flood event in Douglas County.

Table 5-68 Estimated Debris Generated from the 1-Percent Annual Chance Flood Event

	1-Percent Annual Chance Flood Event Area			
Jurisdiction	Total (tons)	Finish (tons)	Structure (tons)	Foundation (tons)
Castle Pines (C)	0	0	0	0
Castle Rock (T)	109	99	6	4
Larkspur (T)	3	1	1	1
Lone Tree (C)	114	94	10	10
Parker (T)	219	157	37	25
Unincorporated Douglas County	1,827	1,071	400	356
Douglas County (Total)	**2,272**	**1,422**	**453**	**396**

Sources: Hazus v4.2

Notes: C= City; T= Town

Impact on the Environment

As Douglas County and its jurisdictions evolve with changes in population and density, flood events may increase in frequency and/or severity as land use changes, more structures are built, and impervious surfaces expand. Furthermore, flood extents for the 1-percent annual chance flood event will continue to evolve alongside natural occurrences such as climate change and/or severe weather events. These flood events will inevitably impact Douglas County's natural and local environment.

Furthermore, the environmental impacts of a flood can include significant water-quality and debris-disposal issues. Flood waters can back up sanitary sewer systems and inundate wastewater treatment plants, causing raw sewage to contaminate residential and commercial buildings and the flooded waterway. The contents of unsecured containers of oil, fertilizers, pesticides, and other chemicals get added to flood waters. Hazardous materials may be released and distributed widely across the floodplain. Water supply and wastewater treatment facilities could be offline for weeks. After the flood waters subside, contaminated and flood-damaged building materials and contents must be properly disposed of. Contaminated sediment must be removed from buildings, yards, and properties. In addition, severe erosion is likely; such erosion can negatively impact local ecosystems.

Overall, the acreage of natural land makes up 47.4-percent of the County's total land area (USGS NLCD 2016). Natural land areas from the 2016 land use type dataset includes areas of forested land, and wetlands. Severe flooding will not only influence the habitat of these natural land areas, it can be disruptive to species that reside in these natural habitats. Overall, 2.5-percent and 2.7-percent of the natural land area in the County is exposed to the 1-percent and 0.2-percent annual chance flood event boundary, respectively.

Cascading Impacts on Other Hazards

Flood events can exacerbate the impacts of disease outbreaks and cause sedimentation and erosion problems. Floods may impact the volume of debris flow and cause further degradation of soil stability changing plant communities and potentially affecting exposure to geological hazards. Flooding could increase the risk of transmitting water-borne and vector diseases by contaminating drinking water facilities (WHO 2020). See Sections 5.4.13 through 5.4.16 and 5.4.8 for more information on the geological and pandemic hazards of concern, respectively.

Future Changes that May Impact Vulnerability

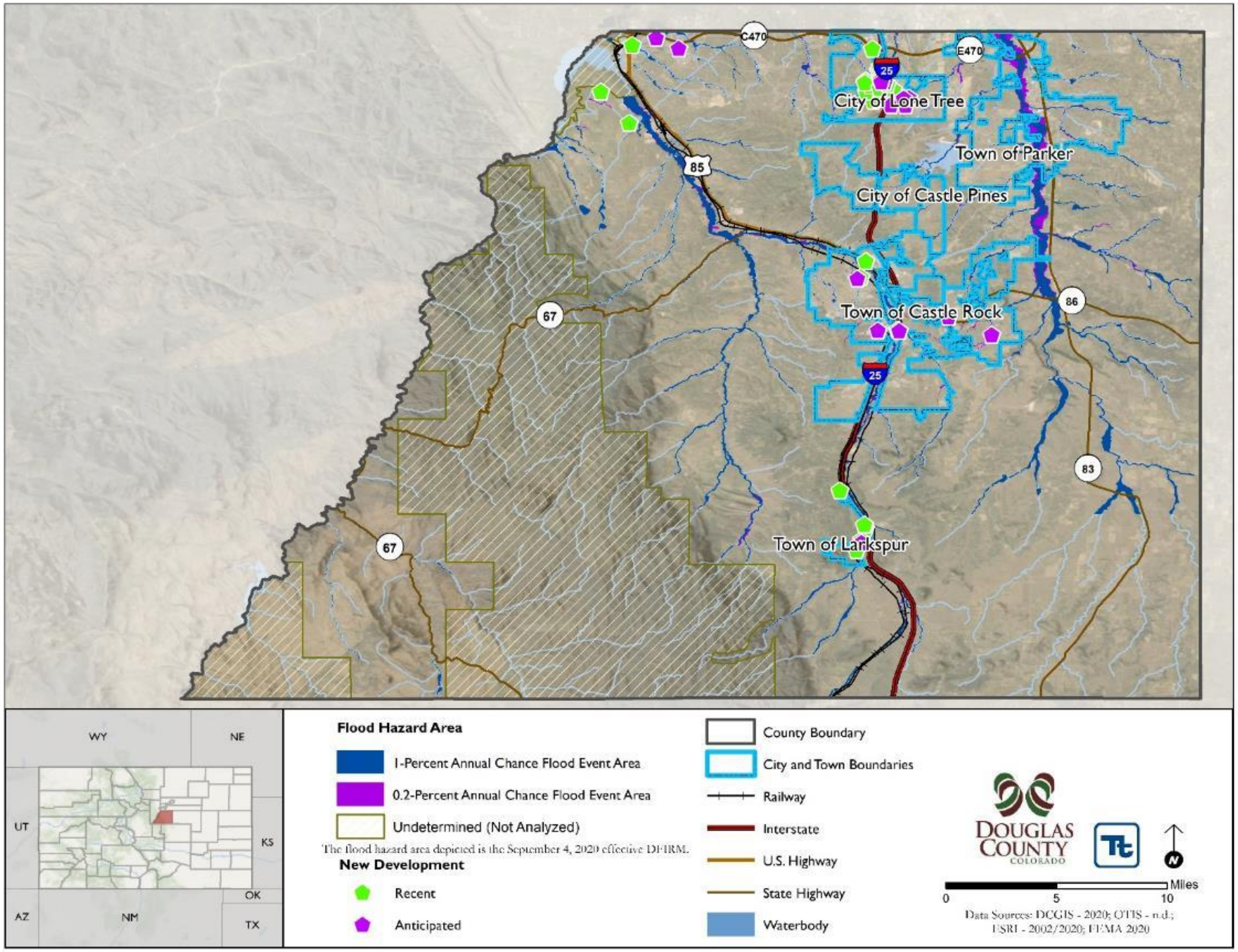
Understanding future changes that impact vulnerability in the County can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development.
- Projected changes in population.
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development

As discussed and illustrated in Section 4 (County Profile), areas targeted for future growth and development have been identified across the County. Any areas of growth located in the flood inundation areas could be potentially impacted by flooding. Refer to the maps in the jurisdictional annexes (Section 9) to view the new development locations throughout the County and their proximity to the 1-percent annual chance flood hazard event boundary. There are zero new development sites located within the 1-percent annual chance flood event hazard area and 1 new development sites located in the 0.2-percent annual chance flood event hazard area. Please refer to Figure 5-21 to see new development locations and their proximity to the flood hazard area.

Figure 5-21 New Development and 1- and 0.2-Percent Annual Chance Flood Event Hazard Area in Douglas County



Projected Changes in Population

According to the State of Colorado Department of Local Affairs, the population in Douglas County has increased by approximately 2.07-percent or 6,946 persons between 2017 and 2018 (SOC DLA 2019). As more people will reside in the County, there are possibilities that people will move to locations that are more susceptible than others to flooding. This includes areas that are directly impacted by flood events and those that are indirectly impacted (i.e., isolated neighborhoods, flood-prone roadways, etc.). Refer to Section 4 (County Profile) for additional discussion on population trends.

Climate Change

As discussed earlier, annual precipitation amounts in the region are projected to increase, primarily in the form of heavy rainfalls, which have the potential to increase the risk to flash flooding and riverine flooding, and flood critical transportation corridors and infrastructure (NYSERDA 2014). Increases in precipitation may alter and expand the floodplain boundaries and runoff patterns, resulting in the exposure of populations, buildings, and critical facilities and infrastructure that were previously outside the floodplain. This increase in exposure would result in an increased risk to life and health, an increase in structural losses, a diversion of additional resources to response and recovery efforts, and an increase in business closures affected by future flooding events due to loss of service or access.

Change of Vulnerability Since 2015 HMP

Since the 2015 analysis, population statistics have been updated using the 5-Year 2014-2018 American Community Survey Population Estimates. A flood exposure analysis and Hazus modeling was conducted via a customized general building stock and critical facility inventory rather than an analysis of National Flood Insurance Program (NFIP) properties. In addition, the FEMA 2020 Effective DFIRMs were referenced to assess the 1-percent and 0.2-percent annual chance flood extents. The updated building stock inventory and flood data was imported into Hazus v4.2 to complete a riverine analysis for the 1-percent annual chance flood event.

Overall, this vulnerability assessment uses a more accurate and updated building inventory which provides more accurate estimated exposure and potential losses for Douglas County.

Identified Issues

The following issues were identified in Douglas County with regard to flooding:

- Flash floods and debris flows in wildfire burn areas remain a concern due to the extent of burn areas (particularly in the southwestern section of the County) and isolated, vulnerable infrastructure.

5.4.7 Hazardous Material Transportation Incidents

This section provides the hazard profile and vulnerability assessment for the hazardous material and transportation incidents for Douglas County.

Profile

Hazard Description

Hazardous material transportation incidents are inter-related and predominantly anthropogenic-caused hazards. Hazardous substances are substances that are considered severely harmful to human health and the environment, as defined by the United States Environmental Protection Agency (USEPA) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (Superfund Law). Many are commonly used substances which are harmless in their normal uses but are quite dangerous if released. The Superfund law designates more than 800 substances as hazardous and identifies many more as potentially hazardous due to their characteristics and the circumstances of their release (USEPA 2013). Superfund's definition of a hazardous substance includes the following:

- Any element, compound, mixture, solution, or substance designated as hazardous under section 102 of CERCLA.
- Any hazardous substance designated under section 311(b)(2)(a) of the Clean Water Act (CWA), or any toxic pollutant listed under section 307(a) of the CWA. There are over 400 substances designated as either hazardous or toxic under the CWA.
- Any hazardous waste having the characteristics identified or listed under section 3001 of the Resource Conservation and Recovery Act.
- Any hazardous air pollutant listed under section 112 of the Clean Air Act, as amended. There are over 200 substances listed as hazardous air pollutants under the Clean Air Act (CAA).
- Any imminently hazardous chemical substance or mixture which the EPA Administrator has "taken action under" section 7 of the Toxic Substances Control Act (USEPA 2013).

If released or misused, hazardous substances can cause death, serious injury, long-lasting health effects, and damage to structures and other properties, as well as the environment. Many products containing hazardous substances are used and stored in homes and these products are shipped daily on highways, railroads, waterways, and pipelines.

Extent

The extent of a hazardous substance release will depend on whether it is from a fixed or mobile source, the size of impact, the toxicity and properties of the substance, duration of the release, and the environmental conditions (for example, wind and precipitation, terrain, etc.).

Hazardous substance releases can contaminate air, water, and soils, possibly resulting in death and/or injuries. Dispersion can take place rapidly when the hazardous substance is transported by water and wind. While often accidental, releases can occur as a result of human carelessness, intentional acts, or natural hazards. When caused by natural hazards, these incidents are known as secondary events. Hazardous substances can include toxic chemicals, radioactive substances, infectious substances, and hazardous wastes. Such releases can affect nearby populations and contaminate critical or sensitive environmental areas.

Location

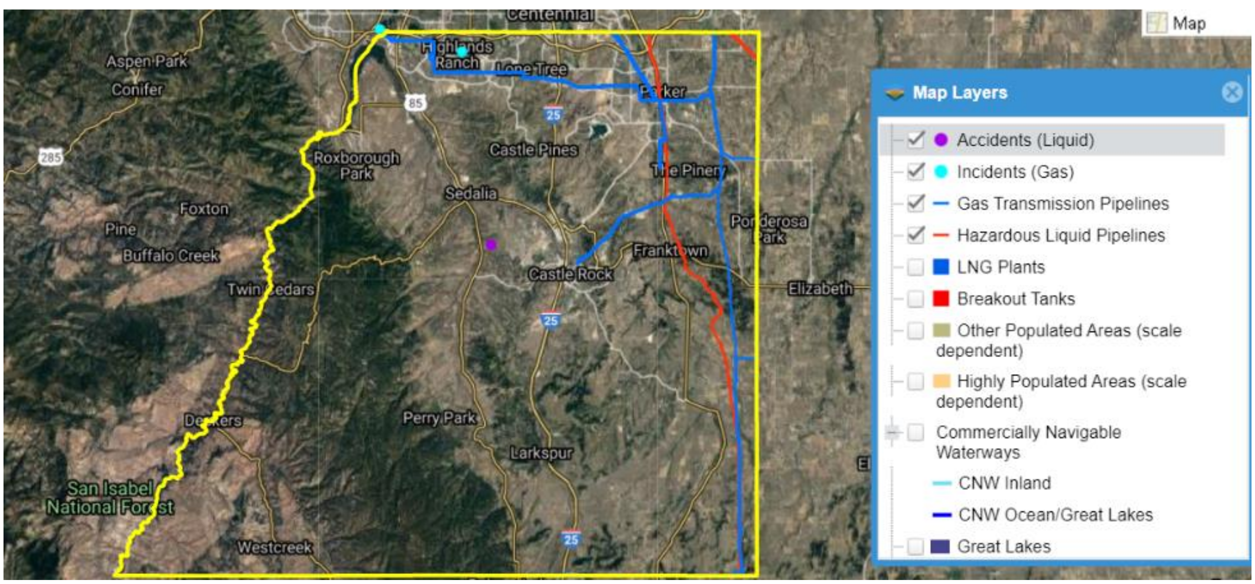
Hazardous material transport incidents are likely to occur along corridors where high volumes of hazardous materials are transported, or in locations where materials are stored or manufactured. Recent hazardous material incidents in Douglas County have occurred along natural gas distribution lines, as well as on roadways and in parking areas.

There are several major petroleum and gas pipelines that traverse Douglas County. The Magellan Pipeline Company operates the Rocky Mountain pipeline for refined oil that enters from the southeast corner of the County and runs along State Route 83 into Centennial. The Phillips 66 Pipeline that carries refined crude oil between Borger and Denver crosses through a small portion of the County in Ponderosa East.

The Colorado Interstate Gas Company operates the natural gas Pueblo-Watkins Mainline that also enters the County in the southeast corner and travels north. East of Castlewood Canyons and the Pinery, the Palmer Divide Mainline joins with the Pueblo-Watkins Mainline which runs north to the City of Aurora. South of the pinery, a natural gas loop runs west to Castle Rock and is owned by Black Hills Energy. In the Town of Parker, a natural gas pipeline operated by the Public Service Company of Colorado divides in Parker, with one line running west to Highlands Ranch and one running north to Cottonwood in the Town of Parker. Figure 5-22 shows the locations of pipelines in Douglas County.

In addition to pipelines, transportation networks carrying hazardous materials include railroads and roadways. The BNSF and Union Pacific Railroads carry freight through Douglas County. These railroad lines are connected to State, regional, and national railroad networks. Major roadways in Douglas County include Interstate 25 (which continues north to Canada and south to Mexico), US-85, and Colorado State Routes 83, 86, 67, and 105. These major roadways bolster the County's connectivity and offer alternate routes to the interstate.

Figure 5-22: National Pipeline Mapping System for Douglas County



Sources: Pipeline and Hazardous Materials Safety Administration 2020

Previous Occurrences and Losses

Between 1953 and 2020, FEMA did not issue a disaster (DR) or emergency (EM) declaration for the State of Colorado for hazardous material or transportation-related events. For the 2021 HMP update, known hazardous material transportation incidents that have impacted Douglas County between 2014 and 2020 are identified in Table 5-69.

Table 5-69 Hazardous Material and Transportation Incidents in Douglas County, 2014 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Douglas County Designated ?	Description
October 21, 2014	Gasoline Spill	N/A	N/A	A gasoline spill occurred at the Cottonwood Shopping Center in Parker.
December 6, 2014	Diesel Fuel Spill	N/A	N/A	Diesel fuel was noticed to be leaking by a driver in Parker, who then deployed mitigating measures to stop and clean up the leak.
December 30, 2014	Gasoline Spill	N/A	N/A	A driver in Highland Ranch struck a dumpster while unloading, resulting in the spill of 10 gallons of gasoline.
January 20, 2015	Fuel Spill	N/A	N/A	A semi-truck jackknifed on Interstate 25 in Lone Tree. The truck’s fuel tank punctured, spilling 75 gallons of fuel.
August 26, 2015	Jet Fuel Spill	N/A	N/A	This hazardous material spill in Larkspur resulted from a broken component or device. The truck carrying the hazardous material had a breakage in its read driven line, subsequently dragging along the highway. This caused the jet fuel to catch on fire, burning most of the fuel.
November 27, 2015	Chemical Burn	N/A	N/A	A paint-striping truck caught fire in Castle Rock, resulting in the deployment of a Hazmat team.
January 8, 2016	Diesel Fuel Spill	N/A	N/A	Hazmat response was required when a semi-truck was involved in an automobile crash, resulting in the leak of diesel fuel in Castle Rock.
August 3, 2016	Gasoline Spill	N/A	N/A	A 20-foot hose broke when a driver in Littleton moved a tractor/trailer with the hoses attached to the tanks. This caused 1 gallon of fuel to spill, which the driver cleaned up with absorbent pads.
November 7, 2016	Gas Line Leak	N/A	N/A	A high pressure gas line lead at a construction site broke, resulting in the closure of Meadows Boulevard in Castle Rock.
January 12, 2017	Natural Gas Leak	N/A	N/A	A break occurred in a three-inch natural gas pipeline near the intersection of Parker Road and Twenty Mile Road in Parker.
June 20, 2017	Gasoline Spill	N/A	N/A	A driver in Littleton over-filled a tank and spilled 40 gallons of gasoline.
August 16, 2017	Diesel Spill	N/A	N/A	A driver of a vehicle in Parker inadvertently opened a trailer compartment and released 20 gallons of diesel fuel. The driver deployed booms to prevent the material from entering the storm drain and an environmental company was hired to clean up the spill.
March 26, 2018	Diesel Spill	N/A	N/A	In Castle Rock, a driver of a vehicle spilled one cup of diesel following the opening of a cap off hose.
April 20, 2018	Diesel Spill	N/A	N/A	A crash on Interstate 25 in Lone Tree caused a truck’s 110-gallon tank of diesel fuel to leak.
July 6, 2018	Gasoline Spill	N/A	N/A	A suspected DUI resulted in a box truck/sedan collision in Parker, causing a fuel spill.
July 24, 2019	Corrosive Liquids Spill	N/A	N/A	A freight truck in Lone Tree was struck with equipment, which caused damage, releasing corrosive liquids. The dock personnel used absorbents, later placed in a container, for proper disposal.
August 31, 2019	Natural Gas Leak	N/A	N/A	A natural gas leak occurred at a construction site along Copperhead Trail in Parker.
March 30, 2020	Diesel Spill	N/A	N/A	A driver in Parker spilled 1 gallon of diesel. Driver cleaned up the spill with absorbent pads.

Sources: Pipeline and Hazardous Materials Safety Administration 2020; North American Hazmat Situations and Deployments Map 2020

Climate Change Projections

Climate change is expected to increase temperatures and the severity of storm events in Colorado. Hazardous material spills are non-natural incidents; therefore, there are no implications for impacts from climate change. However, climate change can have secondary impacts on this hazard. Increase in frequency or severity of severe weather events could lead to an increase in transportation incidents. This can cause an increase in transportation incidents with vehicles carrying hazardous materials. Additionally, secondary impacts, such as excessive heat on containers may occur, but also can occur during normal fluctuations in temperature.

Probability of Future Occurrences

Predicting hazardous material transportation incidents in Douglas County is difficult but can be modeled or anticipated using reviews of existing incident data and finding trends in accident times, locations, and environmental conditions. Broadly speaking, accidents can occur at anytime and anywhere in the County. Small spills occur throughout the year and the probability for these events are high. The risk of major incidents in a given year is rare. However, minor hazardous material incidents occur with some regularity in the County

Based on the recent incident events, the likelihood of future occurrence of hazardous material and transportation incidents in Douglas County can be considered *high* (hazard event is likely to occur within 25 years) as defined by the Risk Factor Methodology probability criteria (refer to Section 5.1).

Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable to the identified hazard. The following discusses Douglas County's vulnerability, in a qualitative nature, to the hazardous material transportation hazard.

Impact on Life, Health and Safety

Depending on the type and quantity of chemicals released and the weather conditions, an incident can affect larger areas that cross jurisdictional boundaries. When hazardous substances are released in the air, water or on land they may contaminate the environment and pose greater danger to human health. The general population may be exposed to a hazardous substances release through inhalation, ingestion or dermal exposure. Exposure may be either acute or chronic, depending upon the nature of the substance and extent of release and contamination.

For the purposes of this HMP, the entire population in Douglas County is exposed to hazardous material transportation incidents. Those particularly vulnerable to the effects of hazardous substances incidents are populations located along major transportation routes because of the quantities of chemicals transported on these major thoroughfares. Potential losses from hazardous substances incidences include human health and life and property resources. These types of incidents can lead to injury, illnesses, and/or death from both the involved persons and those living in the impacted areas. Human safety and welfare can become compromised from negative health effects of poisoning or exposure to toxic substances, fires, or explosions.

Impact on General Building Stock

Potential losses to the general building stock caused by a hazardous substance's incident is difficult to quantify. The degree of damages to the general building stock depends on the scale of the incident.

Potential losses may include inaccessibility, loss of service, contamination and/or potential structural and content losses if an explosion occurs. The closure of waterways, railroads, airports and highways as a result of a hazardous material spill has the potential to impact the ability to deliver goods and services efficiently. Potential impacts may be local, regional, or statewide depending on the magnitude of the event and level of service disruptions.

Impact on Critical Facilities

Potential losses to critical facilities caused by a hazardous material spill is difficult to quantify. Potential losses may include inaccessibility, loss of service, contamination and/or potential structural and content losses if an explosion occurs. Refer to Section 4 (County Profile) which summarizes the number and type of critical facilities in Douglas County. All critical facilities in Douglas County are exposed to the hazard.

Impact on Economy

If a significant hazardous material spill occurred, not only would life, safety, and building stock be at risk, but the economy of Douglas County could be affected as well. A significant incident in an urban area may force businesses to close for an extended period of time because on contamination or direct damage caused by an explosion if one occurred. The exact impact on the economy is difficult to determine, given the uncertain nature of the size and scope of incidents.

Impact on the Environment

Hazardous material incidents can cause contamination of ecosystems, including air, water, and soil. Liquid spills occurring on transportation networks can immediately discharge to adjacent waterways or leach into the ground. Leaks of hazardous material gases can cause noxious aerosols that impact plan and animal life. Impacts to the environment can be mitigated through quick response and preparedness.

Cascading Impacts on Other Hazards

Severe storms, winter storms, earthquakes, soil incidents, floods, or wildfires can cause disruption to transportation networks that result in hazardous material incidents. Adverse meteorological conditions can be compounded by the need to respond to a hazardous material incident.

Future Changes that May Impact Vulnerability

Understanding future changes that impact vulnerability in the County can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development

Any areas of growth could be potentially impacted by hazardous substances incidents because the entire County is exposed and vulnerable. An increase in development and population has the ability to increase the likelihood of a hazardous substance incident.

Projected Changes in Population

The County experienced an increase in population between the 2010 Census (285,465) and the estimated 2018 Community Survey estimated population of 328,614. The population of the County is expected to continue increasing. The increase in population will expose more people to hazardous material incidents as the region grows in population, requires additional services,

Climate Change

Because a hazardous substance or transportation incident is human-caused hazard, no direct climate change impacts are associated with the hazard. However, changes in precipitation and temperature can indirectly impact these incidents by making transportation networks more hazardous for transportation hazardous materials.

Changes in Vulnerability Since the 2015 HMP

The hazardous material transportation incident hazard is a new hazard identified in the 2021 Hazard Mitigation Plan Update

Identified Issues

- Warning time for hazardous material spills is minimal to none; it is uncertain when they will occur.
- Secondary hazards can lead to fire, air quality issues, and impacts to public health.

5.4.8 Pandemic & Disease Outbreak

This section provides the hazard profile and vulnerability assessment for the pandemic and disease outbreak hazard for Douglas County.

Profile

Hazard Description

A pandemic is a disease affecting the population of an extensive area that could range from countries to continents. Pandemic events can cause pervasive and sudden illness in all age groups, with the extent of infected people dependent on transmission mode, contact between infected and non-infected persons, and the ease of the illness' spread (Colorado 2018). There have been a number of pandemics in recent history, for which Douglas County is vulnerable.

Public health service in Douglas County is provided by the Tri-County Health Department (TCHD). The TCHD also serves Adams and Arapahoe Counties and provides a wide array of services, including infectious disease prevention, health care services, emergency preparedness and response, maternal health, and WIC benefits.

For the 2021 update, the pandemic and disease outbreak profile will discuss West Nile Virus, influenza, and the current COVID-19 pandemic.

West Nile Virus

West Nile Virus is a mosquito-transmitted disease that first appeared in the United States in 1999. West Nile Virus has been present globally for decades but has spread across the continental United States relatively recently. Though severe cases of West Nile Virus are rare (comprising less than 1% of people infected), the West Nile Virus can cause brain inflammation (encephalitis) and inflammation of the brain's lining (Meningitis). Mild infection symptoms include fever, body aches, headaches, and skin rashes.

West Nile Virus is transmitted through mosquito bites, which become infected themselves when feeding on infected birds. The Virus can also be spread by blood transfusion, organ transplants, mother-to-unborn child, and breast milk. There is not a specific treatment for West Nile Virus, and prevention of the disease entails modifications to the environment to prevent standing water and habitat for mosquitos, wearing insect repellent, and avoiding mosquito bites more generally.

Influenza

The risk of a global influenza pandemic has increased over the last several years. This disease is capable of claiming thousands of lives and adversely affecting critical infrastructure and key resources. An influenza pandemic has the ability to reduce the health, safety, and welfare of the essential services workforce; immobilize core infrastructure; and induce fiscal instability.

Pandemic influenza is different from seasonal influenza (or "the flu") because outbreaks of seasonal flu are caused by viruses that are already among people. Pandemic influenza is caused by an influenza virus that is new to people and is likely to affect many more people than seasonal influenza. In addition, seasonal flu occurs every year, usually during the winter season, while the timing of an influenza pandemic is difficult to predict. Pandemic influenza is likely to affect more people than the seasonal flu, including young adults. A severe pandemic could change daily life for a time, including limitations on travel and public gatherings (Barry-Eaton District Health Department 2013).

At the national level, the CDC's Influenza Division has a long history of supporting the World Health Organization (WHO) and its global network of National Influenza Centers (NIC). With limited resources, most international assistance provided in the early years was through hands-on laboratory training of in-country staff, the annual provision of WHO reagent kits (produced and distributed by CDC), and technical consultations for vaccine strain selections. The Influenza Division also conducts epidemiologic research including vaccine studies and serologic assays and provided international outbreak investigation assistance (CDC 2010).

Coronavirus

Coronavirus disease (COVID-19) is an infectious disease first identified in 2019. The virus rapidly spread into a global pandemic by spring of 2020. Older people, and those with underlying medical problems like cardiovascular disease, diabetes, chronic respiratory disease, and cancer are more likely to develop serious illness (WHO 2020). With the virus being relatively new, information regarding transmission and symptoms of the virus is still new. The COVID-19 virus spreads primarily through droplets of saliva or discharge from the nose when an infected person coughs or sneezes. Reported illnesses have ranged from mild symptoms to severe illness and death. Reported symptoms include trouble breathing, persistent pain or pressure in the chest, new confusion or inability to arouse, and bluish lips or face. Symptoms may appear 2-14 days after exposure to the virus (based on the incubation period of MERS-CoV viruses) (CDC 2020)

In an effort to slow the spread of the virus, the federal government and states have urged the public to avoid touching of the face, properly wash hands often, use various social distancing measures, and wear masks while in public. At the time of this plan update, two vaccines are available for COVID-19 and distribution of vaccines has occurred nationally. Clinical trials evaluating potential treatments remain ongoing (WHO 2020).

Extent

The exact size and extent of an infected population depends on how easily the illness is spread, the mode of transmission, and the amount of contact between infected and uninfected individuals. The transmission rates of pandemic illnesses are often higher in more densely populated areas. The transmission rate of infectious diseases will depend on the mode of transmission of a given illness.

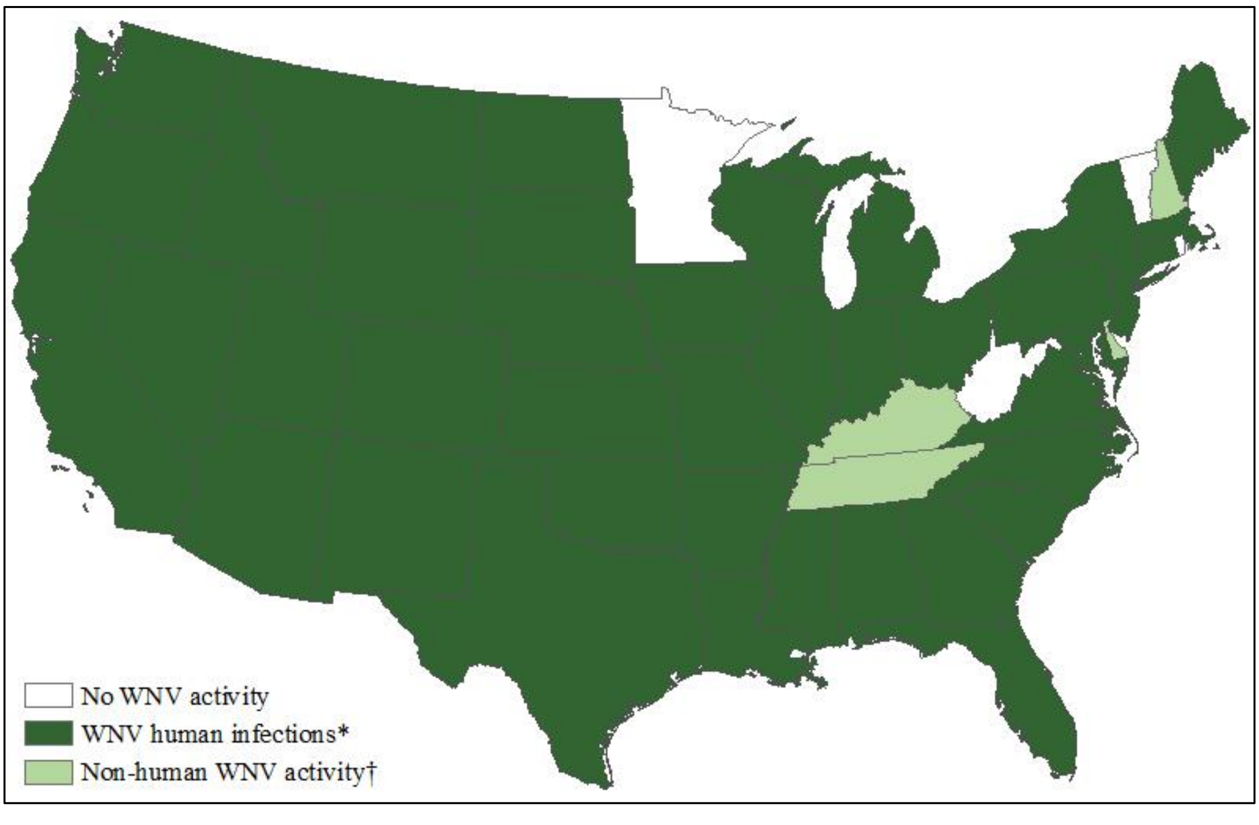
The extent and location of disease outbreaks depends on the preferred habitat of the species, as well as the species' ease of movement and establishment. The magnitude of disease outbreaks species ranges from nuisance to widespread. The threat is typically intensified when the ecosystem or host species is already stressed, such as periods of drought. The already weakened state of the ecosystem causes it to more easily be impacted to an infestation.

West Nile Virus

Seasonality is a major factor in the spread of disease. For example, the mosquito season in Colorado begins in the spring and ends in mid-September. Transmission of mosquito-borne illnesses in Douglas County can generally be limited to this period of time unless a resident travels to another region and is bitten by a mosquito. Influenza, however, is most prevalent in the fall or winter (CDC 2020).

Since it was discovered in the western hemisphere, WNV has spread rapidly across North America, affecting thousands of birds, horses and humans. As of January 5, 2021, nearly every state, including Colorado, has reported WNV human infections. Figure 5-23 shows the activity of WNV by state. The figure shows that Douglas County has had reported WNV human infections.

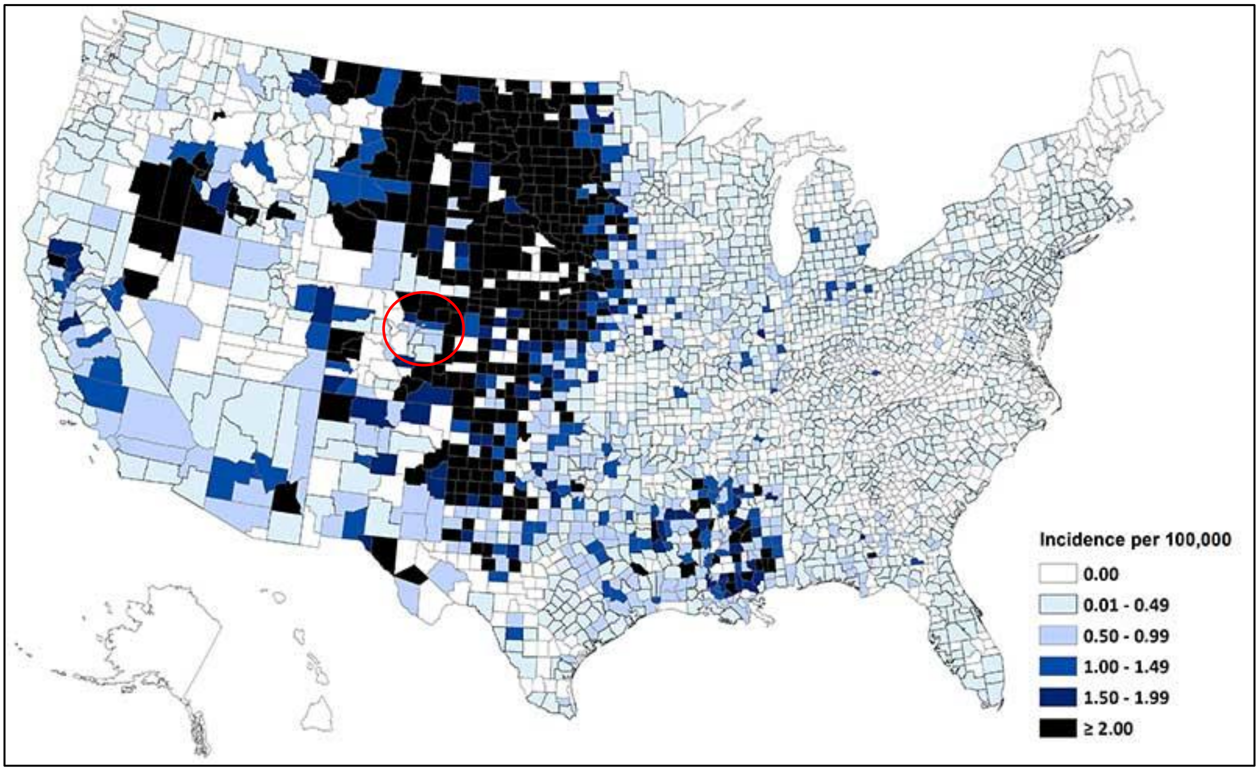
Figure 5-23. WNV Activity by State 2020



Source: CDC 2021

The CDC has a surveillance program for WNV. Data is collected on a weekly basis and reported for five categories: wild birds, sentinel chicken flocks, human cases, veterinary cases and mosquito surveillance (CDC 2019). Figure 5-24 illustrates WNV activity in the U.S. from 1999-2019. This figure shows that Douglas County has an average annual incidence rate of 0.01-0.49.

Figure 5-24. Average Annual Incidence of West Nile Virus Neuroinvasive Disease Reported to CDC by County, 1999-2019



Source: CDC 2019
Note: The circle indicates the approximate location of Douglas County.

Influenza and Coronavirus

The severity of a pandemic or infectious disease threat in Colorado and Douglas County will range significantly depending on the aggressiveness of the virus in question and the ease of transmission. Pandemics around the nation have the potential to affect the populated areas of the State of Colorado.

The CDC and Prevention Community Strategy for Pandemic Influenza Mitigation guidance introduced a Pandemic Severity Index (PSI), which uses the case fatality ratio as the critical driver for categorizing the severity of a pandemic. The index is designed to estimate the severity of a pandemic on a population to allow better forecasting of the impact of a pandemic, and to enable recommendations on the use of mitigation interventions that are matched to the severity of influenza pandemic.

In 1999, the WHO Secretariat published guidance for pandemic influenza and defined the six phases of a pandemic. Updated guidance was published in 2005 to redefine these phases. This schema is designed to provide guidance to the international community and to national governments on preparedness and response for pandemic threats and pandemic disease. Compared with the 1999 phases, the new definitions place more emphasis on pre-pandemic phases when pandemic threats may exist in animals or when new influenza virus subtypes infect people but do not spread efficiently. Because recognizing that distinctions between the two interpandemic phases and the three pandemic alert phases may be unclear, the WHO Secretariat proposes that classifications be determined by assessing risk based on a range of scientific and epidemiological data (WHO 2009). The WHO pandemic phases are outlined in Table 5-70.

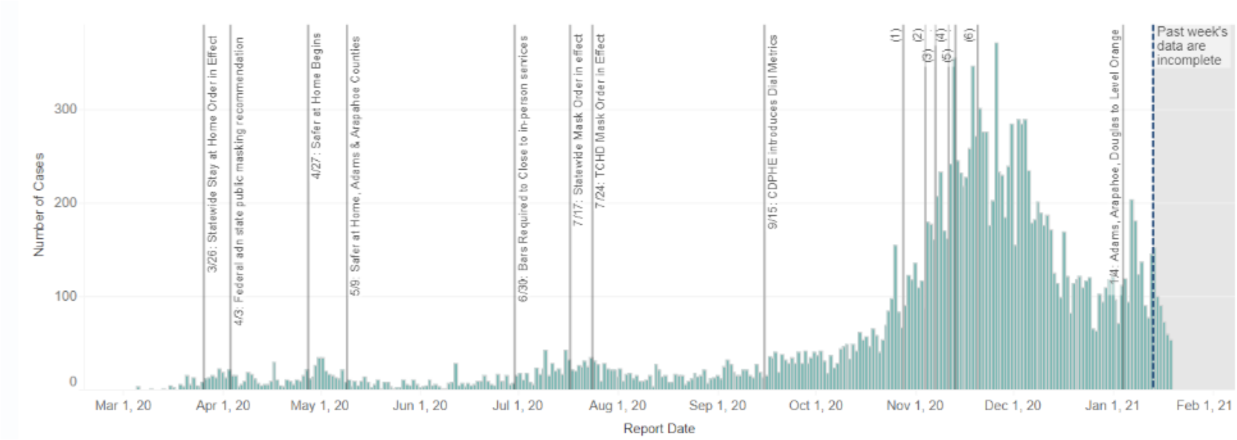
Table 5-70 WHO Global Pandemic Phases

Phase	Description
Preparedness	
Phase 1	No viruses circulating among animals have been reported to cause infections in humans.
Phase 2	An animal influenza virus circulating among domesticated or wild animals is known to have caused infection in humans, and is therefore considered a potential pandemic threat.
Phase 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 outbreaks. Limited human-to-human transmission may occur under some circumstances, for example, when there is close contact between an infected person and an unprotected caregiver. However, limited transmission under such restricted circumstances does not indicate that the virus has gained the level of transmissibility among humans necessary to cause a pandemic.
Response and Mitigation Efforts	
Phase 4	Human infection(s) are reported with a new subtype, but no human-to-human spread or at most rare instances of spread to a close contact.
Phase 5	Characterized by human-to-human spread of the virus into at least two countries in one WHO region. While most countries will not be affected at this stage, the declaration of Phase 5 is a strong signal that a pandemic is imminent and that the time to finalize the organization, communication, and implementation of the planned mitigation measures is short.
Phase 6	The pandemic phase, is characterized by community level outbreaks in at least one other country in a different WHO region in addition to the criteria defined in Phase 5. Designation of this phase will indicate that a global pandemic is under way.

Source: WHO 2009

The most recent large-scale pandemic is COVID-19, which is ongoing at the time of this report's publication. Douglas County's first case of COVID-19 was reported on March 5th, 2020. By March 26th, a statewide stay at home order was issued. The graph below shows the rate of cases in Douglas County through July 2020.

Figure 5-25: COVID-19 Cases in Douglas County, Colorado (As of January 19, 2021)



Source: Tri-County Health Department

A significant metric of COVID-19 has been hospital bed utilization. Efforts to "flatten the curve" of new reported cases are meant to avoid overwhelming medical systems by heading off hospital capacity issues. As of January 2021, Douglas County's daily hospitalization rate was almost always the lowest of the Tri-County region. The percentage of hospital beds occupied by COVID-19 patients reached its highest point to date in December 2020 (19%), though by January 19th, 2021 this figure decreased to 8.4% (Tri-County Health Department 2020).

Location

Disease outbreaks can occur without regard for location. However, factors such as density, visitation, and the length of time in which the public spends in a location all contribute to the spread of infectious diseases. For example, the 2019 novel coronavirus (COVID-19) is more likely spread by persons in close contact. Indoor areas in which people are in close contact with each other appear to be significant vectors for the disease, which is spread through respiratory droplets. Infectious diseases spread by insects may be subject to other types of location hazards. For example, the prevalence of standing water can provide breeding grounds for diseases such as West Nile Virus. Diseases that can infect humans are variable in nature and methods of transmission. Ultimately, residents need to be vigilant about diseases altogether in order to better understand and respond to disease outbreak hazards.

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with disease outbreak events throughout Colorado and Douglas County.

Between 1953 and 2020, FEMA issued a disaster (DR) or emergency (EM) declaration for the State of Colorado for one pandemic-related event. Douglas County was included in this declaration for COVID-19. For the 2021 HMP update, known disease outbreak incidents that have impacted Douglas County between 2002 and 2020 are identified in the table below.

Table 5-71 Public Health Events in Douglas County, 2002 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Douglas County Designated?	Description
2002-Present	Biological	N/A	No	In 2002, the first case of West Nile Virus was recorded in Colorado.
2009-2010	Biological	N/A	No	The H1N1 (influenza A) virus occurred in 2009 as the first influenza pandemic of the 21st century. By May 2010, there were more than 2,000 hospitalizations due to H1N1 in Colorado alone and 69 influenza-associated deaths.
March 2020-Present	Biological	DR-4498 EM-3436	Yes	A novel and highly infectious form of coronavirus began spreading and became a worldwide pandemic in 2020.

Sources: CDC 2020; Colorado Legislative Council Staff 2010; FEMA 2020; Tri-County Health Department

Table 5-71 shows the occurrences of various infectious diseases in Douglas County, Colorado between 2013 and 2018. During this time, the most frequently occurring infectious disease in the County was influenza (hospitalized), for which cases increased from 70 in 2013 to 169 in 2017. Hepatitis C (chronic) was the second-most widely occurring disease in the County, followed by animal bites. Both Hepatitis C and animal bites grew significantly during the reporting period, whereas infections of Pertussis saw decreases. Other frequently-encountered infectious diseases in Douglas County during this reporting period include Campylobacteria, Giardiasis, Group A invasive Strep, Salmonellosis, STEC, and chicken pox. In addition to the diseases listed in the following table, the County has also been impacted by Prairie Dog Disease, hantavirus, rabies, and tularemia.

Table 5-72 Infectious Diseases in Douglas County, 2013-2018

	2013	2014	2015	2016	2017	2018		2013	2014	2015	2016	2017	2018
Acute Flaccid Myelitis						2	INFLUENZA-hospitalized	70	125	91	78	169	144
ANIMAL BITES	36	10	22	77	86	141	LEGIONELLOSIS	1	3	2	2	6	5
BRUCELLOSIS			1				LISTERIOSIS					1	
CAMPYLOBACTER	35	21	33	34	38	44	LYME DISEASE					1	
Candidemia					9	13	MALARIA			2	1	2	
Carbapenem-Resistant Enterobacteriaceae (CRE)					12	12	MEASLES	2		1			
Carbapenem-Resistant Pseudomonas Aeruginosa (CRPA)					62	37	MENINGITIS ASEPTIC/VIRAL	15	6				
CRYPTOSPORIDIOSIS	5	1	8	6	7	5	MENINGOCOCCAL DISEASE					1	
CYCLOSPORIASIS			1		1	3	MUMPS					2	1
DENGUE FEVER			1		3	2	PERTUSSIS	63	63	48	57	60	36
ENCEPHALITIS OTHER					1	3	SALMONELLOSIS	38	31	32	26	42	32
GIARDIASIS	34	18	19	26	29	20	SHIGELLOSIS	2	1	6	18	1	5
GROUP A STREP INVASIVE	8	9	9	17	20	20	Spotted fever group rickettsia					2	1
GROUP B STREP INVASIVE	12	16	13	27	14	14	STEC (shiga toxin producing E.coli)	17	8	11	15	18	21
HAEMOPHILUS INFLUENZAE	2	2	2	5	6	3	STREP PNEUMO INVASIVE	11	12	9	12	13	26
HEMOLYTIC UREMIC SYNDRM	2					1	TOXIC SHOCK-OTHER			1		2	1
HEPATITIS A	4	1	2	2	3		TOXIC SHOCK-STREP		1		1		
HEPATITIS B, ACUTE		1		1			TYPHOID FEVER		1				1
HEPATITIS B, CHRONIC	13	15	27	25	20	23	VARICELLA(CHICKEN POX)	18	27	8	8	14	17
HEPATITIS C, ACUTE		1	1	2	1	2	Vibriosis					1	6
HEPATITIS C, CHRONIC	49	47	64	79	115	126	YERSINIOSIS		1		1	1	4
HEPATITIS D						1							

Source: Colorado Department of Public Health & Environment

Climate Change Projections

Climate change will likely have significant indirect impacts on disease outbreaks. In Colorado, higher temperatures, decreased water availability, and more severe storm events are anticipated due to climate change. According to the World Health Organization, changing climatic conditions are being studied for impacts upon disease transmission. Seasonal infectious diseases that are influenced by meteorological conditions may see significant variability in recurrence and duration. The World Health Organization concludes that variations in infectious disease transmission patterns are likely major consequences of climate change.

Probability of Future Occurrences

Though occurrences of disease outbreaks overall are often difficult to predict at the local level, it is anticipated that Douglas County will continue to be impacted by disease outbreaks for the foreseeable future. Seasonality for cold and flu is well established and anticipated in Colorado on an annual basis. The Tri-County Health Department undertakes a number of infectious disease mitigation and response activities that works to reduce risk for residents in the Tri-County region.

Based on the recent incident events, the future occurrence of disease outbreaks in Douglas County can be considered *frequent* (hazard event is likely to occur within 25 years) as defined by the Risk Factor Methodology probability criteria (refer to Section 5.1).

Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable to the identified hazard. The following discusses Douglas County's vulnerability, in a qualitative nature, to the disease outbreak hazard.

Impact on Life, Health and Safety

The entire population of Douglas County is vulnerable to the disease outbreak hazard. Due to a lack of quantifiable loss information, a qualitative assessment was conducted to evaluate the assets exposed to this hazard and the potential impacts associated with this hazard. Healthcare providers and first responders have an increased risk of exposure due to their frequent contact with infected populations. Areas with a higher population density also have an increased risk of exposure or transmission of disease to do the closer proximity of population to potentially infected people.

Most recently with COVID-19, the Centers for Disease Control and Prevention have indicated that persons over 65 years and older, persons living in a nursing home or long-term care facility, and persons with underlying medical conditions such as diabetes, severe obesity, serious heart conditions, etc. are at a higher risk of getting severely ill (CDC 2020). According to the 2018 American Community Survey, 10.9% of Douglas County residents (or approximately 35,801 people) are over the age of 65.

Impact on General Building Stock

No structures are anticipated to be directly affected by disease outbreaks.

Impact on Critical Facilities

Disease outbreaks would not directly affect critical facilities; however, they could experience secondary impacts. Hospitals and medical lifelines will likely see an increase in patients, but it is unlikely that there will be damages or interruption of services. However, large rates of infection may result in an increase in the rate of hospitalization which may overwhelm hospitals and medical facilities and lead to decreased services for those seeking medical attention. The 2020 coronavirus pandemic has led to overwhelmed hospitals in numerous hotspots. Continuity of operations of critical facilities could also be impacted due to the workforce becoming ill and unable to work. With limited staff, critical facility operations could be affected.

Impact on Economy

Disease outbreaks impacts on the economy and estimated dollar losses are difficult to measure and quantify. Costs associated with the activities and programs implemented to conduct surveillance and address disease outbreaks have not been quantified in available documentation. As evidenced in the COVID-19 outbreak, quarantines, shutdowns, and social distancing measures can have outsized economic impacts, particularly on the leisure, tourism, and food/accommodations sectors.

Impact on the Environment

Disease outbreaks may have an impact on the environment if the outbreaks are caused by invasive species. Invasive species tend to be competitive with native species and their habitat and can be the major transmitters of disease like Zika, dengue, and yellow fever (Placer Mosquito and Vector Control District 2019). Secondary impacts from mitigating disease outbreaks could also have an impact on the environment. Pesticides used to control disease carrying insects like mosquitos have been reviewed by the EPA and the Colorado Department of Agriculture. If these sprays are applied in large concentrations, they could potentially leach into waterways and harm nearby terrestrial species. As a result, pesticides must be registered before they can be sold, distributed, or used in the state (Colorado State University Extension 2020).

Cascading Impacts on Other Hazards

Pandemic and disease outbreak events can be caused by Animal and Plant Diseases or infestations, which is discussed in Section 5.4.1.

Future Changes that May Impact Vulnerability

Understanding future changes that impact vulnerability in the County can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development

Any areas of population growth and human habitation could be potentially impacted by the pandemic/disease outbreak hazard because the entire planning area is exposed and vulnerable. Additional development of structures in close proximity to waterbodies or areas with high population density are at an increased risk.

Projected Changes in Population

Douglas County experienced an increase in population between the 2010 Census and the 2018 American Community Survey estimates. The population of the County is expected to increase in the near future. The increase in population will expose more people to the pandemic hazard as residents move into area and the population exposed increases. Population density changes when households move throughout the County could influence the number of persons exposed to disease outbreaks. Higher density jurisdictions are not only at risk of greater exposure to disease outbreak, density may also reduce available basic services provided by critical facilities such as hospitals and emergency facilities for persons that are not affected by a disease.

Climate Change

The relationship between infectious diseases occurrence and climate change is difficult to predict with certainty. However, there may be linkages between the two. Changes in the environment may create a more livable habitat for vectors carrying disease as suggested by the Centers for Disease Control and Prevention (CDC n.d.). Localized changes in climate and human interaction may also be a factor in the spread of disease.

Changes in Vulnerability Since the 2015 HMP

Disease outbreak is a new hazard profile for the 2021 HMP update. The occurrence and prevalence of COVID-19 in the County underscores the need to address disease outbreak as part of the hazard mitigation planning process.

Identified Issues

- The COVID-19 pandemic revealed that social distancing and quarantine had unprecedented impacts on public gatherings, shopping and activities. This caused significant, unanticipated impacts on economic and social activity, as well as government. The need to adjust operations to account for social distancing has been identified.
- Animal bites and Hepatitis C incidence in the County has grown significantly in the last several years. As of the writing of this hazard mitigation plan, the cause of these increases has not yet been determined.
- Wild animals and the environment can be a source of human infection. Section 5.4.1 discusses the animal diseases and infestation hazard in Douglas County.

5.4.9 Severe Weather (Hail and Lightning)

The following section provides the hazard profile and vulnerability assessment for the hail and lightning hazard in Douglas County.

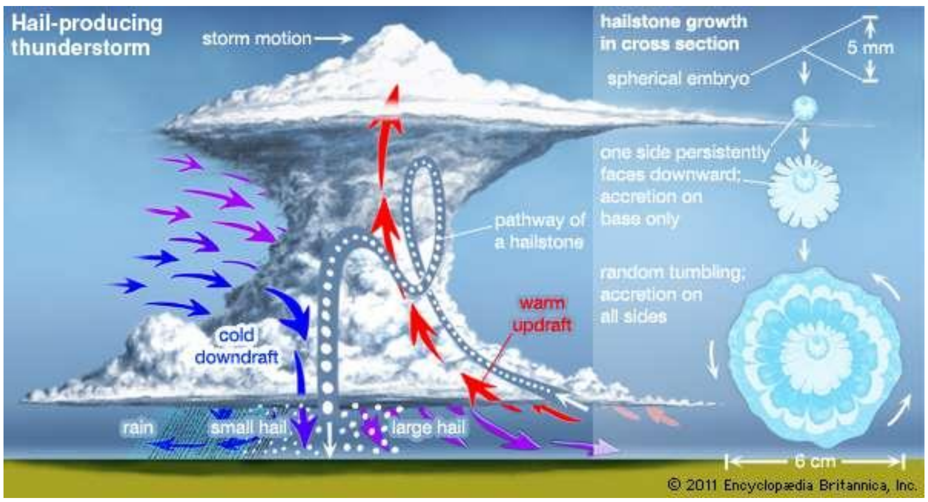
Profile

Hazard Description

Hail

Hail forms inside a thunderstorm where there are strong updrafts of warm air and downdrafts of cold water. If a water droplet is picked up by the updrafts, it can be carried well above the freezing level. Water droplets freeze when temperatures reach 32 °F or colder. As the frozen droplet begins to fall, it might thaw as it moves into warmer air toward the bottom of the thunderstorm, or the droplet might be picked up again by another updraft and carried back into the cold air to re-freeze. With each trip above and below the freezing level, the frozen droplet adds another layer of ice. The frozen droplet, with many layers of ice, falls to the ground as hail. Figure 5-26 shows the hail formation process. Most hail is small and typically less than two inches in diameter (NWS 2009).

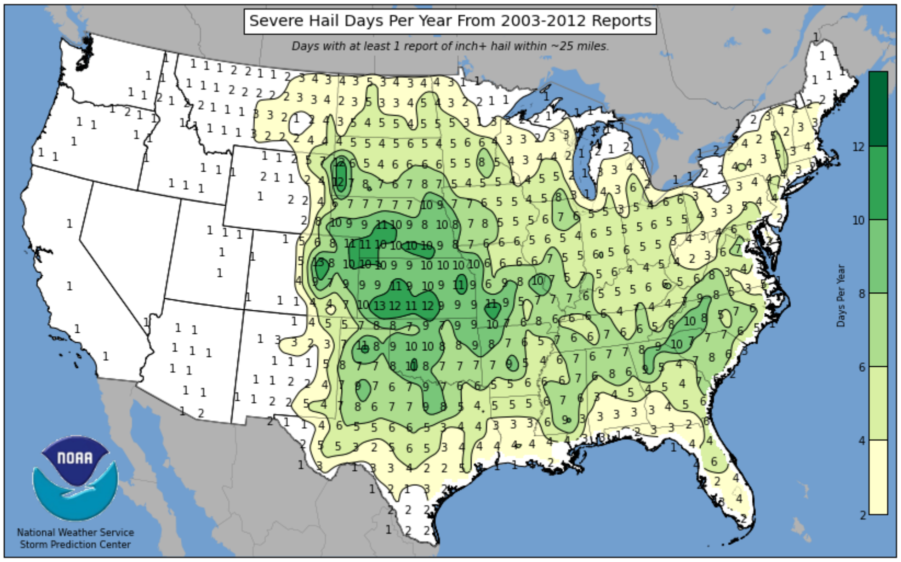
Figure 5-26. Hail Formation



Source: Encyclopedia Britannica 2011

Figure 5-27 shows the annual frequency of hailstorms in the United States as recorded from 2003 to 2012. Hailstorms have been observed in almost every location where thunderstorms occur throughout the United States. They are most frequent in the southern and central plain states where the climate produces violent thunderstorms. The figure shows that Douglas County experiences between two and six severe hail days each year. Severe hail day is defined as a day with at least one report of one-inch or more hail within 25 miles.

Figure 5-27. Severe Hail Days Per Year from 2003-2012

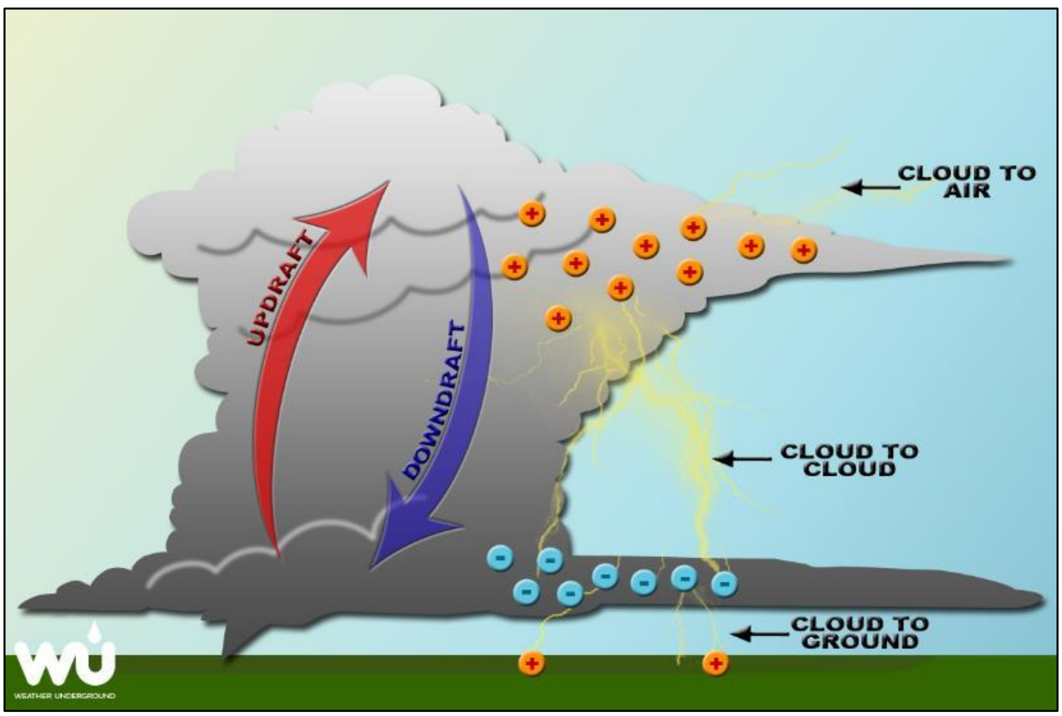


Source: SPC 2020

Lightning

Lightning is a giant spark of electricity in the atmosphere between clouds, the air, or the ground, produced by a thunderstorm (refer to Section 4.3.2 for details regarding the severe thunderstorm and wind storm hazard). Energy from lightning channel heats the air to around 18,000°F. This causes the air to rapidly expand, creating a sound wave known as thunder. Thunder can be heard up to 25 miles away from the lightning discharge (NSSL 2020). Figure 5-28 illustrates how lightning develops.

Figure 5-28. How Lightning Develops



Source: Weather Underground 2020

Lightning is a major cause of storm-related deaths in the United States, with an average of 43 reported fatalities and 243 injuries each year (NWS 2020). Between 1990 and 2003, 39 lightning-related deaths was reported in the State of Colorado, ranking third in the United States for deaths associated with lightning strikes (National Lightning Safety Institute 2003).

Extent

The severity of hail is measured by duration, hail size, and geographic extent. Most hail stones from hail events are made up of variety of sizes. Only the very largest hail stones pose serious risk to people, if exposed. The size of hail is estimated by comparing it to a known object. Table 5-73 describes how hail is measured.

Table 5-73 Hail Size

Severity	Size	Inches in Diameter
Non-Severe Hail Does not typically cause damage and does not warrant severe thunderstorm warning from NWS.	Pea	0.25 inch
	Marble/mothball	0.50 inch
	Dime/Penny	0.75 inch
	Nickel	0.875 inch
Severe Hail Research has shown that damage occurs after hail reaches around 1" in diameter and larger. Hail of this size will trigger a severe thunderstorm warning from NWS.	Quarter	1.0 inch
	Ping-Pong Ball	1.5 inches
	Golf Ball	1.75 inches
	Tennis Ball	2.5 inches
	Baseball	2.75 inches
	Tea Cup	3.0 inches
	Grapefruit	4.0 inches
	Softball	4.5 inches

Source: NOAA 2012; State of Colorado HMP 2018

Lightning is most often associated with moderate to severe thunderstorms. The NWS issues thunderstorm watches and warnings if a thunderstorm is considered severe enough to produce hail at least ¾ inch in diameter, winds of 58 mph or stronger, or a tornado (State of Colorado 2018).

The severity of lightning refers to the frequency of lightning strikes during a storm. The Lightning Activity Level (LAL) is a scale which describes lightning activity. The scale is part of the National Fire Danger Rating System. The scale is a range of numbers, from one to six, which reflects frequency and character of cloud-to-ground lightning (National Wildfire Coordinating Group 2020; NWS 2020).

Severe Thunderstorm Watch
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
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. Get out of 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 a large hail or damaging wind identified by an NWS forecaster on radar or by a trained spotter/law enforcement who is watching the storm.

Table 5-74 Lightning Activity Level

Lightning Activity Level (LAL)	Conditions
1	No thunderstorms
2	Isolated thunderstorms. Light rain will occasionally reach the ground. Lightning is very infrequent, 1 to 5 cloud to ground strikes in a five minute period.
3	Widely scattered thunderstorms. Light to moderate rain will reach the ground. Lightning is infrequent, 6 to 10 cloud to ground strikes in a 5 minute period.
4	Scattered thunderstorms. Moderate rain is commonly produced Lightning is frequent, 11 to 15 cloud to ground strikes in a 5 minute period.
5	Numerous thunderstorms. Rainfall is moderate to heavy. Lightning is frequent and intense, greater than 15 cloud to ground strikes in a 5 minute period.
6	Dry lightning (same as LAL 3 but without rain). This type of lightning has the potential for extreme fire activity and is normally highlighted in fire weather forecasts with a Red Flag Warning.

Sources: National Wildfire Coordinating Group 2020; NWS 2020

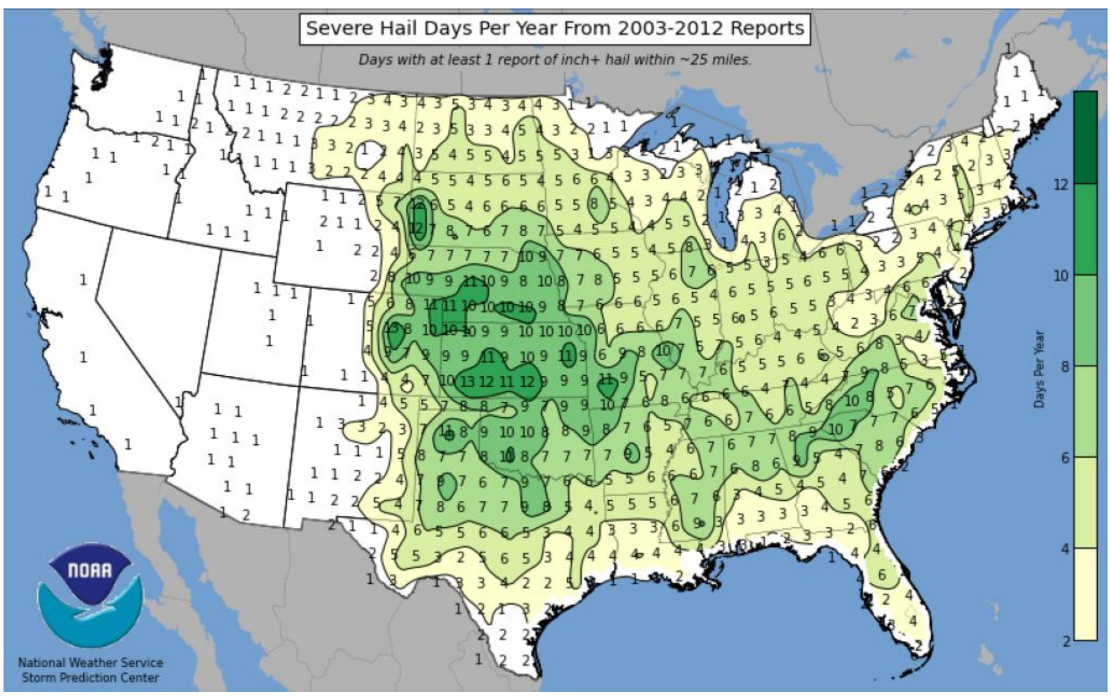
Location

All of Douglas County is exposed and vulnerable to hail and lightning events.

Hail

The State of Colorado is one of the most hail-prone states in the country. 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. According to the figure below, Douglas County has experience approximately between two and six severe hail days each year.

Figure 5-29. Severe Hail Days Per Year from 2003 to 2012 Reports

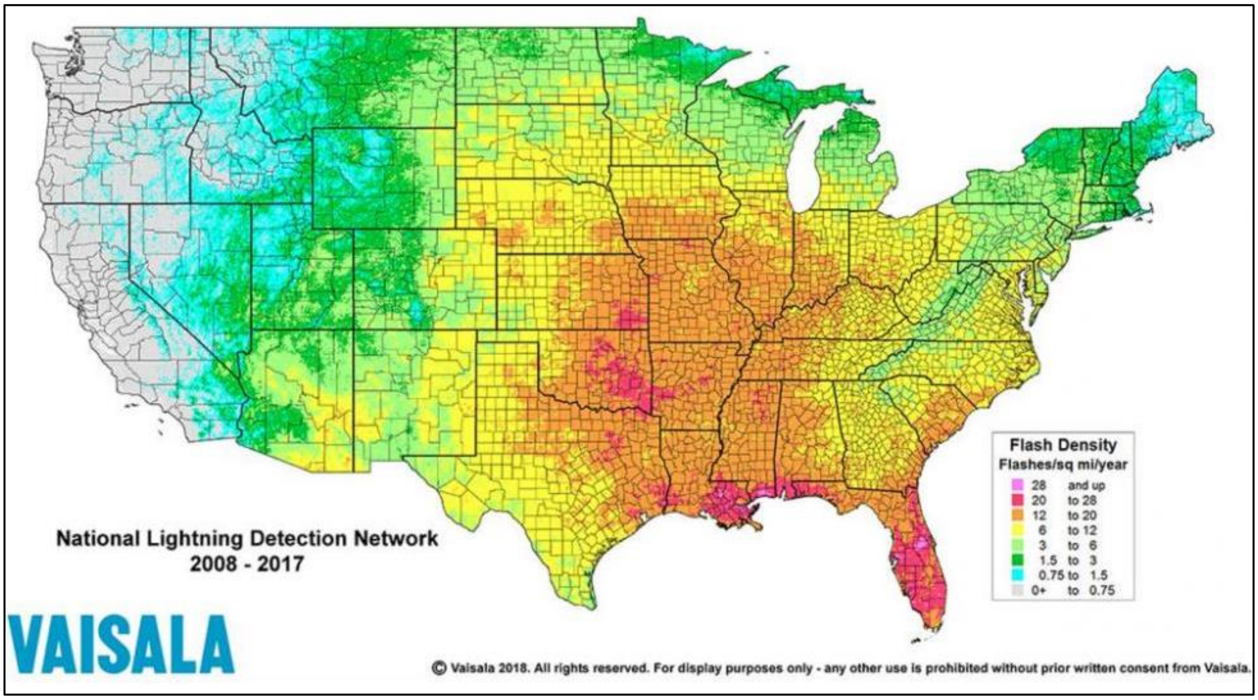


Source: State of Colorado 2018

Lightning

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 (State of Colorado 2018). Therefore, lightning can occur anywhere in Douglas County. The National Lightning Detection Network (NLDN) collects cloud-to-ground lightning data for the continental United States. Figure 5-30 illustrates the cloud-to-lightning incidence across the United States. The figure shows that Douglas County experienced 6 to 12 flashes per square mile each year.

Figure 5-30. Cloud-to-Lightning Incidence, 2008 to 2017



Source: Vaisala 2020

Previous Occurrences and Losses

Numerous sources provided historical information regarding previous occurrences and losses associated with hail and lightning events affecting Douglas County. With so many sources reviewed for the purpose of this HMP, loss and impact information for many events may vary. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP.

Between 1953 and 2020, the State of Colorado has been included in three FEMA declared hail or lightning-related disasters (DR) or emergencies (EM). Douglas County was not included in these declarations, nor have there been USDA agriculture disasters caused by lightning since 2014.

For this 2021 update, known hail and lightning events that have impacted Douglas County between 2014 and 2020 are identified in Table 5-75. The events listed in this table represent only those that were reported to the NOAA-NCEI Storm Events Database and the Storm Predication Center, and may not represent all hail events and damages that have occurred since 2014. However, the events tallied for this analysis does not reflect a comprehensive count of hail or lightning events due to damage limitations and reporting inconsistencies. Therefore, Table 5-75 may not include all events that occurred in Douglas County.

According to the NOAA-NCEI Storm Events Database, Douglas County has been impacted by 107 hail events between 2014 and 2020. These events did not result in property damage that was reported to NOAA (refer to Table 5-75). However, there were five lightning events that caused $16,000 in property damage, one death, and one injury as reported to NOAA-NCEI. According to the Storm Prediction Center's Severe Weather Database, the largest hailstone on record was 2.5 inches on June 8, 2019 in Douglas County.

Table 5-75 Hail and Lightning Events in Douglas County, 2014 to 2020

Date(s) of Event	Event Type	Magnitude	Fatalities	Injuries	Damages	Event Details*
June 4, 2014	Hail	1 inch	0	0	$0	Severe thunderstorms brought large hail to Douglas County, though there was no damage to property or crops.
June 5, 2014	Hail	1 inch	0	0	$0	Severe thunderstorms produced large hail ranging from the size of a quarter to a golf ball. Wind gusts were as fast as 70 mph. The storm lasted for hours in Douglas County, initiating in Parker and making its way to Castle Rock and Franktown in the evening. While most observed hail was about 1 inch, Castle Rock experienced
June 6, 2014	Hail	1 inch	0	0	$0	Thunderstorms produced hail ranging in the size of a quarter to a ping pong ball in Douglas County.
June 8, 2014	Hail	1.25 inches	0	0	$0	A storm brought several tornados, strong winds, heavy rainfall, and large hail across northern Colorado, including in Douglas County's open country. Hail was described as the size of half dollar.
June 14, 2014	Hail	1 inch	0	0	$0	Severe thunderstorms brought large hail to Douglas County.
June 22, 2014	Lighting	N/A	0	0	$1,000	A severe thunderstorm caused lighting strikes in Douglas County, leading to a fire near Elizabeth. There was $1,000 worth of crop damage.
June 24, 2014	Hail	1-1.5 inches	0	0	$0	Douglas County experienced significant hail events, with hail ranging from 1 inch to 1.5 inches.
July 7, 2014	Lightning	N/A	0	0	$10.000	A lightning strike in Douglas County struck a home and caused a small attic fire, contributing to $10,000 worth of property damage.
August 25, 2014	Hail	1 inch	0	0	$0	Douglas County received hail up to the size of a quarter. Northern Douglas County had wind gusts up to 66 mph.
September 29, 2014	Hail	1 inch	0	0	$0	A strong storm system produced large hail in Douglas County. Other counties experienced significant damage, though Douglas County did not.
May 1, 2015	Hail	0.75 inches	0	0	$0	A thunderstorm produced hail in Douglas County.
May 15, 2015	Hail	1.25 inches	0	0	$0	Severe thunderstorms produced nick to half dollar sized hail in Douglas County and surrounding counties.
June 3, 2015	Hail	1-1.75 inches	0	0	$0	Thunderstorms in Douglas County and surrounding counties produced large hail, ranging from the size of a quarter to a tennis ball. Observations in Douglas County noted hail

Date(s) of Event	Event Type	Magnitude	Fatalities	Injuries	Damages	Event Details*
						ranging from 1 inch to 1.75 inches, the largest seen in Douglas County since 2014. This storm lasted for several hours into the evening.
June 5, 2015	Hail	0.88-1.5 inches	0	0	$0	Severe thunderstorms brought hail to Douglas County that was as large as the size of a golf ball in some cases.
June 17, 2015	Hail	1 inch	0	0	$0	Hail was observed as the size of a quarter to the size of a ping pong ball.
June 25, 2015	Hail	0.88-1 inch	0	0	$0	Severe thunderstorms developed during the afternoon into the late evening, producing hail in Douglas County.
August 7, 2015	Hail	1.75 inches	0	0	$0	Very large hail in Douglas County was observed during severe thunderstorms.
August 10, 2015	Hail	1 inch	0	0	$0	Hail up to the size of a quarter was observed.
September 29, 2015	Hail	1.25 inches	0	0	$0	Severe thunderstorms product heavy rain and hail, which impacted northern Douglas County the most.
April 25, 2016	Hail	0.75-1 inch	0	0	$0	A thunderstorm produced hail in Douglas County, which was described as ranging in size from a nickel to a quarter.
May 26, 2016	Hail	0.75-1 inch	0	0	$0	Severe thunderstorms produced hail in Douglas County.
June 6, 2016	Hail	0.75-1.75 inches	0	0	$0	Potent thunderstorms along the Urban Corridor produced large hail, heavy rain, and lightning in Douglas County.
June 7, 2016	Hail	0.75- 1 inch	0	0	$0	Hail was observed the size of a quarter.
June 13, 2016	Hail	0.75 inches	0	0	$0	Severe thunderstorms produced hail, which in some areas was the size of a baseball.
June 19, 2016	Hail	0.75-1 inch	0	0	$0	Hail was the size of a quarter.
June 20, 2016	Hail	1 inch	0	0	$0	Hail in Douglas County and in surrounding counties ranged from the size of a quarter to a golf ball.
June 25, 2016	Hail	0.75 inches	0	0	$0	A thunderstorm produced heavy rain and dime-sized hail.
July 1, 2016	Hail	1-2 inches	0	0	N/A	A potent thunderstorm produced large hail, ranging from 1 to 2 inches. Castle Rock experienced property damage with hail smashing cars and shattering windows. Damage also extended to shutters, roofs, siding, and fencing.
July 7, 2016	Hail	1 inch	0	0	$0	Severe thunderstorms produced damaging straight-line winds and hail.
July 15, 2016	Hail	1 inch	0	0	$0	Severe thunderstorms produced damaging hail.
May 6, 2017	Lightning	N/A	0	0	$1,000	One woman was slightly injured from a dangerously close lightning strike. There was $1,000 in property damage.
May 7, 2017	Lightning	N/A	1	1	$5000	After lightning hit a nearby tree in Sedalia, a woman and her horse were killed. A teenage girl was also seriously injured. There was $5,000 in property damage as well, after winds destroyed trees, power poles, and electrical lines.

Date(s) of Event	Event Type	Magnitude	Fatalities	Injuries	Damages	Event Details*
May 26, 2017	Hail	1-1.5 inches	0	0	$0	Douglas County and surrounding counties experienced severe thunderstorms and large hail.
August 5, 2017	Hail	1.5 inches	0	0	$0	A severe thunderstorm in Castle Rock produced hail with a 1.5 inch diameter.
August 15, 2017	Hail	1 inch	0	0	$0	Douglas County and its surrounding counties experienced hail from a severe thunderstorm.
May 14, 2018	Hail	1 inch	0	0	$0	Douglas Counties and its surrounding counties experienced severe thunderstorm and large hail. Clean up was required in Douglas County, as hail had accumulated several inches on roadways and stranded vehicles.
May 28, 2018	Hail	1 inch	0	0	$0	Severe thunderstorms produced tornadoes and hail in Douglas County and surrounding counties.
May 30, 2018	Hail	0.88-1 inch	0	0	$0	Douglas and Boulder counties experience severe thunderstorms and hail.
June 19, 2018	Hail	1 inch	0	0	$0	Douglas County received 1 inch hail following a hail storm within the Front Range Urban Corridor and across the northeast plains of Colorado. The Rocky Mountain Insurance Information Association reported $276.4 million in property damage, which included portions of Douglas County.
July 5, 2018	Hail	1 inch	0	0	$0	Isolated thunderstorms in Douglas and Park counties brought hail to affected areas.
July 16, 2018	Hail	1 inch	0	0	$0	Potent thunderstorms brought strong winds, heavy rain, and hail to Douglas County and surrounding counties. Hail was described to range in size from a quarter to a golf ball.
July 23, 2018	Hail	0.88 inches	0	0	$0	Hail was described as the size of a nickel in Douglas County.
August 6-August 7, 2018	Hail	1.25 inches	0	0	$0	A severe thunderstorm brought hail to Douglas County and surrounding counties.
June 6, 2018	Hail	0.88-2.5 inches	0	0	$0	Potent thunderstorms spread eastward from the Denver area across the plains of Colorado, producing very large hail ranging from the size of a quarter to a tennis ball. Douglas and Elbert counties saw the largest hail. The storms produced a brief tornado, with wind gusts up to 64 mph.
June 30, 2019	Lightning	N/A	0	0	N/A	Eight hikers were injured, leaving one critically hurt, as a result of a nearby lightning strike. Two of the hikers required assistance and suffered from minor burns. Another victim was taken to the hospital after sustaining critical injuries.
July 4, 2019	Hail	1-1.5 inches	0	0	$0	
July 15, 2019	Hail	1.25 inches	0	0	$0	Potent thunderstorms in Douglas County and surrounding counties brought large hail and wind as fast as 60-70 mph. This caused minor property damage.
July 21, 2019	Hail	1 inch	0	0	$0	Severe thunderstorms in Douglas County and surrounding counties produced large hail and strong winds.

Date(s) of Event	Event Type	Magnitude	Fatalities	Injuries	Damages	Event Details*
July 22, 2019	Hail	0.88 inches	0	0	$0	Severe thunderstorms in Douglas County and surrounding counties produced large hail and strong winds.
September 6, 2019	Hail	1.25 inches	0	0	N/A	Severe thunderstorms produced large hail and heavy rain in Douglas County and its surrounding counties. A lightning strike caused extensive damage in Douglas County after causing a house fire.

Source(s): FEMA 2020; NOAA-NCEI 2020; SPC 2020
** Many sources were consulted to provide an update of previous occurrences and losses; event details and loss/impact information may vary and has been summarized in the above table*
FEMA Federal Emergency Management Agency
HMP Hazard Mitigation Plan
NCEI National Centers for Environmental Information
NOAA National Oceanic and Atmospheric Administration
NWS National Weather Service

Climate Change Projections

The results of Colorado's changing climate are not yet fully known, though climate change is generally anticipated to result in more frequent and severe weather events. Researchers at Colorado State University estimate that climate change may cause an additional three days of hail per year by 2100, as well as amplify human exposure by 178% in the same period (Childs et al. 2020).

Probability of Future Occurrences

Table 5-76 summarizes data regarding the probability of occurrences of hail events in Douglas County based on the historic record. The information used to calculate the probability of occurrences is based on the 2015 Douglas County HMP, the NOAA-NCEI Storm Events Database, and the Storm Prediction Center.

Table 5-76 Probability of Future Occurrence of Hail Events

Hazard Type	Number of Occurrences Between 1954 and 2020	% chance of occurrence in any given year
Hail	358	100%
Lightning	26	38.8%

Source: NOAA-NCEI 2020; SPC 2020
Note: Disaster occurrences include federally declared disasters since the 1950 Federal Disaster Relief Act, and selected storm events since 1968. Due to limitations in data, not all hail and lightning events occurring between 1954 and 1996 are accounted for in the tally of occurrences. As a result, the number of hazard occurrences is underestimated.

Douglas County is expected to continue experiencing the direct and indirect impacts of hail and lightning events each year that may induce secondary hazards such as infrastructure deterioration or failure, utility failures, power outages, and transportation delays, accidents and inconveniences. It is estimated that Douglas County will continue to experience hail and lightning events each year.

Based on historical records and input from the Core Planning Team, the probability of occurrence for hail events in the County is considered *frequent* (Hazard event is likely to occur within 25 years). Refer to Sections 5.1 and 5.3 for additional information on the hazard ranking methodology and probability criteria.

Vulnerability Assessment

To understand risk, a community must evaluate assets exposed to and vulnerable to the identified hazard. The entire Douglas County is exposed and vulnerable to the hail hazard; therefore, all assets within Douglas County (population, structures, critical facilities, and lifelines), as described in Section 4 (County Profile), are potentially vulnerable to a hail event. The following text evaluates and estimates the potential impact of the hail hazard in the County.

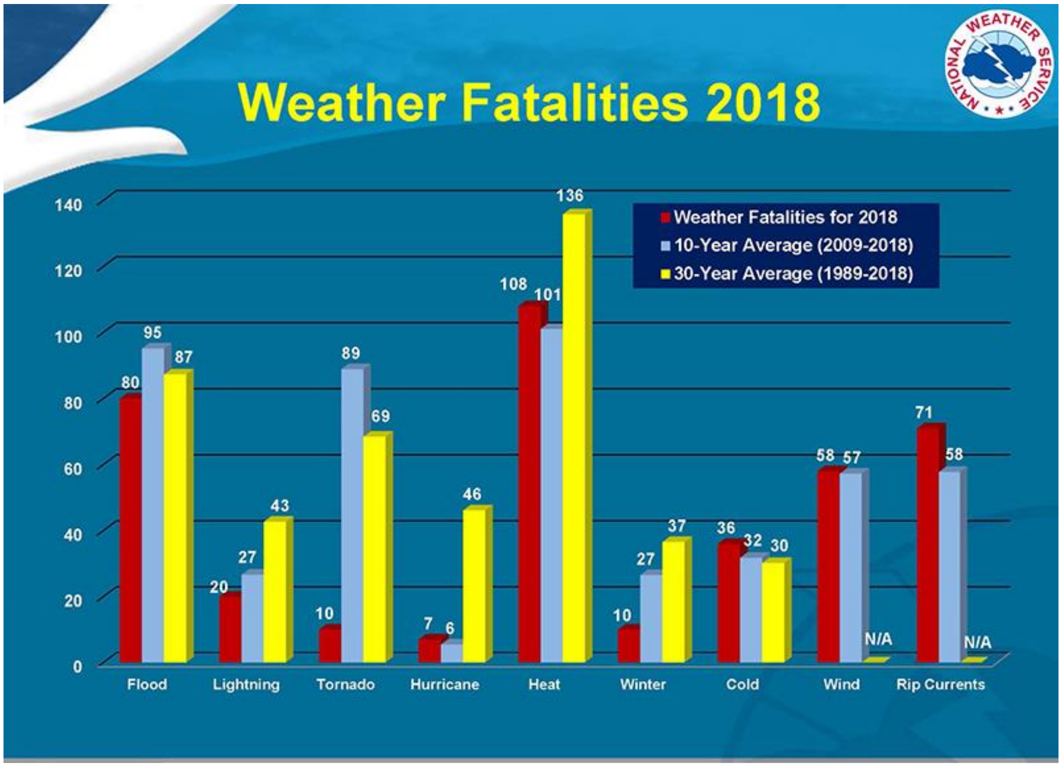
Impact on Life, Health and Safety

The impact of hail events on life, health, and safety is dependent upon several factors including the severity of the event and whether adequate warning time was provided to residents. The entire population of Douglas County (328,614) is assumed to be exposed to this hazard (U.S. Census 2018 ACS 5-Year Population Estimate).

People are vulnerable to the effects of hail events, including injuries, power outages, impacts on transportation routes, damage to homes, and damage to vehicles. First responders are also at risk of being injured during a significant hail event if they are responding to an incident. People located outdoors (e.g. recreational activities, farming, emergency responders) are considered most vulnerable to hailstorms because there is little to no warning time, and shelter might not be available. Moving to a lower risk location can decrease a person's vulnerability.

Across the United States, the 10-year average (2009 to 2018) for lightning-caused fatalities is 27, while the 30-year average (1989 to 2018) is 43 (NOAA 2020). Refer to Figure 5-31 for an illustration of these statistics. According to the NOAA-NCEI Storm Events Database, there has been one fatality and nine injuries as a result of lightning events from 2014 to 2020.

Figure 5-31. Weather Fatalities in the United States, 2018



Source: NOAA 2020

The impact of a lightning on life, health, and safety is dependent upon several factors including the severity of the event and whether adequate warning time was provided to residents. The entire population of Douglas County is assumed to be exposed to lightning strikes.

Lightning can be responsible for deaths, injuries, and property damage. Lightning-based deaths and injuries typically involve heart damage, inflated lungs, or brain damage, as well as loss of consciousness, amnesia, paralysis, and burns, depending on the severity of the strike. Additionally, most people struck by lightning survive, although they may have severe burns and internal damage. People located outdoors (i.e., recreational activities and farming) are considered most vulnerable to lightning strikes because there is little to no warning, and shelter might not be available. Moving to a lower risk location will decrease a person's vulnerability.

Impact on General Building Stock

For the purpose of this plan update, the entire general building stock and all infrastructure in Douglas County are considered exposed to the hail and lightning hazards.

Depending on the size of the hail and severity of the storm, Douglas County could see damage from hail impacting structures. While damage to the building stock is possible as a result of hail or lightning, it is difficult to estimate and would not have as wide of an impact as a high wind or tornado event.

Lightning can spark wildfires or building fires, especially if structures are not protected by surge protectors on critical electronic, lighting, or information technology systems. While damage to the building stock is possible as a result of lightning, it is difficult to estimate and would not have as wide of an impact as a high wind or tornado event.

Impact on Critical Facilities

All critical facilities in Douglas County are vulnerable to being affected by hail and lightning events.

Impact on Economy

Hail-producing severe storms impact the economy; impacts include loss of business function, damage to inventory, relocation costs, wage loss, and rental loss due to the repair or replacement of buildings. Additionally, vehicles parked outdoors are vulnerable to hail damage and could increase economic impacts of a storm.

According to NOAA's Technical Paper on *Lightning Fatalities, Injuries, and Damage Reports in the United States from 1959 - 1994*, monetary losses for lightning events range from less than $50 to greater than $5 million (larger losses associated with forest fires with homes destroyed and crop loss) (NOAA 1997).

Impact on the Environment

The impact of severe storm events on the environment varies, but researchers are finding that the long-term impacts of more severe weather can be destructive to the natural and local environment. National organizations such as USGS and NOAA have been studying and monitoring the impacts of extreme weather phenomena as it impacts long term climate change, streamflow, river levels, reservoir elevations, rainfall, floods, landslides, erosion, etc. (USGS 2017).

Cascading Impacts on Other Hazards

Hail and lightning events may escalate the impacts from other hazards of concern. Lightning can cause wildfires, which are discussed in Section 5.4.17. Hail and lightning often occur alongside severe storms that bring strong winds and flash floods.

Future Changes that May Impact Vulnerability

Understanding future changes that effect vulnerability in the County can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development.
- Projected changes in population.
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development

Any areas of growth could be potentially impacted by the hail hazard because the entire County is exposed and vulnerable.

Projected Changes in Population

The County experienced an increase in population between the 2010 Census (285,465) and the estimated 2018 American Community Survey estimated population of 328,614. The population of the County is expected to increase over the next few years. The increase in population will expose more people to the hail and lightning hazard.

Climate Change

Colorado's climate is changing, though exact impacts to temperature, precipitation, and weather events are currently variable. However, climate change may amplify human exposure to hail by up to 178% by 2100, and there may be three additional days of hail per year by 2100. This may result in potential impacts to Douglas County's ecosystems, residents, and properties (Childs et al. 2020).

Scientists have correlated lightning flash rate to convective available potential energy (CAPE) multiplied by the precipitation rate. When examined as a proxy for climate models for the continental United States, scientists have predicted that lightning strikes may increase 12+/- 5% per degree Celsius of global warning and by approximately 50% over the course of the century (Romps et al. 2014).

Changes in Vulnerability Since the 2015 HMP

Douglas County's population increased since the last plan; increasing the number of people impacted during a lightning. Therefore, the entire County remains vulnerable to lightning.

Issues Identified

Important issues associated with hail and lightning events in Douglas County include the following:

- Buildings and critical facilities that lack backup power sources are vulnerable to power outages resulting from lightning strikes.
- The increase in lightning strikes may result in additional wildfires resulting from strikes. Much of Douglas County is vulnerable to wildfires.

5.4.10 Severe Weather (Tornadoes)

The following section provides the hazard profile and vulnerability assessment for the tornado hazard in Douglas County.

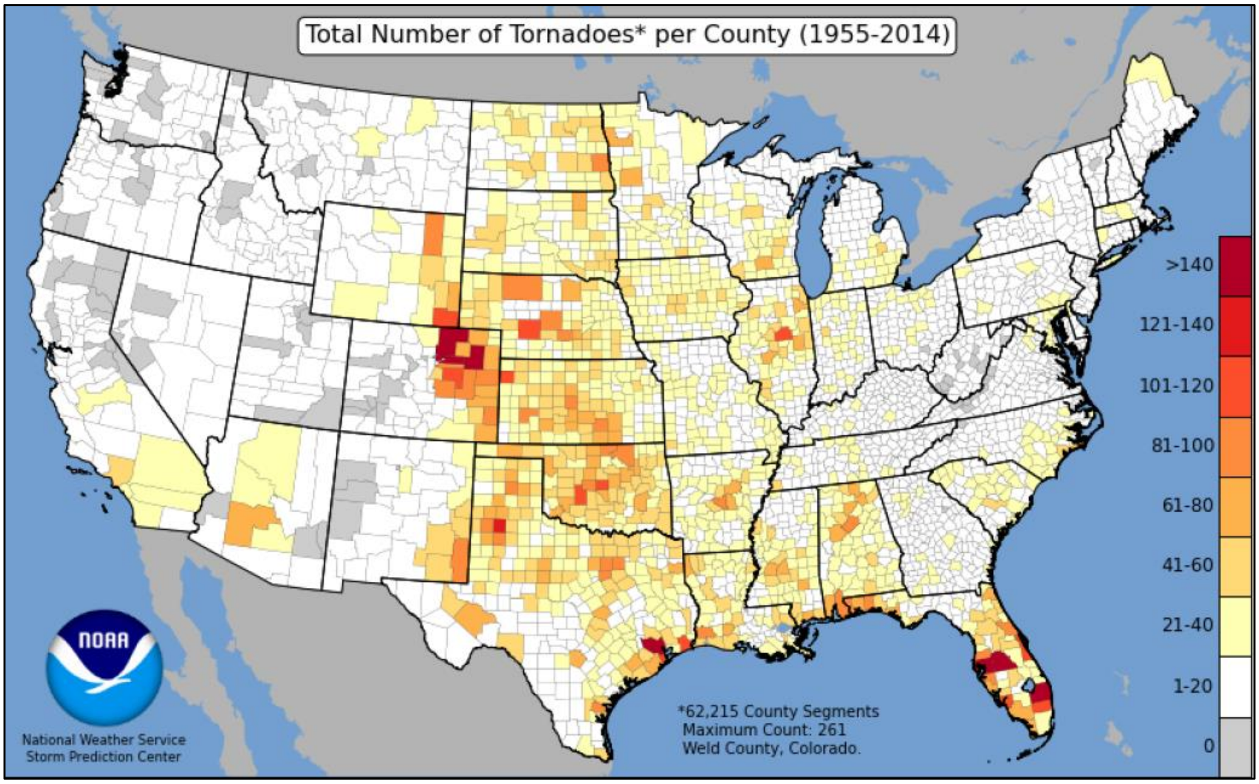
Profile

Hazard Description

A tornado appears as a rotating, funnel-shaped cloud that extends from a thunderstorm to the ground with whirling winds that can reach 250 miles per hour (mph). Damage paths can be greater than 1 mile wide and 50 miles long. Tornadoes typically develop from either a severe thunderstorm or hurricane as cool air rapidly overrides a layer of warm air. Tornadoes typically move at speeds between 30 and 125 mph and can generate combined wind speeds (forward motion and speed of the whirling winds) exceeding 300 mph. The lifespan of a tornado rarely is longer than 30 minutes (FEMA 1997). Tornadoes can occur at any time of the year, with peak seasons at different times for different states (NSSL 2013).

The figure below shows the total number of tornadoes, per county, between 1955 and 2014. The figure shows that Douglas County had between 41 and 60 tornadoes.

Figure 5-32. Tornadoes Per County, 1955 to 2014



Source: State of Colorado HMP 2018

Extent

Damage from tornadoes can vary from minor damage that breaks tree limbs to massive damage demolishing homes in its path. The type of damage depends on the intensity, size, and duration of the tornado. The magnitude or severity of a tornado is categorized using the Enhanced Fujita Tornado Intensity Scale (EF Scale). This is the scale now used exclusively for determining tornado ratings by comparing wind speed and actual damage. Figure 5-33 illustrates the relationship between EF ratings, wind speed, and expected tornado damage. The County can experience tornadoes ranking from EF0 to EF3.

Figure 5-33. Explanation of EF-Scale Ratings

EF Rating	Wind Speeds	Expected Damage
EF-0	65-85 mph	'Minor' damage: shingles blown off or parts of a roof peeled off, damage to gutters/siding, branches broken off trees, shallow rooted trees toppled.
EF-1	86-110 mph	'Moderate' damage: more significant roof damage, windows broken, exterior doors damaged or lost, mobile homes overturned or badly damaged.
EF-2	111-135 mph	'Considerable' damage: roofs torn off well constructed homes, homes shifted off their foundation, mobile homes completely destroyed, large trees snapped or uprooted, cars can be tossed.
EF-3	136-165 mph	'Severe' damage: entire stories of well constructed homes destroyed, significant damage done to large buildings, homes with weak foundations can be blown away, trees begin to lose their bark.
EF-4	166-200 mph	'Extreme' damage: Well constructed homes are leveled, cars are thrown significant distances, top story exterior walls of masonry buildings would likely collapse.
EF-5	> 200 mph	'Massive/incredible' damage: Well constructed homes are swept away, steel-reinforced concrete structures are critically damaged, high-rise buildings sustain severe structural damage, trees are usually completely debarked, stripped of branches and snapped.

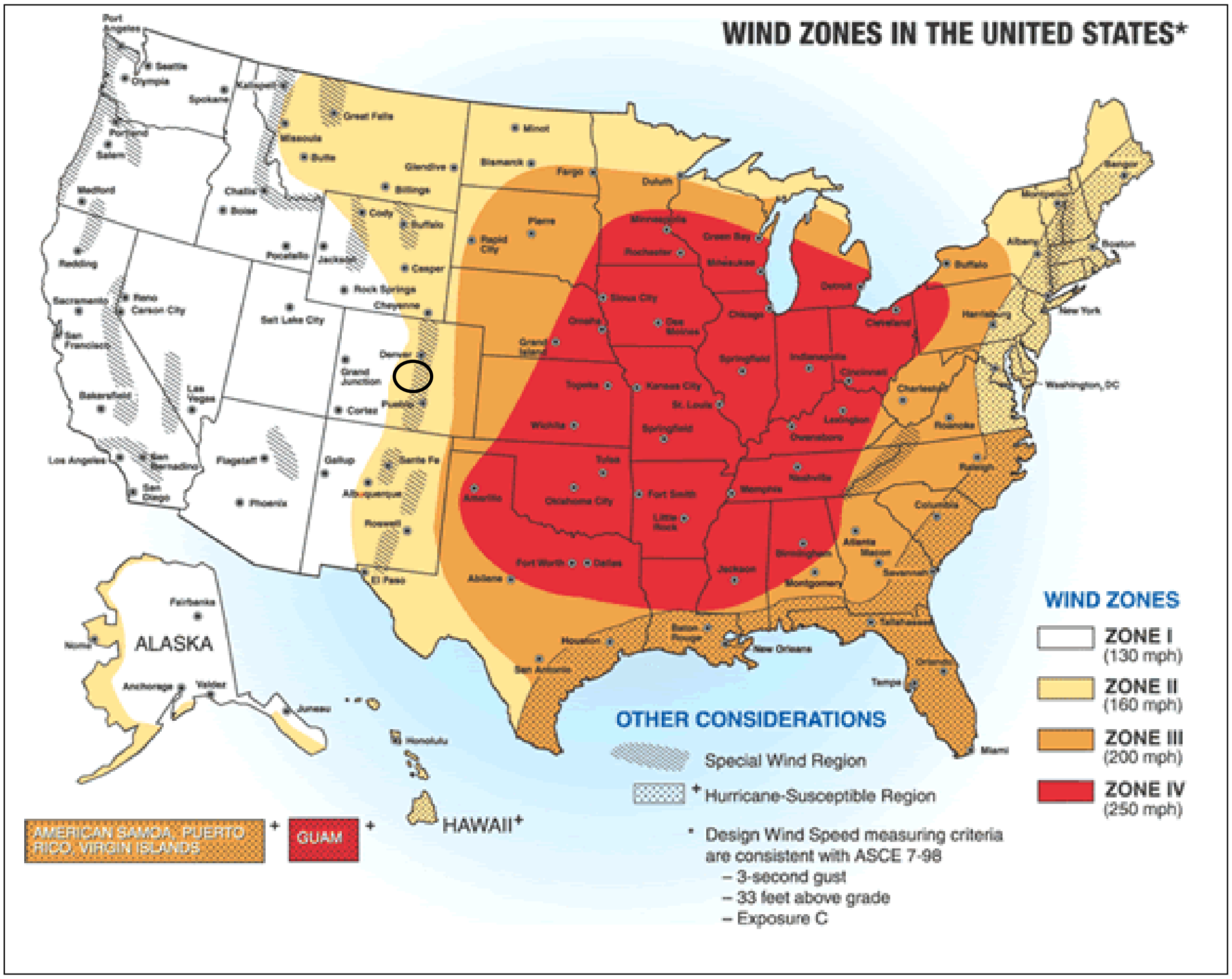
Source: NWS 2020

The NWS issues tornado watches and warnings. A tornado watch is issued by the SPC in Norman, Oklahoma. They are issued when conditions are favorable for the development of tornadoes in and close to the watch area. Their size can vary depending on the weather situation. Watches are typically issued for a duration of four to eight hours. A tornado warning is issued by the local NWS office and will include where the tornado was located and what municipalities will be in its path. It is issued when a tornado is indicated by a radar or spotters. Warnings are issued for a duration of 30 minutes (NWS 2020). The current average lead time for tornado warnings is 13 minutes. Occasionally, tornadoes develop so rapidly, that little, if any, advance warning is possible (NOAA 2011).

Location

Similar to that of thunderstorms, tornadoes do not have any specific geographic boundary and can occur anywhere in Douglas County. According to the FEMA Winds Zones of the United States map, Douglas County is located in Wind Zone II, where wind speeds can reach up to 160 mph. Figure 5-34 illustrates wind zones across the United States, which indicate the impacts of the strength and frequency of wind activity per region. The information on the figure is based on 40 years of tornado data and 100 years of hurricane data collected by FEMA.

Figure 5-34. Wind Zones in the United States



Source: FEMA 2014
Note: The black oval indicates the approximate location of Douglas County.

Previous Occurrences and Losses

Several different sources have provided historical information regarding previous occurrences and losses associated with tornadoes events in Douglas County. According to NOAA-NCEI Storm Events Database, Douglas County has been impacted by three tornado events that did not cause fatalities or reported property damage.

Table 5-77. Tornado Events 2014-2020

Hazard Type	Number of Occurrences Between 2014 and 2020	Total Fatalities	Total Injuries	Total Property Damage ($)	Total Crop Damage ($)
Tornado	3	0	0	N/A	$0
TOTAL	**3**	**0**	0	N/A	$0

Source: NOAA-NCEI 2020

Between 1953 and 2020, the State of Colorado was included in one tornado-related FEMA major disaster (DR) or emergency (EM) declarations. This disaster declaration included Douglas County (FEMA 2020). Table 5-49 lists the FEMA DR declaration for Douglas County.

Table 5-78 Tornado-Related FEMA Declarations for Douglas County, 1953 to 2020

FEMA Declaration Number	Date(s) of Event	Incident Type	Incident Title
DR-200	June 19th, 1965	Tornado	Tornadoes, Severe Storms, and Flooding

Source: FEMA 2020; USDA 2020

The events listed in Table 5-79 represent only those that were reported to NOAA-NCEI and the Storm Prediction Center and may not represent all tornado events and damages that have occurred since 2000.

Table 5-79 Tornado Events in Douglas County, 2014 to 2020

Date(s) of Event	Event Type	Fatalities	Injuries	Damages	Event Details*
June 8. 2014	Tornado (EF0)	0	0	$0 in property or crop damage	One of many tornadoes caused by an upper level weather disturbance and its associated cold front, this tornado touched down in the open country of Greenland, causing no damage to property or crops.
July 21, 2015	Tornado (EF1)	0	0	$0 in property or crop damage	A tornado touched down in Pike National Forest, causing damage to the affected area. As it traveled eastward, no damages were seen in Douglas County.
September 6, 2019	Tornado (EF0)	0	0	N/A	A weak tornado touched down in an open field near Highland Ranch. As a result, Douglas County experienced large hail and heavy rain. In Douglas County, a bolt of lightning caused a house fire, yielding extensive damage.

Source(s): FEMA 2020; NOAA-NCEI 2020
** Many sources were consulted to provide an update of previous occurrences and losses; event details and loss/impact information may vary and has been summarized in the above table*
N/A Not reported/not available
FEMA Federal Emergency Management Agency
NCEI National Centers for Environmental Information

Climate Change Projections

The results of Colorado's changing climate are not yet fully known, though climate change is generally anticipated to result in more frequent and severe weather events. Researchers at Colorado State University estimate that climate change may cause an additional day of tornadoes per year by 2100, as well as amplify human exposure by more than double in the same period (Childs et al. 2020).

Probability of Future Occurrences

Tornadoes occur on an annual basis throughout the State of Colorado. Most tornadoes occur between May and July, with most occurring in June (State of Colorado HMP 2018). Table 5-80 summarizes data regarding the probability of occurrences of tornado events in Douglas County based on the historic record.

The information used to calculate the probability of occurrences is based on NOAA-NCEI storm events database results and the SPC severe weather database files.

Table 5-80 Probability of Future Occurrence of Tornado Events

Hazard Type	Number of Occurrences Between 1953 and 2020	% chance of occurrence in any given year
Tornado (all magnitudes)	63	92.7%

Source: NOAA-NCEI 2020; SPC 2020

Douglas County is expected to continue experiencing the direct and indirect impacts of tornadoes each year. Based on historical records and input from the Core Planning Team, the probability of occurrence for tornadoes in the County is considered *frequent* (hazard event is likely to occur within 25 years). However, due to the rarity of tornadoes resulting in a significant loss event, the probability of occurrence for tornadoes in the risk ranking was ranked to be *occasional* (Hazard event is likely to occur within 100 years). Refer to Sections 5.1 and 5.3 for additional information on the hazard ranking methodology and probability criteria.

Vulnerability Assessment

To understand risk, a community must evaluate assets exposed to and vulnerable to the identified hazard. The entire Douglas County planning area is exposed and vulnerable to the tornado hazard; therefore, all assets within the County (population, structures, critical facilities, and lifelines), as described in Section 4 (County Profile), are potentially vulnerable to a tornado event. The following text evaluates and estimates the potential impact of the tornado hazard in the County.

Impact on Life, Health and Safety

Impacts of a tornado on life, health, and safety depend on several factors, including severity of the event and whether adequate warning time was provided to residents. All residents in Douglas County are exposed to the tornado hazard.

Residents impacted by tornadoes may be displaced or require temporary to long-term sheltering. In addition, downed trees, damaged buildings, and debris carried by winds associated with tornadoes can lead to injury or loss of life. Similar to other natural hazards, socially vulnerable populations are most susceptible, based on a number of factors including their physical and financial ability to react or respond during a hazard and locations and construction quality of their housing. Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions based on the major economic impact on their family and may not have funds to evacuate. The population over the age of 65 is also more vulnerable and, physically, they may have more difficulty evacuating. The elderly are considered most vulnerable because they require extra time or outside assistance during evacuations and are more likely to seek or need medical attention that may not be available due to isolation during a storm event. Section 4 (County Profile) presents the statistical information regarding these populations in the County.

Impact on General Building Stock

The entire County's building stock is exposed to the tornado hazard. Damage to buildings depends on several factors, including wind speed, storm duration, path of the storm track or tornado, and distance from the tornado funnel.

Manufactured housing (i.e. mobiles homes) is particularly vulnerable to high winds and tornadoes. The U.S. Census Bureau defines manufactured homes as "movable dwellings, 8 feet or wider and 40 feet or more long, design to be towed on its own chassis, with transportation gear integral to the unit when it leaves the factory, and without need of a permanent foundation (Census, 2010)." They can include multi-wides and expandable manufactured homes but exclude travel trailers, motor homes, and modular housing. Due to their light-weight and often unanchored design, manufactured housing is extremely vulnerable to high winds and will generally sustain the most damage.

Table 5-81 displays the number of manufactured housing units in the County. Total counts were obtained from the 2014-2018 American Community Survey 5-Year Estimates. While the number is a very small percentage of total homes in the County (0.2% of the total housing units), the structures and the population living in the structures are vulnerable to tornado events.

Table 5-81 Manufactured Housing Units in Douglas County

Municipality	Number of Manufactured Homes
Douglas County	324

Source: U.S. Census 2018

Impact on Critical Facilities

Utility infrastructure could suffer damage from tornadoes associated with falling tree limbs or other debris, resulting in the loss of power or other utility service. Loss of service can impact residents, critical facilities, and business operations alike. Interruptions in heating or cooling utilities can affect populations, such the young and elderly, who are particularly vulnerable to temperature-related health impacts. Loss of power can impact other public utilities, including potable water, wastewater treatment, and communications. In addition to public water services, property owners with private wells might not have access to potable water until power is restored. Lack of power to emergency facilities, including police, fire, EMS, and hospitals, will inhibit a community's ability to effective respond to an event and maintain the safety of its citizens.

Impact on Economy

Tornados also impact the economy, including loss of business function (e.g., tourism, recreation), damage to inventory, relocation costs, and wage loss and rental loss due to repair/replacement of buildings. Impacts on transportation lifelines affect both short-term (e.g., evacuation activities) and long-term (e.g., day-to-day commuting and goods transport) transportation needs. Utility infrastructure (power lines, gas lines, electrical systems) could sustain damage, and impacts could result in loss of power, which can affect business operations and provision of heating or cooling to the population.

Impact on Environment

The impact of severe storm events on the environment varies, but researchers are finding that the long-term impacts of more severe weather can be destructive to the natural and local environment. National organizations such as USGS and NOAA have been studying and monitoring the impacts of extreme weather phenomena as it impacts long term climate change, streamflow, river levels, reservoir elevations, rainfall, floods, landslides, erosion, etc. (USGS 2017).

Cascading Impacts on Other Hazards

Severe storms events may escalate the impacts from other hazards of concern, such as drought or erosion. Loose soils can be disturbed and become airborne during tornado events, causing disruption to farms and the ecosystem.

Future Changes that May Impact Vulnerability

Understanding future changes that effect vulnerability in the County can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development.
- Projected changes in population.
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development

Any areas of growth could be potentially impacted by the tornado hazard because the entire County is exposed and vulnerable. Residential development, specifically manufactured homes, may be considered more vulnerable to the tornado hazard.

Projected Changes in Population

The County has experienced an increase in population between the 2010 Census (285,465) and the estimated 2018 American Community Survey estimated population of 328,614. The population of the County is expected to increase over the next few years. The increase in population will expose more people to the tornado hazard.

Climate Change

Colorado's climate is changing, though exact impacts to temperature, precipitation, and weather events are currently variable. However, climate change may amplify human exposure to tornadoes by up to 117% by 2100, and there may be one additional tornado day per year by 2100. This may result in potential impacts to Douglas County's ecosystems, residents, and properties (Childs et al. 2020).

Changes in Vulnerability Since the 2015 HMP

Douglas County's population increased since the last plan, increasing the number of people vulnerable during a tornado. Therefore, the entire County remains vulnerable to tornado events.

Issues Identified

Important issues associated with tornadoes in Douglas County include the following:

- Mobile homes are vulnerable to damaging winds from tornadoes
- Dead or dying trees are more susceptible to falling during a tornado
- Power outages lead to disruption of services and can cause disruption in communication

5.4.11 Severe Weather: Thunderstorms and Windstorms

The following section provides the hazard profile and vulnerability assessment for the thunderstorm and wind hazard in Douglas County.

Profile

Hazard Description

Thunderstorms

A thunderstorm is a storm with lightning and thunder produced by cumulonimbus cloud, usually producing gusty winds, heavy rain, and sometimes hail or tornadoes (NWS 2009). Thunderstorms are usually short-lived (less than two hours), but they can deliver strong winds and enough rain to cause urban or flash flooding. The NWS considers a thunderstorm severe only if it produces damaging wind gusts of 58 mph or higher or large hail one-inch (quarter size) in diameter or larger or tornadoes (NWS 2009). Thunderstorms can occur at any time. However, they are most common in the Southeast, Great Plains, and Mississippi River Valley. Thunderstorms are also frequent in the mountainous regions of New Mexico and Colorado [NSSL] 2020). For details on lightning events in Douglas County, refer to Section 5.4.9 (Hail and Lightning).

It is estimated that each year there are 16 million thunderstorms worldwide. Approximately 100,000 thunderstorms occur in the United States each year (NSSL 2020). Figure 5-35 illustrates the average number of days with thunderstorms using data from 1993 to 2018. This figure shows that Douglas County experiences between 54 and 63 days of thunderstorms each year.

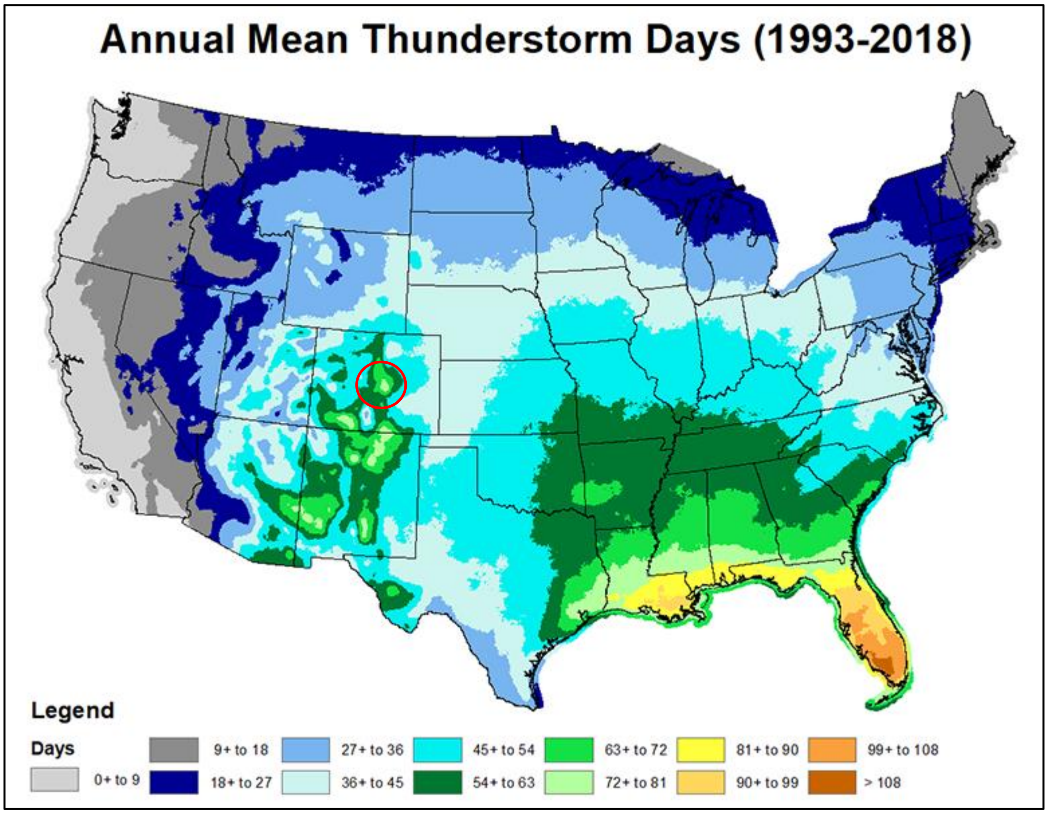
Thunderstorms can lead to flooding, landslides, strong winds, tornadoes, lightning, and hail. Roads could become impassable from flooding, downed trees or power lines, or a landslide. Strong straight-line winds (up to more than 12 mph) associated with thunderstorms can down trees and utility poles, causing utility outages. Thunderstorms can create tornadoes with winds of up to 300 mph. Lightning can damage homes and injure people. In the United States, an average of 300 people are injured and 80 people are killed by lightning each year. Thunderstorms can produce hail up to the size of softballs damaging cars and windows, and killing livestock caught out in the open (NSSL 2020).

Windstorms and High Winds

Wind begins with differences in air pressures and occurs through rough horizontal movement of air caused by uneven heating of the earth's surface. Wind occurs at all scales, from local breezes lasting a few minutes to global winds resulting from solar heating of the earth. High winds are often associated with other severe weather events such as thunderstorms, derechos, tornadoes, nor'easters, hurricanes, and tropical storms.

High winds are often associated by other severe weather events such as thunderstorms, tornadoes, hurricanes, and tropical storms. Wind begins with differences in air pressures. It is rough horizontal movement of air caused by uneven heating of the earth's surface. Wind occurs at all scales, from local breezes lasting a few minutes to global winds resulting from solar heating of the earth (Rosenstiel School of Marine & Atmospheric Science 2005).

Figure 5-35. Annual Mean Thunderstorm Days, 1993-2018



Source: National Weather Service 2020
Note: The approximate location of Douglas County is outlined in a red circle.

High winds in Colorado generated during the cold season are due to air pressure differences and Chinook winds developing across the Front Range. Winds traveling the leeward slopes of mountains (Bora) can cause episodic high winds. Generally, high winds can cause flying debris, reduced visibility due to dust, and structural damage. The National Weather Service issues high wind watches where the chance for high winds to develop in the following two days is greater than 50 percent. Bora winds can also cause low wind chill values (NWS 2020).

Extent

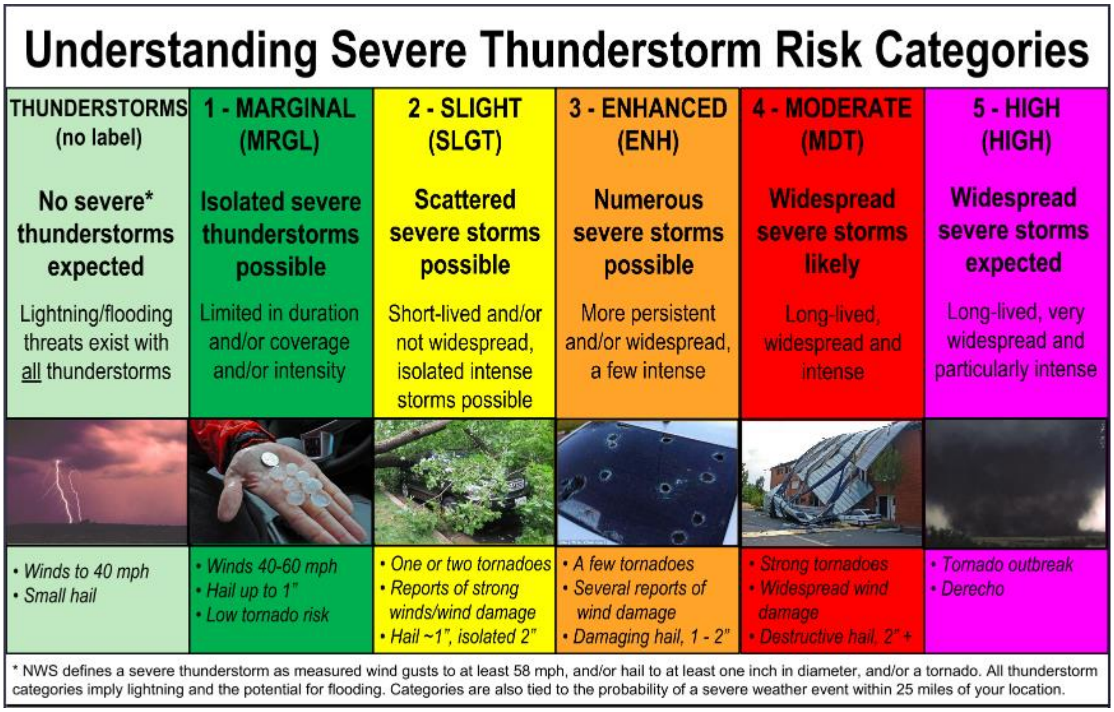
Severe thunderstorm watches and warnings are issued by the local NWS office and the Storm Prediction Center (SPC). The NWS and SPC will update the watches and warnings and notify the public when they are no longer in effect. Watches and warnings for thunderstorms in Douglas County are as follows:

- Severe Thunderstorm Warnings are issued when there is evidence based on radar or a reliable spotter report that a thunderstorm is producing, or forecast to produce, wind gusts of 58 mph or greater, structural wind damage, or hail one-inch in diameter or greater. A warning will include where the storm was located, what municipalities will be impacted, and the primary threat associated with the severe thunderstorm warning. After it has been issued, the NWS office will follow up periodically with Severe Weather Statements that contain updated information on the severe thunderstorm and advise the public when the warning is no longer in effect (NWS 2009, NWS 2010).

- Severe Thunderstorm Watches are issued by the SPC when conditions are favorable for the development of severe thunderstorms over a larger-scale region for a duration of at least three hours. Tornadoes are not expected in such situations, but isolated tornado development can also occur. Watches are normally issued well in advance of the actual occurrence of severe weather. During the watch, the NWS will keep the public informed on what is happening in the watch area and also advise public when the watch has expired or been cancelled (NWS 2009, NWS 2010).

Figure 5-36 presents the severe thunderstorm risk categories, as provided by the SPC.

Figure 5-36 Severe Thunderstorm Risk Categories.



Source: SPC 2017

Winds associated with thunderstorms are measured according to the Beaufort Wind Scale, as outlined in Table 5-82. This scale was one of the first to estimate wind speeds. In Colorado, wind speed is correlated with elevation. Differences in elevation, temperatures, and seasonality can cause wide variability of winds in the State (State of Colorado 2018).

Table 5-82 Beaufort Wind Scale

Force	Wind (Knots)	WMO Classification	Appearance of Wind Effects on Land
0	Less than 1	Calm	Calm, smoke rises vertically
1	1-3	Light Air	Smoke drift indicates wind direction, still wind vanes
2	4-6	Light Breeze	Wind felt on face, leaves rustle, vanes begin to move
3	7-10	Gentle Breeze	Leaves and small twigs constantly moving, light flags extended
4	11-16	Moderate Breeze	Dust, leaves, and loose paper lifted, small tree branches move
5	17-21	Fresh Breeze	Small trees in leaf begin to sway
6	22-27	Strong Breeze	Larger tree branches moving, whistling in wires
7	28-33	Near Gale	Whole trees moving, resistance felt walking against wind
8	34-40	Gale	Twigs breaking off trees, generally impedes progress
9	41-47	Strong Gale	Slight structural damage occurs, slate blows off roofs

Force	Wind (Knots)	WMO Classification	Appearance of Wind Effects on Land
10	48-55	Storm	Seldom experienced on land, trees broken or uprooted, considerable structural damage occurs
11	56-63	Violent Storm	If experienced on land, widespread damage
12	64+	Hurricane	Violence and destruction

Source: NWS 2020

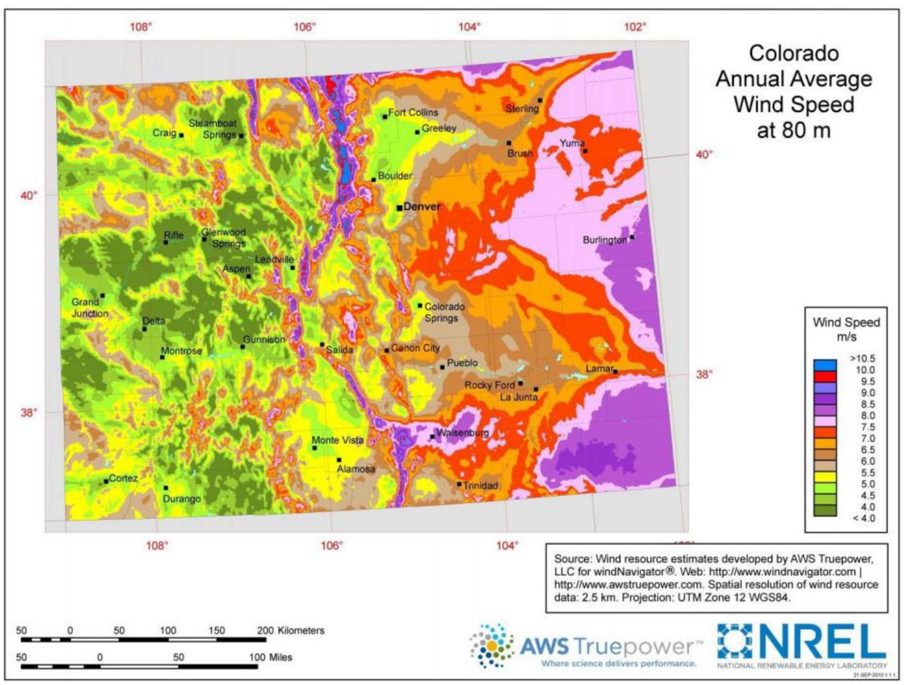
The NWS issues advisories and warnings for winds. Issuance is normally site-specific. High wind advisories, watches, and warnings are products issued by the NWS when wind speeds can pose a hazard or are life threatening. The criterion for each of these varies from state to state. According to the NWS, wind warnings and advisories for Douglas County are as follows:

- *High Wind Warnings* are issued when sustained wind speeds of 40 mph or greater lasting for one hour or longer or for winds of 58 mph or greater for any duration or widespread damage are possible.
- *Wind Advisories* are issues when sustained winds of 30 to 39 mph are forecast for one hour or longer, or wind gusts of 46 to 57 mph for any duration (NWS 2020; NHC 2020).

Location

Since thunderstorms can develop anywhere in the United States, all of Douglas County is exposed and vulnerable to the impacts of thunderstorms. In Colorado, reports of severe winds are most common in northeastern Colorado, including the northern Eastern Plains and the Front Range. The 2018 Enhanced State Hazard Mitigation Plan indicates that the foothills between Fort Collins and Trinidad (which includes Douglas County) are prone to 60 to 100 mph winds (State of Colorado 2018). Table 5-84 shows the distribution of average wind speeds in the State of Colorado.

Figure 5-37: Annual Average Wind Speeds at 80M



Source: National Renewable Energy Laboratory in the State of Colorado HMP

The northwestern portion of Douglas County is located within a Special Wind Region as designated in ASCE 7-10 (*Minimum Design Loads for Buildings and Other Structures*). The Special Wind Region results from exceptional wind speeds resulting from the County's location in the Front Range, where mountains and gorges result in wind speed anomalies (CPPWind 2020).

Previous Occurrences and Losses

Many sources have provided historical information regarding previous occurrences and losses associated with thunderstorms in Douglas County. According to the NOAA-NCEI Storm Events Database, Douglas County has been impacted by 61 wind events between 2014 and 2020 that caused $10,000 in property damage and no crop damage.

Table 5-83 Impacts from Wind Events in Douglas County, 2014-2020

Hazard Type	Number of Occurrences Between 2014 and 2020	Total Fatalities	Total Injuries	Total Property Damage ($)	Total Crop Damage ($)
High Wind	44	0	23	$0	$0
Strong Wind	2	0	0	$10,000	$0
Thunderstorm Wind	15	0	0	$0	$0

Source: NOAA-NCEI 2020

Note: Due to data limitations, historic data is not available for some years. These numbers reflect underestimations.

Between 2014 and 2020, Douglas County was not included in thunderstorm-related FEMA major disaster (DR) or emergency (EM) declarations. This HMP update includes known thunderstorm and wind events that have impacted Douglas County between 2014 and 2020. These events are shown in Table 5-84. The events listed in Table 5-84 represent only those that were reported to the NOAA-NCEI Storm Events Database and FEMA, and may not represent all thunderstorm and wind events that have occurred since 2014.

Table 5-84 Wind Events in Douglas County, 2014-2020

Date(s) of Event	Event Type	Magnitude (wind speed in knots)	Fatalities	Injuries	Damages	Event Details*
August 25, 2014	Thunderstorm Wind	57	0	0	N/A	As a result of this severe storm, hail the size of a quarter poured down on the County. Wind was as fast as 66 miles per hour in northern Douglas County.
August 27, 2014	Thunderstorm Wind	50	0	0	N/A	Thunderstorm winds produced large hail, which was described as ranging from the size of a nickel to a golf ball. Wind was as fast as 65 miles per hour.
November 10, 2014	Strong Wind	45	0	0	N/A	Strong winds followed an Arctic cold front, causing strong gusts above the timberline.
July 25, 2016	Thunderstorm Wind	52	0	0	N/A	The County experienced intense straight-line winds.
April 17, 2018	Strong Wind	74	0	0	N/A	A strong wind from a powerful post-frontal bora contributed to the spread of a fire that damaged several homes. A wind speed of 74 mph was recorded at the Cheesman

Date(s) of Event	Event Type	Magnitude (wind speed in knots)	Fatalities	Injuries	Damages	Event Details*
						Reservoir and tens of thousands of power outages were reported.
July 25, 2018	Thunderstorm Wind	60	0	0	N/A	This storm made its way across many counties throughout Colorado, traveling from Boulder, Douglas, Elbert, and Weld counties. Wind speeds up of 54 miles per hour in Sedalia and 60 miles per hour in Parker. This severe storm caused significant damage across the counties, though no damage was noted in Douglas County. However, damage in other counties included damage to homes and vehicles. Trees also fell as a result of this storm. Damage can be attributed to winds as high as 80 miles per hour in some regions, along with quarter sized hail and heavy rain. It was noted that a farm in Broomfield off of York Street experienced a loss of 200 acres of corn. The storm also resulted in power outages throughout affected areas that lasted for several hours.

Source(s): FEMA 2020; NOAA-NCEI 2020
N/A Not available/not recorded
FEMA Federal Emergency Management Agency
NCEI National Centers for Environmental Information
NOAA National Oceanic and Atmospheric Administration
NWS National Weather Service

Climate Change Projections

Changes in wind speeds due to climate change vary on the continental scale. Models suggest an increase in wind speeds between the Hudson Bay region in Canada and Texas, which is a swathe of North America that includes portions of Colorado. However, there is overall uncertainty with the impact of climate change on wind speeds (Eichelberger et al. 2008).

Probability of Future Occurrences

Table 5-85 summarizes data regarding the probability of occurrences of thunderstorm events in Douglas County based on the historic record. The information used to calculate the probability of occurrences is based on the 2015 Douglas County HMP, the NOAA-NCEI Storm Events Database, SPC, and FEMA.

Table 5-85 Probability of Future Occurrence of Thunderstorm and Wind Events

Hazard Type	Number of Occurrences Between 1953 and 2020	% chance of occurrence in any given year
Strong Winds	4	5.9%
Thunderstorm Wind	32	47.7%
High Wind	148	100%

Source: NOAA-NCEI 2020; FEMA 2020
Source: Due to data limitations, not all wind events between 1953 and 2020 are included here. These numbers reflect an underestimate.

Douglas County is expected to continue experiencing the direct and indirect impacts of wind events each year. Based on historical records and input from the Core Planning Team, the probability of occurrence for thunderstorm events in the County is considered *frequent* (Hazard event is likely to occur within 25 years). Refer to Sections 5.1 and 5.3 for additional information on the hazard ranking methodology and probability criteria.

Vulnerability Assessment

To understand risk, a community must evaluate assets exposed to and vulnerable to the identified hazard. The entire Douglas County is exposed and vulnerable to the thunderstorm and wind hazard; therefore, all assets within the County (population, structures, critical facilities, and lifelines), as described in Section 4 (County Profile), are potentially vulnerable to a thunderstorm event. The following text evaluates and estimates the potential impact of the thunderstorm hazard in the County.

Impact on Life, Health and Safety

The impact of thunderstorms on life, health, and safety is dependent upon several factors including the severity of the event and whether adequate warning time was provided to residents. The entire population of Douglas County (328,614) is assumed to be exposed to this hazard (U.S. Census 2018 ACS 5-Year Population Estimate).

The most common problems associated with thunderstorms are immobility and loss of utilities. Although the entire population of the County is exposed to thunderstorms, some populations are more vulnerable. Vulnerable populations include the elderly, low income, linguistically isolated populations, people with life-threatening illnesses, and residents living in areas that are isolated from major roads. Power outages can be life threatening to those dependent on electricity for life support. In general, populations who lack adequate shelter during a thunderstorm, those who are reliant on sustained sources of power in order to survive, and those who live in isolated areas with limited ingress and egress options are the most vulnerable.

> People located outdoors (i.e., recreational activities and farming) are considered most vulnerable to hailstorms, thunderstorms, and tornadoes because there is little to no warning, and shelter might not be available. Moving to a lower risk location will decrease a person's vulnerability.

Economically disadvantaged populations are more vulnerable because they often evaluate evacuation needs and make decisions based on the economic impact to their family. The population over the age of 65 (35,801) is also vulnerable, can physically have difficulty evacuating, and are more likely to seek or need medical attention, which may not be available due to isolation during a storm event (U.S. Census 2018 ACS 5-Year Population Estimate). Section 4 (County Profile) provides for the statistics for these populations for Douglas County.

As a result of the impacts of thunderstorms, residents can be displaced or require temporary to long-term sheltering. In addition, downed trees, damaged buildings, and debris carried by high winds from thunderstorms can lead to injury or loss of life. Socially vulnerable populations are most susceptible, based on a number of factors, including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing.

Impact on General Building Stock

The entire building stock of Douglas County is vulnerable during a thunderstorm; however, properties in poor condition or in particularly vulnerable locations may be at a higher risk. Buildings located under or near overhead lines or near large trees are more susceptible to damages associated with downed trees and wires.

Impact on Critical Facilities

Overall, all critical facilities in Douglas County are vulnerable to being affected by thunderstorms. Utility infrastructure could suffer damage from high winds associated with falling tree limbs or other debris, resulting in the loss of power or other utility service. Loss of service can impact residents, critical facilities, and business operations alike. Interruptions in heating or cooling utilities can affect populations, such the young and elderly, who are particularly vulnerable to temperature-related health impacts. Loss of power can impact other public utilities, including potable water, wastewater treatment, and communications. In addition to public water services, property owners with private wells might not have access to potable water until power is restored. Lack of power to emergency facilities, including police, fire, EMS, and hospitals, will inhibit a community's ability to effective respond to an event and maintain the safety of its citizens.

Impact on Economy

Thunderstorm events can impact the economy of the County. Impacts include loss of business function, damage to inventory, relocation costs, wage loss, and rental loss due to the repair or replacement of buildings. HAZUS-MH v4.2 estimates the total economic loss associated with each probabilistic event (direct building losses and business interruption losses). Business interruption losses include losses associated with the inability to operate a business because of the wind damage sustained during a storm or the temporary living expenses for those displaced from their home because of an event.

Impact to the Environment

The impact of severe storm events on the environment varies, but researchers are finding that the long-term impacts of more severe weather can be destructive to the natural and local environment. National organizations such as USGS and NOAA have been studying and monitoring the impacts of extreme weather phenomena as it impacts long term climate change, streamflow, river levels, reservoir elevations, rainfall, floods, landslides, erosion, etc. (USGS 2017). For example, severe weather that creates longer periods of rainfall can erode natural banks along waterways and degrade soil stability for terrestrial species. Tornadoes can tear apart habitats causing fragmentation across ecosystems. Researchers also believe that a greater number of diseases will spread across ecosystems because of impacts that severe weather and climate change will have on water supplies (NOAA 2013c). Overall, as the physical environment becomes more altered, species will begin to contract or migrate in response, which may cause additional stressors to the entire ecosystem within Douglas County.

Cascading Impacts on Other Hazards

Severe storms events may escalate the impacts from other hazards of concern, such as coastal erosion or infestation and invasive species. Severe winds can be destructive to the natural coastlines if the coastal land area is left barren. Furthermore, changes in the land area caused by severe storm events can alter the distribution of species throughout the County, exacerbating the presence of invasive species who can survive in distressed environments.

Future Changes that May Impact Vulnerability

Understanding future changes that effect vulnerability in the County can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development.
- Projected changes in population.
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development

Understanding future changes that impact vulnerability in the County can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. Development contributes to increased exposure of people and property to the impacts of wind events. Areas targeted for potential future growth and development could be potentially impacted by thunderstorms since the entire County is exposed to the thunderstorm hazard.

Projected Changes in Population

The County experienced an increase in population between the 2010 Census (285,465) and the estimated 2014-2018 American Community Survey estimated population of 328,614. The population of the County is expected to increase over the next few years. The increase in population will expose more people to the thunderstorm hazard.

Climate Change

Major clusters of summertime thunderstorms in North America will grow larger, more intense, and more frequent later this century in a changing climate, unleashing far more rain and posing a greater threat of flooding across wide areas (UCAR 2017). An increase in storms will produce more wind events and may increase tornado activity. Additionally, an increase in temperature will provide more energy to produce storms that generate tornadoes (Climate Central 2016). Overall, Douglas County will continue to remain vulnerable to the thunderstorm hazard.

Anticipated changes in wind speeds due to climate change vary. Models suggest an increase in wind speeds between the Hudson Bay region in Canada and Texas, which is a swathe of North America that includes portions of Colorado. However, there is overall uncertainty with the impact of climate change on wind speeds (Eichelberger et al. 2008).

Changes in Vulnerability Since the 2015 HMP

Douglas County's population increased since the last plan; increasing the number of people impacted during a thunderstorm. Therefore, the entire County remains vulnerable to thunderstorms.

Issues Identified

Important issues associated with severe storm events in Douglas County include the following:

- Older building stock in the County could be more vulnerable to winds associated with thunderstorms as they may have been built to low or no code standards.

- Critical facilities and other structures may not have a source of backup power; during power outages associated with high winds, these facilities might not function properly or provide the necessary needs to the County.
- The impacts of drought might lead to dead or dying trees. These trees are more susceptible to falling during thunderstorms. This can cause power outages, close roadways, and damage buildings and property.
- High winds can also spread wildfires and hinder efforts to suppress wildfires' spread.

5.4.12 Severe Winter Storm

The following section provides the hazard profile and vulnerability assessment for the severe winter storm hazard in Douglas County.

Profile

Hazard Description

Severe winter storms bring the threat of snow, freezing rain, and ice storms to Douglas County. A winter storm is a weather event in which the main types of precipitation are snow, sleet, or freezing rain. They can be a combination of heavy snow, blowing snow, and dangerous wind chills. According to the National Severe Storms Laboratory (n.d.), the three basic components needed to make a winter storm include the following:

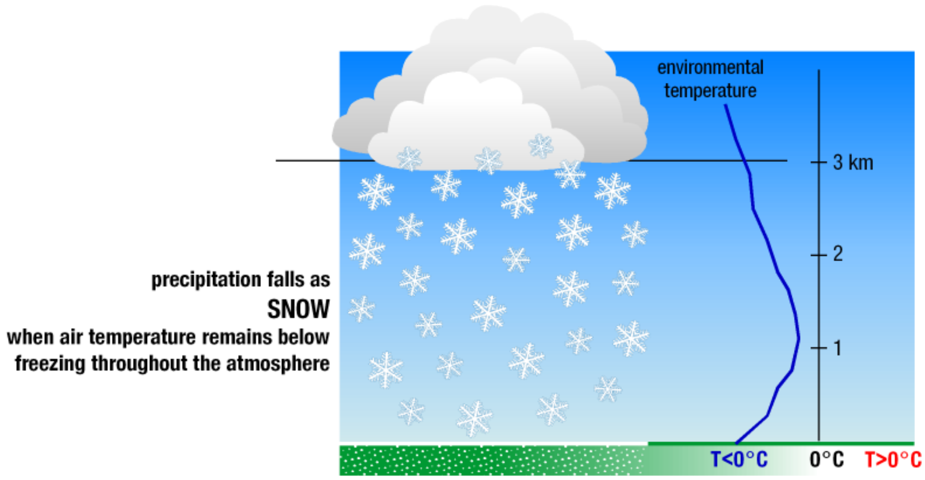
- Below freezing temperatures (cold air) in the clouds and near the ground to make snow and ice.
- Lift, something to raise the moist air to form clouds and cause precipitation, such as warm air colliding with cold air and being forced to rise over the cold dome or air flowing up a mountainside (oliographic lifting).
- Moisture to form clouds and precipitation, such as air blowing across a large lake or the ocean.

Some winter storms are large enough to immobilize an entire region while others might only affect a single community. Winter storms typically are accompanied by low temperatures, high winds, freezing rain or sleet, and heavy snowfall. The aftermath of a winter storm can have an impact on a community or region for days, weeks, or even months; potentially causing cold temperatures, flooding, storm surge, closed and blocked roadways, downed utility lines, and power outages. In Douglas County, winter storms include snowstorms (heavy snow), blizzards, and ice storms. Extreme cold temperatures and wind chills are associated with winter storms; however, they are discussed in Section 5.4.5 (Extreme Temperatures).

Heavy Snow

According to the National Weather Service (NWS), snow is precipitation in the form of ice crystals, formed directly from the freezing of water vapor in the air. It originates in clouds when temperatures are below the freezing point (32 °F) and water vapor in the atmosphere condenses directly into ice without going through the liquid stage. Once an ice crystal has formed, it absorbs and freezes additional water vapor from the surrounding air, growing into snow crystals or a snow pellet, which then falls to the earth. Snow falls in different forms: snowflakes, snow pellets, or sleet. Figure 5-38 depicts snow creation.

Figure 5-38 Snow Creation



Source: NOAA-NSSL, 2015

Blizzards

A blizzard is a winter snowstorm with sustained or frequent wind gusts of 35 miles per hour (mph) or more, accompanied by falling or blowing snow reducing visibility to or below 0.25 mile, as the predominant conditions over a 3-hour period. Extremely cold temperatures often are associated with blizzard conditions but are not a formal part of the definition. The hazard, created by the combination of snow, wind, and low visibility, significantly increases when temperatures are below 20 °F. A severe blizzard is categorized as having temperatures near or below 10 °F, winds exceeding 45 mph, and visibility reduced by snow to near zero. Storm systems powerful enough to cause blizzards usually form when the jet stream dips far to the south, allowing cold air from the north to clash with warm, moister air from the south. Blizzard conditions often develop on the northwest side of an intense storm system. The difference between the lower pressure in the storm and the higher pressure to the west creates a tight pressure gradient, resulting in strong winds and extreme conditions caused by the blowing snow (The Weather Channel 2012).

Ice Storms

An ice storm describes those events when damaging accumulations of ice are expected during freezing rain situations. Significant ice accumulations typically are accumulations of 0.25-inches or greater (NWS 2013). Heavy accumulations of ice can bring down trees, power lines, utility poles, and communication towers. Ice can disrupt communications and power for days. Even small accumulations of ice can be extremely dangerous to motorists and pedestrians (NWS 2008).

Extent

In the State of Colorado and Douglas County, the winter storm season runs from November to April each year (State of Colorado 2018). The magnitude or severity of a severe winter storm depends on several factors, including a region's climatological susceptibility to snowstorms, snowfall amounts, snowfall rates, wind speeds, temperatures, visibility, storm duration, topography, time of occurrence during the day and week (e.g., weekday versus weekend), and time of season.

The NWS uses the Winter Storm Severity Index (WSSI) to assist forecasters in maintaining situational awareness of the possible significant of weather-replated impacts. The index is also used to help communicate a general level of potential societal impacts; however, it does not depict official watches and warnings (State of Colorado 2018; Weather Prediction Center 2021).

Potential Winter Storm Impacts	
	No Impacts Impacts not expected.
	Limited Impacts Rarely a direct threat to life and property. Typically results in little inconveniences.
	Minor Impacts Rarely a direct threat to life and property. Typically results in an inconvenience to daily life.
	Moderate Impacts Often threatening to life and property, some damage unavoidable. Typically results in disruptions to daily life.
	Major Impacts Extensive property damage likely, life saving actions needed. Will likely result in major disruptions to daily life.
	Extreme Impacts Extensive and widespread severe property damage, life saving actions will be needed. Results in extreme disruptions to daily life.

Additionally, National Oceanic and Atmospheric Administration's (NOAA's) National Climatic Data Center (NCDC) is produces the Regional Snowfall Index (RSI) for significant snowstorms that impact the eastern two-thirds of the United States. The RSI ranks snowstorm impacts on a scale from 1 to 5 and is based on the spatial extent of the storm, the amount of snowfall, and the interaction of the extent and snowfall totals with population (based on the 2000 Census). The NCDC has analyzed and assigned RSI values to over 500 storms since 1900 (NOAA 2015). Table 5-86 presents the five RSI ranking categories.

Table 5-86 RSI Ranking Categories

Category	Description	RSI Value
1	Notable	1–3
2	Significant	3–6
3	Major	6–10
4	Crippling	10–18
5	Extreme	18.0+

Source: NOAA 2015
Note: RSI = Regional Snowfall Index

According to NWS (2009), the magnitude of a severe winter storm can be qualified into five main categories by event type:

- Heavy Snowstorm – snowfall accumulating to 4 inches or more in a 12 hours or less or snowfall accumulating to six inches or more in 24 hours or less.
- Sleet Storm – Significant accumulations of solid pellets that form from the freezing of raindrops or partially melted snowflakes causing slippery surfaces, posing a hazard to pedestrians and motorists.
- Ice Storm – Significant accumulation of rain or drizzle freezing on objects (trees, power lines, roadways) as it strikes them, causing slippery surfaces and damage from sheer weight of ice accumulations; significant ice accumulations are usually ¼" or greater.
- Blizzard – sustained winds or frequent gusts of 35 mph or more; considerable blowing snow with visibility frequently below one-quarter mile prevailing over an extended period.
- Severe Blizzard – Wind velocity of 45 mph, temperatures of 10°F or lower, a high density of blowing snow with visibility frequently measured in feet prevailing over an extended period.

The NWS uses winter weather watches, warnings, and advisories to ensure that people know what to expect in the coming hours and days.

- Watches

- Blizzard – Conditions are favorable for blizzard conditions to be met in the next 12 to 48 hours.
- Winter Storm - Issued when sinter storm conditions, defined above, are possible within 24 to 48 hours.

- Warnings
  - Blizzard – Issued when sustained winds or frequent gusts ≥ 35 mph combined with blowing and or falling snow, reducing visibility below 1/4 mile for 3 hours or more, when imminent or expected within the next 36 hours. Temperatures are assumed below 32°F, and snow should accumulate at least one inch in 12 hours.
  - Winter Storm - Issued when the following conditions, capable of producing high impact and potentially life threatening conditions, are occurring or expected to occur within the 36 hours: snow - ≥1 inch in 12 hours; sleet - ≥1/2 inch in 12 hours; and or a combination of snow, sleet, ice with snow or sleet meeting warning criteria
  - Ice Storm - Issued when ≥1/8 inch of Ice is expected to accrete on trees, power lines, and bridges/overpasses for the entirety of the event. These conditions are capable of producing high impact and potentially life threatening conditions and are either occurring or expected to occur within the next 36 hours.
- Advisories
  - Winter Weather - Issued when the following conditions, capable of producing significant, but not necessarily life threatening, inconveniences, are occurring or expected to occur within the next 36 hours:
    - Snow: 1/2 to 1 inch in 12 hours
    - Sleet: < 1/2 inch in 12 hours
    - Ice: < 1/8 inch in 12 hours
    - Combination: Snow, sleet, and ice with snow or sleet meeting advisory criteria.

Location

Winter storms occur on a regional scale and can happen anywhere in the State of Colorado; therefore, the entire Douglas County can experience winter storm events.

Previous Occurrences and Losses

Many sources have provided historical information regarding previous occurrences and losses associated with severe winter storm events in Douglas County. According to the NOAA-NCEI storm events database, Douglas County has been impacted by 65 winter weather events between 2014 to 2020. Table 5-87 and Table 5-**88** summarize these statistics, as well as the annual average number of events and the percent chance of these individual severe winter storm hazards occurring in Douglas County in future years (NOAA-NCEI 2020).

Table 5-87 Severe Winter Events 2014 to 2020

Hazard Type	Number of Occurrences Between 2014 to 2020	Total Fatalities	Total Injuries	Total Property Damage ($)	Total Crop Damage ($)
Blizzard	5	0	0	$0	$0
Heavy Snow	6	0	0	$0	$0
Ice Storm	0	0	0	$0	$0

Hazard Type	Number of Occurrences Between 2014 to 2020	Total Fatalities	Total Injuries	Total Property Damage ($)	Total Crop Damage ($)
Sleet	0	0	0	$0	$0
Winter Storm	25	0	0	$0	$0
Winter Weather	39	1	0	$0	$0
Total	**65**	**1**	**0**	**$0**	**$0**

Source: NOAA-NCEI 2020

Between 1954 and September 2020, FEMA included the State of Colorado in three winter storm-related major disaster (DR) declarations. Generally, these disasters cover a wide region of the state; therefore, they may have impacted many counties. As a result, Douglas County was included in two winter storm-related declarations in 2003 and 2007 (FEMA 2020). Douglas County has not been subject to any USDA disaster declarations for agricultural losses since 2017.

For this 2021 update, known severe winter storm events that have impacted Douglas County between 2014 and 2020 are identified in Table 5-**88**. The events listed in this table represent only those that were reported to the NOAA-NCEI Storm Events Database and FEMA, and may not represent all hail events and damages that have occurred since 2014. However, the events tallied for this analysis does not reflect a comprehensive count of winter storm events due to damage limitations and reporting inconsistencies. Therefore, Table 5-**88** may not include all events that occurred in Douglas County.

Table 5-**88** Severe Winter Weather Events in Douglas County, 2014 to 2020

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Event Details*
January 3, 2014	Winter Weather	N/A	N/A	Winter weather impacted Western Douglas County and surrounding counties, leading to heavy snow in parts of the North Central Mountains and parts of the Front Range Foothills. The heaviest snow was seen north of Interstate 70. Most of the affected region saw snowfall ranges of 4 to 8 inches, though some areas noted snowfall as high as 11.5 inches.
January 27, 2014	Winter Weather	N/A	N/A	Western Douglas County and surrounding counties experienced heavy snowfall, up to 10.5 inches in some areas. The Front Range Foothills experienced a period of moderate to heavy snowfall as a result of this storm.
January 30, 2014	Winter Storm, Winter Weather	N/A	N/A	This winter storm swept across most of Douglas County (North, Central, and West Douglas County) and many surrounding counties. Winter weather was noted East of Douglas County as a result of the storm. As a result, snow totals exceeded 2 feet over a 3-day period, with heavy snowfall spilling over into northern foothills and adjacent plains. The region north of Interstate 70 experienced the heaviest snowfall. Within the Urban Corridor and Northeast Plains, storm totals ranged from 5 to 11 inches. Prior to heavy snowfall within the Front Range Foothills was strong downslope winds with speeds greater than 80 mph.
March 1, 2014	Winter Weather	N/A	N/A	This winter weather resulted in a chain of accidents in the northbound lanes of Interstate 25 in Northern Douglas County. As a result of such poor driving conditions and excessive speed, 104 vehicles were involved in the chain of accidents,

Table 5-88 Severe Winter Weather Events in Douglas County, 2014 to 2020

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Event Details*
				with one fatality and 30 injuries. The interstate was closed for around 5 hours.
March 7, 2014	Winter Storm	N/A	N/A	A winter storm swept across West Douglas County and the surrounding area, bringing heavy snowfall to parts of the North Central Mountains and Front Range Foothills. Most of the region saw snowfall ranging from 5 to 9 inches, though a few towns experienced 10 to 11 inches of snow.
April 2, 2014	Winter Storm, Winter Weather	N/A	N/A	Affecting most of Douglas County (North, Central, West, and East Douglas County) and surrounding counties, this winter storm brought moderate to heavy snow, with storm totals as high as 21.5 inches in the Front Range Mountains, Foothills, and Urban Corridor.
April 12, 2014	Heavy Snow	N/A	N/A	West Douglas County and surrounding counties experienced heavy snow to the mountains and foothills of the Front Range. Snowfall ranged from 6 to 13 inches in affected areas.
May 11, 2014	Winter Storm	N/A	N/A	A strong storm system moved from southwest Colorado, impacting North, East, West, and Central Douglas County, along with the surrounding counties. This produced heavy snow over the Front Range, where snow fell as much as 2.5 feet, and adjacent plains. Snow in the mountains and foothills ranged between 11 to 30 inches, and snowfall in other affected areas ranged from 5.5 to 10.5 inches.
November 11, 2014	Winter Weather	N/A	N/A	Most of Douglas County (Central, East and West) and surrounding counties were impacted by winter weather, leading to moderate to heavy snowfall in and near the Front Range Mountains and Foothills. The storm lasted three days, with snowfall mostly ranging from 4 to 6 inches, but as high as 15.5 inches.
December 14, 2014	Winter Weather	N/A	N/A	Central and East Douglas County saw winter weather as a result of a storm system in the North Central Mountains that subsequently brough strong winds and heavy snow to the northeast plains of Colorado. In the surrounding regions of Douglas County, snowfall was as high as 4 feet deep.
December 25, 2014	Winter Storm, Winter Weather	N/A	N/A	A winter storm impacted West Douglas County and surrounding areas near the Front Range Foothills. This also brought winter weather to North, Central, and East Douglas County. Most storm totals ranged from 2 to 5 inches of snow, though Logan County received 1 to 2 feet of snow.
January 1, 2015	Winter Storm, Winter Weather	N/A	N/A	A winter storm swept through Central and East Douglas County, along with surrounding counties, resulting in winter weather in North Douglas County. This storm brought on moderate to heavy snow in affected area, with snowfall 2 miles south of Parker as high as 9 inches. The area northwest of Parker and six miles east-northeast of Centennial saw eight inches of snow, 7.5 inches just northeast of Castle Rock, and five inches in Aurora.
January 21, 2015	Winter Weather	N/A	N/A	Moderate to heavy snow developed in and near the Front Range Foothills, bringing winter weather to West, East, and Central Douglas County. Surrounding areas saw storm totals as high as 11.9 inches of snow.
January 31, 2015-February 1, 2015	Winter Storm, Winter Weather	N/A	N/A	A band of heavy snowfall developed over the Urban Corridor and extended to Parker, bringing 8 inches of snow to Parker. As a result of this heavy period of snowfall, winter weather was noted in North, Central, and East Douglas County. Snowfall mostly ranged from 3 to five inches in affected areas.
February 15, 2015	Winter Storm,	N/A	N/A	A winter storm swept through West Douglas County and surrounding counties as a result of heavy snow in and near the

Table 5-88 Severe Winter Weather Events in Douglas County, 2014 to 2020

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Event Details*
	Winter Weather			Front Range Foothills, bringing as much as 20 inches of snow to some towns. As a result, North, East, and Central Douglas County experienced winter weather. Though most affected areas had 3 to 7 inches of snow, Castle Pines received 8.5 inches of snow.
February 25, 2015	Heavy Snow, Winter Weather	N/A	N/A	A storm system brought heavy snow to West Douglas County and the surrounding area in and near the Front Range Foothills. As a result, Central, East, and North Douglas County and surrounding counties experienced winter weather. The onset of this storm system resulted in multiple accidents, including a multi-car pileup involving at least 50 cars eastbound along I-70. Additionally, Denver International Airport cancelled about 60 flights. Though some towns received up to almost 20 inches of snow, most affected areas received three to seven inches.
March 3, 3015	Winter Weather	N/A	N/A	West Douglas County and surrounding counties experienced winter weather as a result of a storm system that brough heavy snowfall to parts of the north central mountains and Front Range Foothills.
April 16, 2015	Winter Storm, Winter Weather	N/A	N/A	A storm system affecting West Douglas County and surrounding counties brought heavy, wet snowfall to parts of the Front Range Mountains and Foothills. There was a storm total of 52 inches of snow. Central and East Douglas County experienced winter weather as a result of this storm system.
May 9, 2015	Winter Storm	N/A	N/A	Moderate to heavy rain turned into snowfall as temperatures dropped in the evening, bringing heavy, wet snow. As a result, there was a range of tree damage, causing fatal damage to young trees and the loss of large limbs for old growth trees. Thousands were affected by power outages, and part of I-70 in the high county was shut down due to multiple crashes. This storm impacted Northern Douglas County and surrounding areas.
November 16, 2015	Blizzard, Winter Storm	N/A	N/A	A large Pacific storm system swept into southeast Colorado, bringing blizzard conditions to parts of east central Colorado, including Douglas County. There were many road closures south and southeast of Denver, such as the closure of I-70 in both directions and I-25 from Monument Hill to Castle Rock. The closure of I-25 resulted from a vehicle accident. Due to road closures, 100 to 150 vehicles were stranded. Schools were also closed, and Denver International Airport cancelled over 150 flights. Storm totals included: 14 inches, 3 miles south-southeast of Larkspur; 11 inches near Lone Tree, 7.5 inches near Castle Rock and 6 inches, 3 miles northeast of Parker. Castle Rock experience peak wind gusts of 45 mph. Near Larkspur, snowdrifts 4 to 6 feet deep were reported.
December 15, 2015	Winter Storm	N/A	N/a	A strong Pacific storm system swept into southeast Colorado. A deep upslope brought heavy snow in and near the Front Range Foothills, Palmer Divide, and northeast plains, impacting all of Douglas County and surrounding counties. Denver International Airport canceled about 500 flights, while hundreds of flights were delayed. School and government experienced cancellations, and multiple accidents were reported. 17 inches of snow were reported 6 miles northwest of Larkspur, and 11 inches of snow were reported 4 miles east

Table 5-88 Severe Winter Weather Events in Douglas County, 2014 to 2020

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Event Details*
				of Castle Rock and 3 miles southwest of Lone Tree and Parker.
February 1, 2016	Winter Storm	N/A	N/A	A storm system moved across the Four Corners region, strengthening as it traveled into southeastern Colorado and impacting Douglas County and surrounding counties. A deep east to northeasterly flow upslope created heavy snowfall in and near the Front Range Mountains, Foothills, and adjacent plains. Heavy winds drifted snow along the Palmer Divide and across the northeast plains of Colorado. I-70, I-76, and many roads and highways east of I-25 closed until the following day as a result of unsuitable conditions. Additionally, Denver International Airport cancelled 480 flights on the 1st and 125 flights on the 2nd. Storm totals included 19.5 inches near Parker and 18.5 inches 4 miles north-northwest of Larkspur.
March 17, 2016	Winter Storm, Winter Weather	N/A	N/A	Heavy snowfall in the northern mountains and near the foothills of Boulder and Larimer Counties brought a storm and winter weather to Douglas County and its surrounding area. This storm was produced by the enhanced banding associated with a strong upper level jet stream, combined with the low level upslope that resulted from the passage of a cold front.
March 23, 2016	Blizzard, Winter Storm	N/A	N/A	A storm system from Utah traveled into southeast Colorado, quickly intensifying and developing into a blizzard across the Front Range of Colorado, impacting all of Douglas County. The storm produced intense snowfall at a rate exceeding 3 inches per hour at its peak, though rates averaged 1 to 2 inches per hour. Combined with winds faster than 50 mph, the blizzard produced zero visibilities. Many roads, including I-76, I-70, and I-25 (from Castle Rock to Colorado Springs) became impassable as a result of the heavy snowfall and lack of visibility. Over 2,000 vehicles were trapped on I-25. Several thousand residents along the Front Range experienced power outages as heavy wet snow accumulated on trees. Due to the extensive power outages and blizzard conditions, Denver International Airport was closed for 7 hours, causing around 1,300 flights to be cancelled. Across the Front Range Urban Corridor, as much as 1 to 2 feet of snow fell during the storm, with most of the snow falling within a 12 hour period.
April 15-16, 2016	Heavy Snow	N/A	N/A	A potent spring snowstorm carried heavy, wet snow to the Front Range Foothills and Palmer Divide and its surrounding area, including Douglas County. Snowfall was as high as 2 to 4 feet in the Foothills and 1 to 2 feet across the Mountains and Palmer Divide. In the Urban Corridor, snowfall ranged from 6 to 20 inches. Denver International Airport cancelled 852 flights, mostly on April 16th. Several trees' limbs broke from the weight of accumulated snow, causing power outages that persisted until the 17th. Road closures lasted from 1 to 5 hours, including along I-70 and Highways 85,24, 103, 287, 85, and 119. Storm totals included 20 inches near Castle Rock and Parker. Snow drifts up to 3 feet deep were noted near Castle Rock as a result of strong winds.
November 17, 2016	Winter Weather	N/A	N/A	A fast-moving storm system swept across Colorado, with heavy snow falling on the I-70 corridor, impacting West Douglas County. Road closures on both directions of I-70 for a couple of hours resulted from a 20-vehicle crash involving

Table 5-88 Severe Winter Weather Events in Douglas County, 2014 to 2020

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Event Details*
				semi-trucks. Roads has become wet, quickly turning icy and snowpacked. In the central mountains, snow totals ranged from 7 to 14 inches, while in the Front Range Foothills, totals were between 5 to 10 inches.
December 16, 2016	Winter Storm	N/A	N/A	First passing through West Douglas County and later into North Douglas County, along with surrounding regions, a heavy band of snowfall caused storm conditions across the Denver metro area for several hours. This storm was produced by a warm, moist southwesterly flow aloft overrunning an Arctic airmass with shallow post frontal upslope. Up to 2 inches per hour of snowfall were observed. Several accidents resulted in the evening as snow accumulated. Denver International Airport cancelled 300 flights the following day.
January 1, 2017	Winter Storm, Winter Weather	N/A	N/A	This winter storm brough heavy snow to the north central mountains, Front Range Foothills, and Urban Corridor, specifically impacting North and West Douglas County and the surrounding area. Storm totals ranged from 1 to 3 feet, with heavy snowfall across the I-25 corridor. I-70 eastbound was closed due to several vehicle accidents. 145 flights were cancelled at Denver International Airport.
February 1, 2017	Winter Weather	N/A	N/A	Winter weather, including freezing drizzle, caused road closures and vehicle accidents in the northeast plains of Colorado. North Douglas County and its surrounding region, including the Denver area, were impacted by this weather. There were many crashes on I-25, and delays at schools and businesses were reported. 32 flights were delayed at Denver International Airport.
March 24, 2017	Blizzard	N/A	N/A	Central and East Douglas County, along with surrounding counties, were hit with blizzard conditions as a result of a swiftly moving system that formed over southeastern Colorado. Wind speeds ranged between 45 to 60 mph. Storm totals mostly ranged between 7 to 11 inches. 3 miles northeast of Castle Rock, the storm total was 7 inches of snow. As a result of the blizzard and its drifting snow, Douglas County closed schools, roads, and highways.
April 3, 2017	Winter Weather	N/A	N/A	A period of heavy snowfall occurred in parts of the Front Range Mountains and Foothills, bringing winter weather to West Douglas County and surrounding counties. Storm totals ranged from 5 to 10 inches.
April 28, 2017	Winter Storm	N/A	N/A	This winter storm impacted all of Douglas County, along with several surrounding counties. Storm totals included: 13 inches in Parker, 11 inches at Castle Pines, 10.5 inches at Lone Tree, 10 inches in Larkspur, and 9.5 inches near Lone Tree.
May 17, 2017	Heavy Snow	N/A	N/A	A potent spring storm moved eastward from the Great Basin across Colorado, impacting West Douglas County. Hail as large as a nickel was reported after a series of thunderstorms persisted. Moderate to heavy snow fell across the Front Range mountains and foothills, which lasted for a few days. As rain turned to snow and accumulated on trees, trees were damaged and scattered power outages throughout the affected area. 800 trees on Colorado State University's campus were damaged.
October 8, 2017	Winter Storm	N/A	N/A	98,000 power outages swept across Denver and the surrounding metro area, impacting West Douglas County, as a result of an early season snowstorm that created heavy wet snow. Over half of the outages lasted longer than five minutes to as long as several hours.

Table 5-88 Severe Winter Weather Events in Douglas County, 2014 to 2020

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Event Details*
January 20- 21, 2018	Winter Storm	N/A	N/A	A storm system traveled eastward across Colorado, impacting Douglas County and its surrounding area. Douglas and Jefferson County experienced moderate to heavy snow, which developed in the nearby foothills. Storm totals ranged from 4 to 17 inches, though in Castle Pines, there were 6 inches of snowfall. As the storm traveled eastward, it traveled from West Douglas County at 6 pm on the 20th to North, Central, and East Douglas County by midnight on the 21st.
February 19, 2018	Winter Weather	N/A	N/A	A storm in and near the Front Range Foothills brought moderate to heavy snowfall to West Douglas County and its surrounding region.
March 18, 2018	Winter Weather	N/A	N/A	A storm system in the north-central mountains of Colorado brought heavy snowfall to the region, with moderate to heavy snow in the Palm Divide. Central and East Douglas County, along with its surrounding region, experienced winter weather. Storm totals included 5 inches in Lone Tree.
March 26, 2018	Winter Weather	N/A	N/A	Central, East, and West Douglas County and its surrounding area experienced winter weather as a result a storm that produced moderate to heavy snowfall in and near the southern Front Range Foothills and Palmer Divide.
October 30, 2018	Winter Weather	N/A	N/a	Central, East, and West Douglas County and its surrounding area experienced winter weather as a result a storm that produced moderate to heavy snowfall in and near the Front Range mountains, foothills, and Palmer Divide. Storm totals included 6 inches in Larkspur.
November 11, 2018	Winter Weather	N/A	N/A	Douglas County and its surrounding counties experienced winter weather when a storm system brought moderate to heavy upslope snowfall to the Front Range Mountains, Foothills, and Urban Corridor west of I-25. Storm totals in the foothills of Jefferson and Douglas counties ranged from 6 to 12 inches. 5 to 7 inches were noted in Castle Rock.
January 11, 2019	Heavy Snow, Winter Weather	N/A	N/A	Heavy snow in the southern Front Range Foothills and Palmer Divide, caused by an upslope snow event, brought light to moderate snowfall to Douglas County and surrounding counties.
January 21, 2019	Winter Storm, Winter Weather	N/A	N/A	A potent winter storm produced moderate to heavy snow in the southern Front Range Foothills and Palmer Divide, sweeping across Douglas County and its surrounding region. This storm brought strong northly winds ranging from 45 to 55 mph. Blizzard conditions were noted along I-70 east of Aurora. Parts of I-25 and Highway 24 were closed for several hours, while I-70 was closed the following day after several accidents were reported. The southern Front Range Foothills and Palmer Divide experienced the heaviest snowfall. Castle Pines had a snow total of 5.5 inches.
February 6, 2019	Winter Weather	N/A	N/A	A storm system created light to moderate snowfall in northern Colorado, bringing winter weather to Douglas County and its surrounding region. Heaviest snowfall was reported in and near the Front Range mountains and foothills, though most storm totals were between 4 to 7 inches.
February 22, 2019	Heavy Snow, Winter Weather	N/A	N/A	Snow falling at a rate of 2 to 3 inches per hour impacted Douglas County and its surrounding area, including Denver. Lone Tree received 7.5 inches of snow, and Parker received 6 inches.
March 2, 2019	Winter Weather	N/A	N/A	A potent westerly flow aloft produced heavy snow and strong winds in the north central mountains of Colorado, conducive for avalanches. This produced winter weather in Douglas

Table 5-88 Severe Winter Weather Events in Douglas County, 2014 to 2020

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Event Details*
				County and surrounding counties. Avalanches were reported, notably along I-70 the following day, trapping vehicles on the interstate. No one was injured during this event. 9 hours of avalanche mitigation work was completed on the 5th, causing further interstate closures.
March 13, 2019	Blizzard	N/A	N/A	North Douglas County and surrounding counties experienced hurricane strength winds when storm system or bomb cyclone intensified across the northeast plains.
April 10, 2019	Winter Weather	N/A	N/A	Douglas County and its surrounding counties were impacted by moderate snowfall and strong gusty winds produced by a storm system. Wind gusts ranged from 35 to 55 mph, developing near blizzard conditions with drifting snow and low visibility in some affected areas. Storm totals included 6 inches near Larkspur and Lone Tree. Elsewhere, storm totals ranged from 2 to 5 inches.
October 9, 2019	Winter Weather	N/A	N/A	A strong winter storm created potent wind gusts ranging from 50 to 60 mph, uprooting some trees. The storm also brought a cold front and produced light rain that turned into snow on the 10th. The cold front brought drastic temperature changes: it was 83 degrees during the afternoon on the 9th, but soon dropped to 13 degrees early the next day. The subsequent snow affected the Front Range mountains, foothills, and urban corridor, sweeping into North and West Douglas County and surrounding regions. This weather led to over 300 vehicle crashes.
October 23, 2019	Winter Storm, Winter Weather	N/A	N/A	Douglas County and surrounding counties, notably Jefferson County, received moderate to heavy snow. Most of the foothills received 4 to 9 inches of snow, as seen in Castle Rock, which received 5.5 inches of snow.
October 27, 2019	Winter Weather	N/A	N/A	Douglas County and surrounding areas in the mountains and foothills received light to moderate snow, along with freezing drizzle. Most storm totals ranged between 4 to 8 inches, though 12 inches was the maximum.
October 29, 2019	Winter Storm, Winter Weather	N/A	N/A	A strong storm system over the northern Rockies and across Colorado brought record low temperatures to affected areas, including Douglas County. I-70 was closed due to poor visibility from snow and wind. Storm totals included 10 inches 2 miles east of Parker and 7.5 inches near Castle Pines. Due to poor conditions, there was one fatal car accident on State Highway 6, causing the highway to close. Additionally, many schools closed and flights at Denver International Airport were either delayed or cancelled, leaving 800 passengers stranded overnight at the airport.
November 25, 2019	Winter Storm	N/A	N/A	Heavy snowfall on the Front Range Mountains, Foothills, I-25 corridor, and northeast plains affected all of Douglas County. As heavy snow first developed in and near the Front Range Foothills, West Douglas County was first impacted, followed by the rest of the County 3 hours later. All schools were closed on the 25th and 26th, including universities and colleges in northeast and north central Colorado. All government offices (federal, state, city, and county) were closed on the 25th. I-70 in both directions, I-76, and some east/west highways including US 34 and US 36, were closed due to poor visibility. Denver International Airport cancelled 500 flights. Storm totals included: 16.5 inches in east Parker, 12 inches near Castle Rock and Elizabeth, and 10 inches in Lone Tree.

Table 5-88 Severe Winter Weather Events in Douglas County, 2014 to 2020

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Event Details*
February 3, 2020	Winter Weather	N/A	N/A	The Front Range mountains and foothills received a period of moderate to heavy snowfall, bringing winter weather to Douglas County and its surrounding counties. Storm totals typically ranged from 6 to 11 inches.
February 6, 2020	Winter Weather	N/A	N/A	A prolonged period of heavy snow and strong winds resulted from a combined upper level jetstream and deep fetch of Pacific moisture. This prolonged storm began in the early morning, impacting West Douglas County and the surrounding area. The storm later swept through the rest of Douglas County and surrounding counties in the evening. Wind gusts ranged from 55 to 65 mph. Travel became nearly impossible due to poor conditions. Storm totals typically ranged from 4 to 10 inches, though the mountains had totals from 2 to 4.5 feet.
March 19, 2020	Blizzard, Winter Storm	N/A	N/A	A potent storm brought blizzard conditions to Douglas County and surrounding counties in Colorado's northeast plains. Storm totals included: 10.5 inches near Lone Tree, 9 inches near Castle Rock, and 8.5 inches near Parker. Peak wind gusts were 40 mph, which when combined with snow, caused near zero visibility. Many roads, including portions of eastbound I-70 and I-76 and westbound I-70, were closed during the storm.
April 11, 2020	Winter Weather	N/A	N/A	West Douglas County and its surrounding area experienced winter weather as a result of a cold northerly flow combined with a low level upslope, which created moderate to heavy snowfall. This snow fell in and near the foothills.
April 15, 2020	Winter Weather	N/A	N/A	North and West Douglas County and its surrounding counties experienced winter weather as a result of a Rocky Mountains storm that produced moderate to heavy snow over parts of the mountains, foothills, and plains. The foothills north of I-70 and across the plains north of I-76 saw the heaviest snowfall. An avalanche near Red Peak killed one backcountry skier.

Sources: FEMA 2020; NOAA-NCEI 2020
** Many sources were consulted to provide an update of previous occurrences and losses; event details and loss/impact information may vary and has been summarized in the above table*
FEMA Federal Emergency Management Agency
Mph Miles per Hour
NCEI National Centers for Environmental Information
NOAA National Oceanic and Atmospheric Administration
N/A Not Applicable

Climate Change Projections

Climate change in Colorado has broadly caused higher temperatures, increased precipitation, and changes to surface water flow. However, precipitation will increasingly take the form of rain rather than snow, resulting in less snowpack and an earlier spring thaw in the Rocky Mountains (National Conference of State Legislatures 2008). Climate change will likely cause fewer extreme cold months, and snowpack in lower elevation areas (e.g. below 8,200 feet) will decline precipitously (Ray et al. 2008).

Probability of Future Occurrences

For the 2021 HMP update, the most up-to-date data was collected to calculate the probability of future occurrence of winter storm events, of all types, for Douglas County. Table 5-89 summarizes data regarding the probability of occurrences of severe winter storm events in Douglas County based on the historic record.

The information used to calculate the probability of occurrences is based solely on NOAA-NCEI storm events database results.

Table 5-89 Probability of Future Occurrence of Severe Winter Weather Events in Douglas County

Hazard Type	Number of Occurrences Between 1954 and 2020	% chance of occurrence in any given year
Blizzard	16	23.8%
Heavy Snow	83	100%
Ice Storm	0	N/A
Sleet	0	N/A
Winter Storm	102	100%
Winter Weather	69	100%
Total	**270**	**100%**

Source: NOAA-NCEI 2020
Note: Disaster occurrences include federally declared disasters since the 1950 Federal Disaster Relief Act, and selected storm events since 1968. Due to limitations in data, not all hail and lightning events occurring between 1954 and 1996 are accounted for in the tally of occurrences. As a result, the number of hazard occurrences is underestimated.

Based on the number of winter weather events, the County averages several winter weather events each year. A winter weather event has a 100% chance of occurring in any given year. Based on the history of events and input from the Core Planning Team, the probability for severe winter storm events occurring in the County is considered *frequent* (Hazard event is likely to occur within 25 years). Refer to Sections 5.1 and 5.3 for additional information on the hazard ranking methodology and probability criteria.

Vulnerability Assessment

To understand risk, a community must evaluate assets exposed to and vulnerable to the identified hazard. The entire Douglas County is exposed and vulnerable to the severe winter storm hazard; therefore, all assets within the County (population, structures, critical facilities, and lifelines), as described in Section 4 (County Profile), are potentially vulnerable to a winter weather event. The following text evaluates and estimates the potential impact of the severe winter storm hazard in the County.

Impact on Life, Health and Safety

Winter weather events can immobilize a region and paralyze a city, stranding commuters, closing airports, stopping supply chains, and disrupting emergency 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 (State of Colorado HMP 2018).

According to the 2018 ACS 5-Year Population Estimate, 10.9 percent of the population in Douglas County is 65 and over. Winter storm events can reduce the ability of these populations to access emergency services.

For the purposes of this HMP, the entire population of the County (328,614) is exposed to winter storm events (U.S. Census 2013-2017 ACS 5-Year Population Estimate). The homeless and elderly are considered most susceptible to this hazard; the homeless due to their lack of shelter and the elderly due to their increased risk of injuries and death from falls and overexertion, hypothermia from attempts to clear snow and ice, unable to access medical care if isolated, or limited in-home medical equipment use if power outages occur.

Impact on General Building Stock

The entire general building stock inventory in Douglas County is exposed and potentially vulnerable to the severe winter storm hazard; however, properties in poor condition or in particularly vulnerable locations may be at risk to the most damage. In general, structural impacts include damage to roofs and building frames rather than building content. Current modeling tools are not available to estimate specific losses for this hazard.

Impact on Critical Facilities

Full functionality of critical facilities, such as police, fire, and medical facilities is essential for response during and after a severe winter storm event. These critical facility structures are largely constructed of concrete and masonry; therefore, they should only suffer minimal structural damage from severe winter storm events. Heavy accumulations of ice can bring down trees, electrical wires, telephone poles, utility lines, and communication towers. Communications and power can be disrupted for days while utility companies work to repair the extensive damage. Even small accumulations of ice can cause extreme hazards to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces (NSSL 2006). Winter weather events, such as ice storms, can lead to power outages. Therefore, it is recommended that critical facilities install backup power sources.

Infrastructure at risk for this hazard includes roadways that could be damaged due to salt application and intermittent freezing and warming conditions that can damage roads over time. Severe snowfall requires the clearing roadways and alerting citizens to dangerous conditions; following the winter season, resources for road maintenance and repair might be required.

Impact on Economy

The cost of snow and ice removal and repair of roads from the freeze/thaw process can drain local financial resources. Impacts on the economy also include commuter difficulties into or out of the area for work or school. The loss of power and closure of roads prevent commuters within the County.

Impact on the Environment

Severe winter weather can have a major impact on the environment. Not only does winter weather create changes in natural processes, the residual impacts of a community's methods to maintain its infrastructure through winter weather maintenance may also have an impact on the environment. For example, an excess amount of snowfall and earlier warming periods may affect natural processes such as flow within water resources (USGS n.d.). Rain-on-snow events can also exacerbate runoff rates with warming winter weather. Consequentially, these flow rates and excess volumes of water can erode banks, tear apart habitat along the banks and coastline, and disrupt terrestrial plants and animals.

Furthermore, chemically based winter maintenance practices have its own effect on the natural environment. Melting snow and ice that carry deicing chemicals onto vegetation and into soils can contaminate the local waterways. Elevated salt levels may hinder vegetation from absorbing nutrients, slowing plant growth (The Environmental Literacy Council 2015).

Cascading Impacts on Other Hazards

Severe winter weather events may exacerbate flooding. As discussed, the freezing and thawing of snow and ice associated with winter weather events can create major flooding issues in the County. Maintaining winter weather hazards through snow and ice removal could minimize the potential risk of flooding during a warming period.

Future Changes that May Impact Vulnerability

Understanding future changes that impact vulnerability in the County can assist in planning for future development and ensure that appropriate mitigation, planning, and preparedness measures are in place. The County considered the following factors to examine potential conditions that can affect hazard vulnerability:

- Potential or projected development.
- Projected changes in population.
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development

Any areas of growth could be potentially impacted by the severe winter storm hazard because the entire County is exposed and vulnerable. The ability of new development to withstand severe winter storm impacts lies in sound land use practices and consistent enforcement of codes and regulations for new construction.

Projected Changes in Population

The County has experienced an increase in population between the 2010 Census (285,465) and the estimated 2018 American Community Survey estimated population of 328,614. The population of the County is expected to increase over the next few years. With an increase in population, more people will be exposed to winter weather events. Additionally, the age of the population, changes in their geography, and how climate change could alter the winter weather received (rain versus snow) will be important to continue to assess future changes in vulnerability.

Climate Change

Climate is defined not just as average temperature and precipitation, but also by type, frequency, and intensity of weather events. Both globally and at the local level, climate change can potentially alter prevalence and severity of weather extremes, such as winter storms. While predicting changes in winter storm events under a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating future climate change impacts on human health, society, and the environment (U.S. EPA 2006). Based on the projections, the County can expect to experience increasing rain rather than snow during the winter months. In the immediate future, Douglas County can anticipate continuing to experience the impacts of winter weather events.

Change of Vulnerability Since 2015 HMP

Douglas County's population increased since the last plan; increasing the number of people impacted during a winter weather event. Therefore, the entire County remains vulnerable to severe winter storm events.

Issues Identified

Important issues associated with a severe winter storm in the planning area include the following:

- Older building stock in the County might be more vulnerable to aftermath of a winter storm event. Heavy snow loads on the roofs of buildings might not be able to withstand the extra weight.
- Ice and freezing temperatures can lead to frost heaving, damaging roads, bridges, buildings, and foundations of homes and buildings.
- The impacts of drought can lead to dead or dying trees. These trees are more susceptible to falling during winter storm events from the weight of snow and ice causing power outages, closed roadways, and damage to buildings and property.
- Downed power lines from the weight of snow and ice lead to power outages, leaving many homes without a source of heat.

5.4.13 Soil Hazards: Erosion and Deposition

The following section provides the hazard profile and vulnerability assessment for the erosion and deposition hazard in Douglas County.

Hazard Profile

Description

Erosion entails the transportation and removal of earth materials from one location to another by moving ice, water, waves, or wind. Erosion occurs naturally but can be exacerbated by anthropogenic activity that modifies the built environment. Deposition is the placing of the eroded material in a new location. All material that is eroded is later deposited in another location. In Colorado, erosion typically occurs due to water and winds, though can also occur due to landslides and debris flows, excessive runoff, and wildfire (State of Colorado 2018).

Erosion caused by water is the primary concern for Douglas County. Water erosion is the detachment and removal of soil by water. The process can occur naturally or be accelerated by human activity. The rate of erosion can be a slow process that continues relatively unnoticed or can occur very rapidly. The rate is dependent on the type of soil, the local landscape, and weather conditions (Ritter 2018; USDA 2001).

There are three types of water erosion that can occur: sheet, rill, and gully. Sheet erosion is the most difficult to see as it is a uniform soil layer being remove from an area over the surface. Rill erosion starts as water flowing over the soil surface concentrates into small streams, creating channels of water flow. Gully erosion is when rill erosion is not kept under control and creates gullies (deeper and wider cuts) (Soil Science Society of America 2020).

Erosion can be most severe where urbanization, development, recreational activities, logging and agricultural practices take place. Extreme rainfall events, lack of vegetative cover, fragile soils and steep slopes combine to accelerate erosion (Ritter 2018).

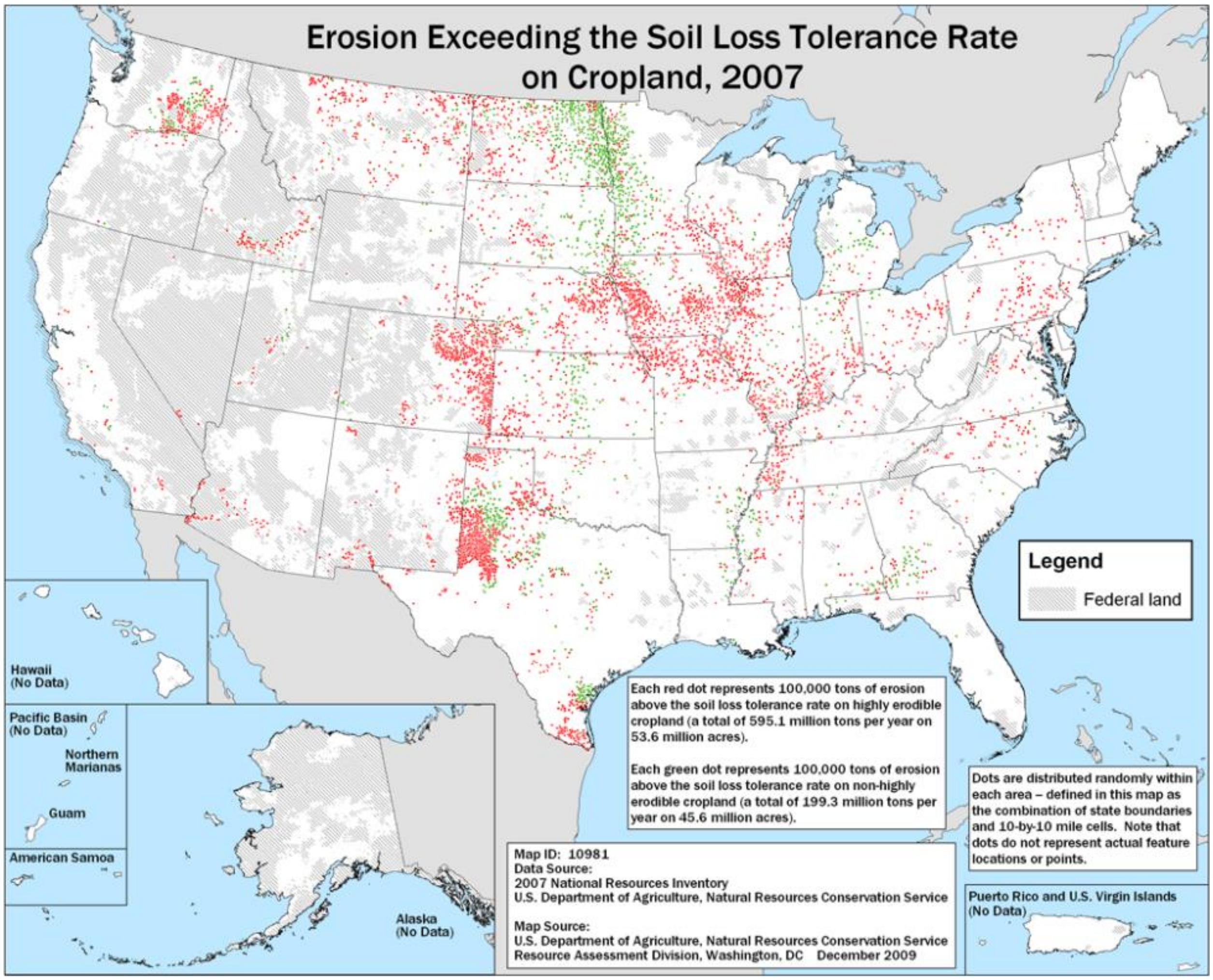
Extent and Location

It is difficult to directly measure erosion and the risk of erosion. There are other properties, however, that can be used to measure erosion: soil surface stability, aggregate stability, infiltration, compaction, and content of organic matter. Measuring these properties can help with understanding the susceptibility of erosion at a specific location. Comparing visual observations along with quantitative measurements can help provide information about soil surface stability, sedimentation, and soil loss (USDA 2001).

Erosion and deposition pose threats for property, infrastructure, the natural environment, and agriculture. Sedimentation resulting from erosion can pollute surface waterways, obstruct the flow of water, and cause flooding. Figure 5-39 illustrates the locations of where erosion exceeded the soil loss tolerance rates across the United States. Each red dot represents 100,000 tons of erosion above the soil loss tolerance. According to this figure, areas of erosion exceeding the soil loss tolerance rates was not identified in the area of Douglas County.

Figure 5-40 through Figure 5-43 show the risk of erosion in Douglas County. As seen in the maps, erosion-susceptible areas are most commonly found along the County's streams and waterways.

Figure 5-39 National Erosion Loss Rates



Source: NRI 2010

Figure 5-40 Erosion Risk in Douglas County

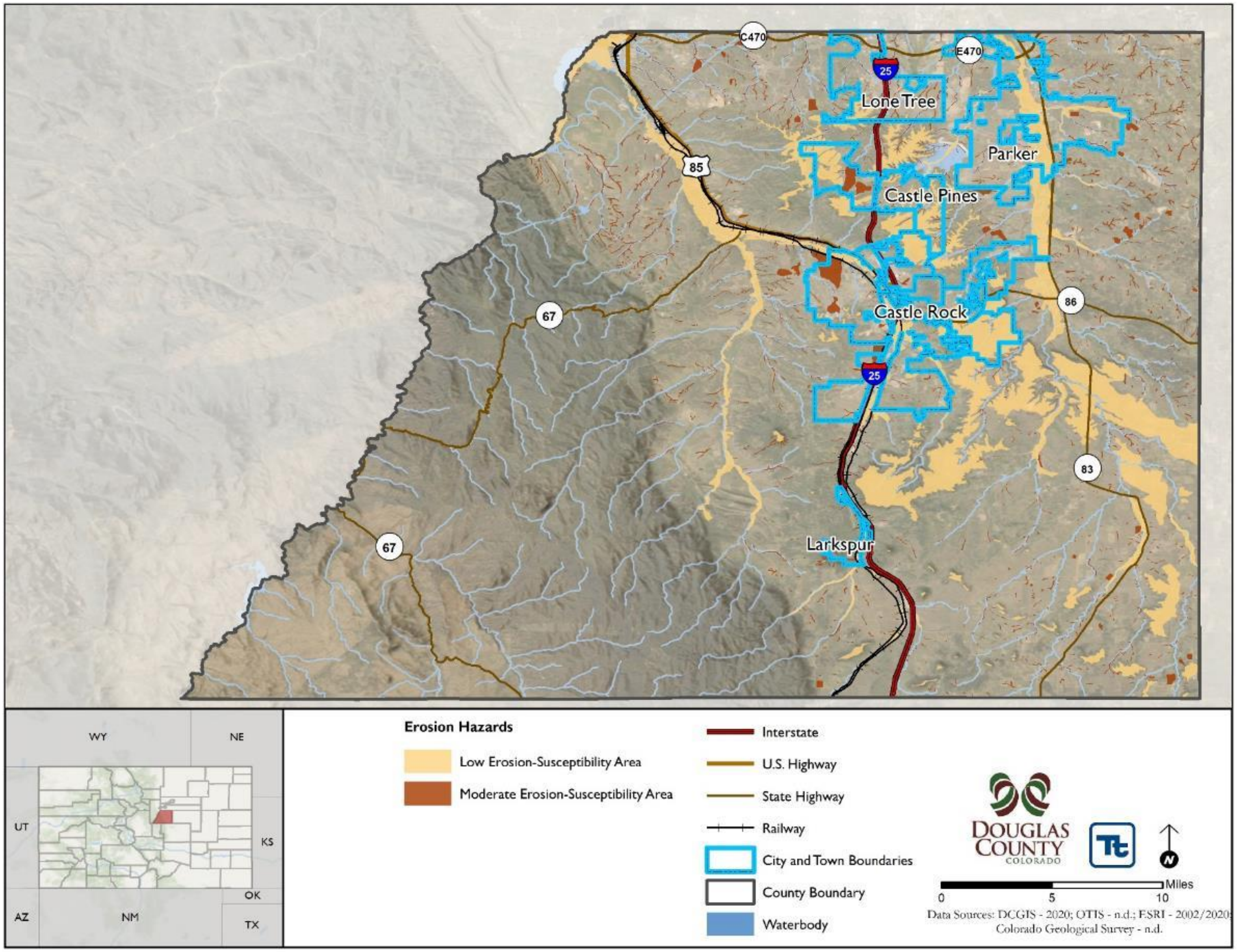


Figure 5-41 Erosion Risk in Douglas County (Northeast)

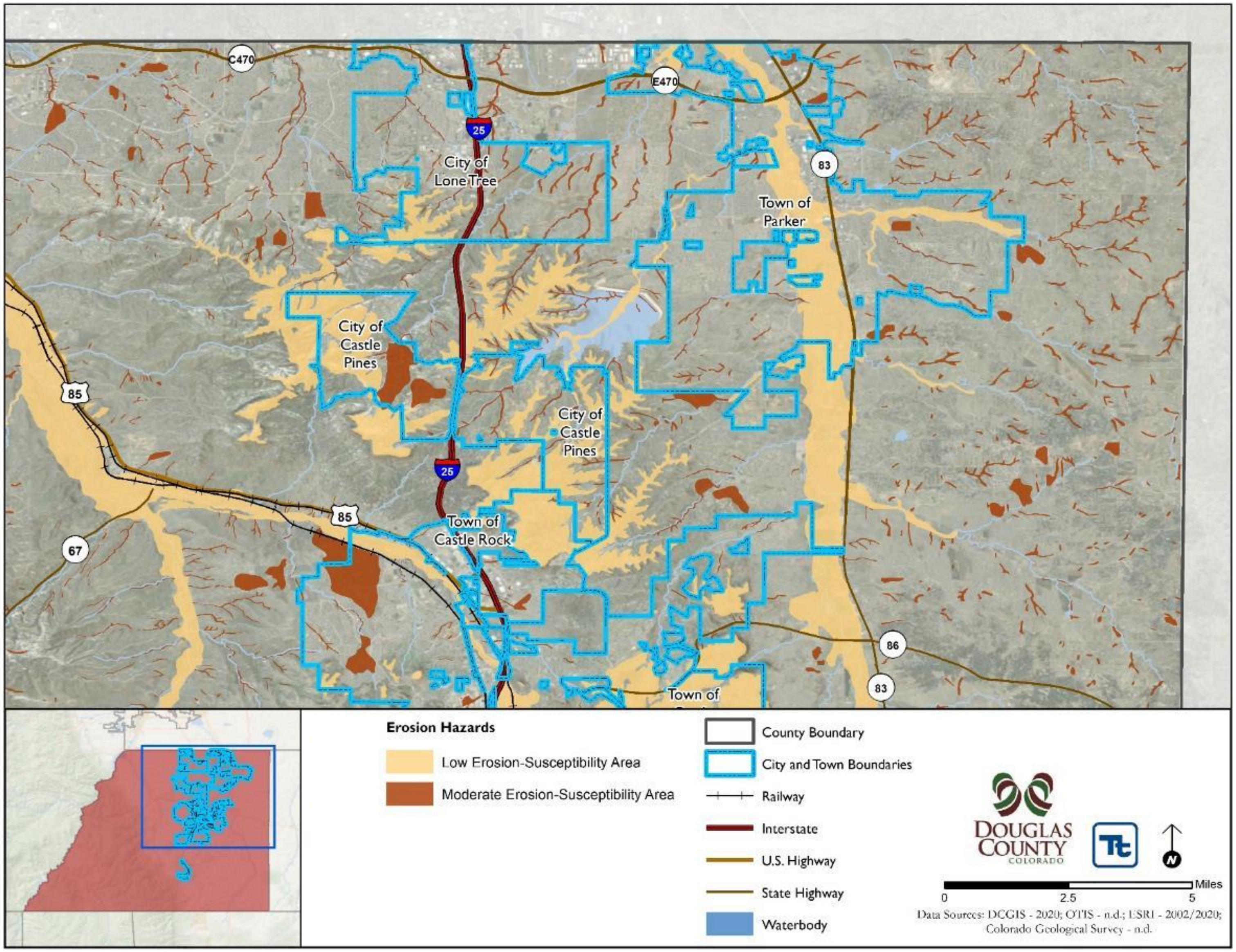


Figure 5-42 Erosion Risk in Douglas County (Northwest)

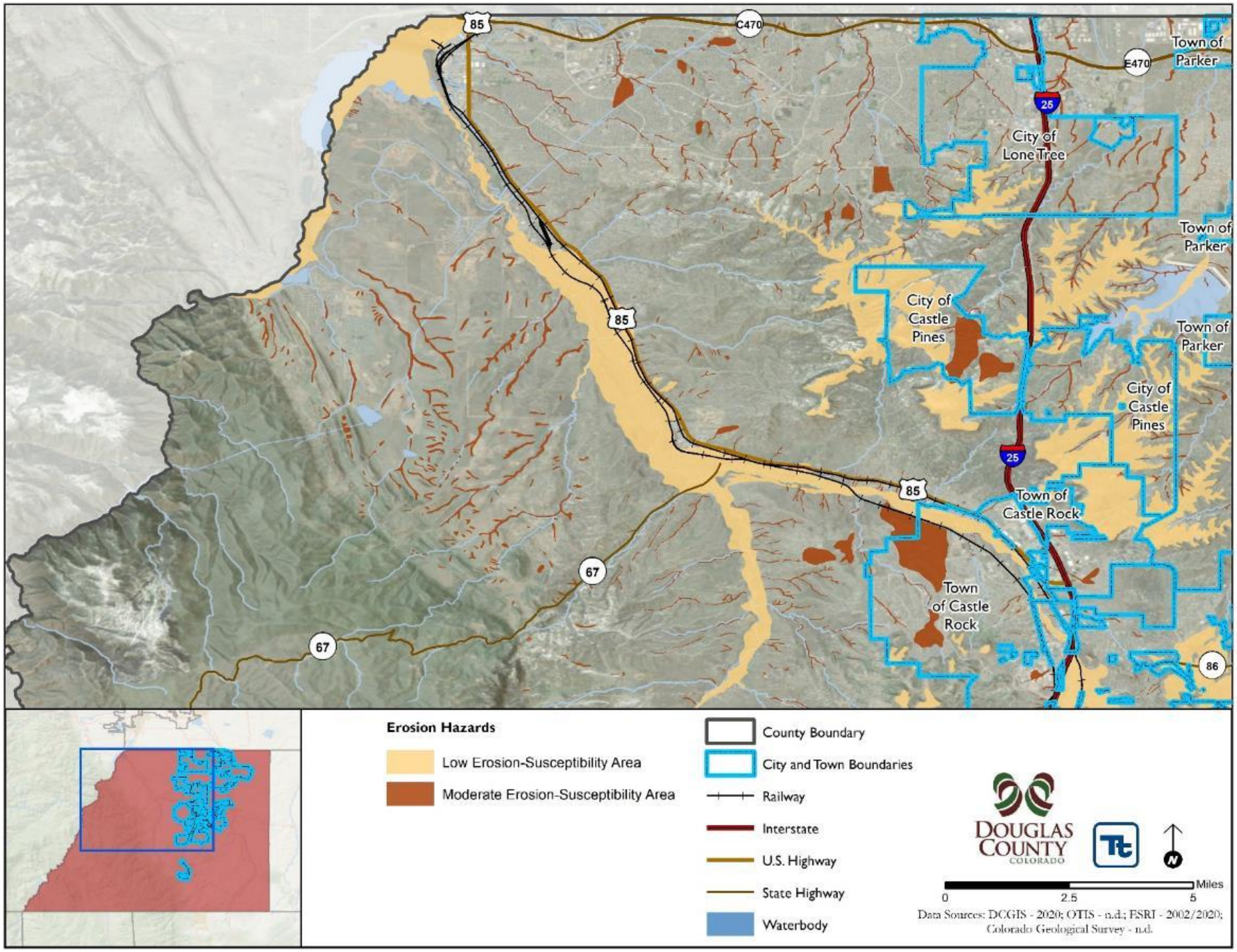
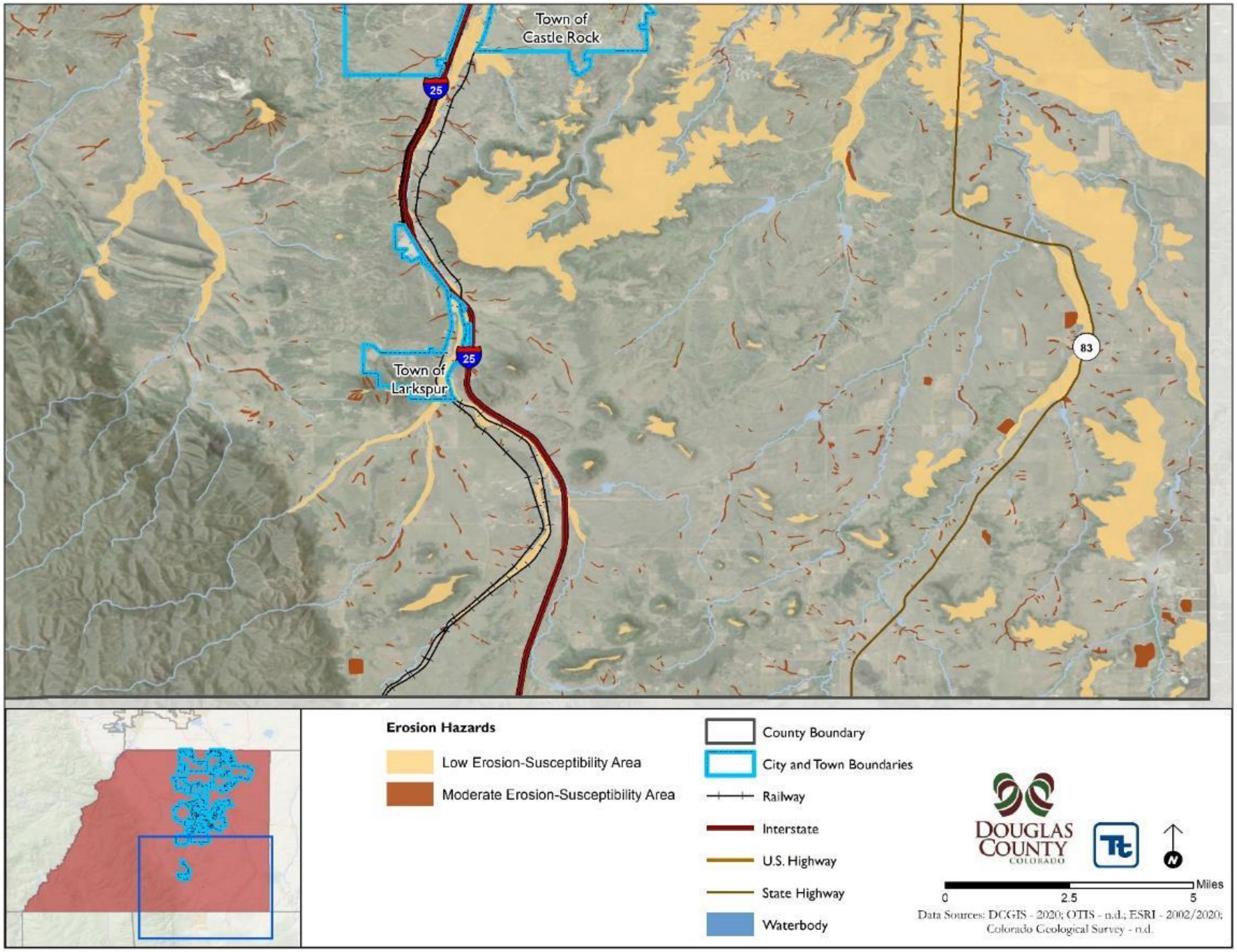


Figure 5-43 Erosion Risk in Douglas County (Southeast)



Previous Occurrences and Losses

Between 1953 and January 2021, the State of Colorado and Douglas County were not included in any erosion-related FEMA disaster declarations. For the 2021 HMP Update, there was limited information regarding erosion in Douglas County. The following information was obtained from local sources, the prior hazard mitigation plan update, and geological reports.

- During road construction at an airport near Larkspur, improper drainage and heavy water runoff caused significant erosion (unknown year).
- In the wake of the 1996 Buffalo Creek wildfire, flash flooding occurred in the burn area that brought 160,000 cubic yards of eroded, decomposed granite washed into Strontia Springs at the County boundary. Erosion occurred again in the wake of the Hayman fire, impacting the Cheesman Reservoir (Hartman 2020).
- In August 2003, flash flooding occurred in the wake of heavy rains at the confluence of the Westcreek and Trail Creek. Drainage along the Trail Creek was notably eroded, resulting in flattened vegetation. This erosive event occurred in the Hayman Fire burn area.
- In August 2004, flash flooding occurred in the Hayman Fire burn area. Mudslides closed US Highway 67 for several hours, and the vicinity of the Shady Brook YMCA camp experienced erosion of culverts and roads.
- Ongoing erosion along Plum Creek, a tributary to the Chatfield Reservoir, has occurred due to urban runoff. In Chatfield State Park at the County's boundary, a mitigation project is currently being undertaken to arrest erosion (Chatfield Reservoir Mitigation Company 2020).

Climate Change Projections

Climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration. Increase in global temperature could affect the snowpack and its ability to hold and store water. Warming temperatures also could increase the occurrence and duration of droughts, which would increase the probability of wildfire, reducing the vegetation that helps to support steep slopes. All of these factors would increase the probability for erosion to occur.

Probability of Future Events

It is anticipated that erosion will continue to occur in Douglas County. As the frequency of erosion-causing events occur due to climate change, the probability for future events will likely increase as well. Based on historical records and input from the Core Planning Team, the probability of occurrence for erosion events in the County is considered occasional (hazard event is likely to occur within 100 years). Refer to Sections 5.1 and 5.3 for additional information on the hazard ranking methodology and probability criteria.

Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable to the identified hazard. Erosion may impact public safety, property, infrastructure, environmental resources and local economies. The following text evaluates and estimates the potential impact of erosion on Douglas County.

Impact on Life, Health and Safety

Overall, an event related to erosion would be an isolated incident and impact the population within the immediate area of the incident. Erosion can cause damage to residential buildings and displacing residents and erosion events could event block off or damage major roadways, inhibiting travel for emergency responders or populations trying to evacuate the area.

Erosion can create water quality problems in surface waters and drainage ways. These problems can adversely impact the health and biological diversity of water bodies. According to the USDA, this includes:

- Excess nutrients impact water quality through eutrophication, a process where excess nitrogen and phosphorus causes unwanted biological growth in water bodies.
- Sediment reduces water quality by making the water cloudy. Turbidity prevents sunlight from penetrating the water and reduces photosynthesis and underwater vegetation. Oxygen levels are reduced in turbid waters, further degrading habitat for fish and other aquatic organisms.
- Sediment can build up in stream channels, lowering flow capacity. The problem of low stream capacity is compounded as runoff increases from newly built-up or paved areas and causes stream channels to receive larger amounts of water in shorter periods of time. This leads to more frequent flooding in areas that never or only rarely flooded in the past. In floodprone areas, levees may need to be built or enlarged to better protect public safety.
- A financial burden results from cleanup of sediment-damaged areas. Taxpayers often bear the cost of removing sediment from public roads, road ditches, culverts or streams; not to mention damage to homes and the safety hazards associated with flooding. Other costs of erosion that are borne by the public are degraded soils, a polluted environment, more runoff, greater need for irrigation, and aesthetically unpleasing sites (USDA 2000).

Vulnerable populations such as persons over 65 may have more difficulty seeking medical attention that may not be available during a hazard event. In Douglas County, there are 11,333 persons in poverty and 35,801 persons over 65 years old (American Community Survey 2018). Additionally, vulnerable populations below poverty are likely to evaluate their risk and make decisions to reconstruct and repair structures and evacuate based on net economic impacts on their families. Based on the spatial analysis, the Town of Castle Rock has the greatest number of persons exposed to the moderate erosion susceptibility area, 15,415 individual or 25.8-percent. The City of Castle Pines has the greatest percentage of persons exposed to the moderate erosion-susceptibility area, 50.7-percent or 5,360 persons. Table 5-90 shows the estimated population living in the low and moderate erosion susceptibility area.

Table 5-90 Estimated Population Located in the Erosion-Susceptibility Hazard Area in Douglas County

Jurisdiction	American Community Survey (2014-2018) Population	Estimated Population Exposed: Low Erosion-Susceptibility Hazard Area – Number of People	Low Erosion-Susceptibility Hazard Area – Percent of Total	Moderate Erosion-Susceptibility Hazard Area – Number of People	Moderate Erosion-Susceptibility Hazard Area – Percent of Total
Castle Pines (C)	10,573	1,974	18.7%	5,360	50.7%
Castle Rock (T)	59,680	5,323	8.9%	15,415	25.8%
Larkspur (T)	257	3	1.2%	65	25.2%
Lone Tree (C)	14,209	48	0.3%	7	0.1%
Parker (T)	52,563	895	1.7%	7,218	13.7%
Unincorporated Douglas County	191,332	4,336	2.3%	5,714	3.0%
Douglas County (Total)	**328,614**	**12,580**	**3.8%**	**33,779**	**10.3%**

Source: American Community Survey 2018 (ACS 2014-2018); Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Impact on General Building Stock

Erosion can impact structures located along the banks of waterways, having the potential to destabilize the foundation of structures. It can also impact infrastructure such as dams, levees, roads, and other developed land. To estimate the buildings exposed to the erosion hazard, the low and moderate erosion susceptibility areas were overlaid upon the updated building inventory at the structure level. The replacement cost value of the structures with their center in the wildfire risk hazard areas were totaled (refer to Table 5-91 for the distribution of estimated exposure within moderate and low erosion hazard areas). Overall, 4,943 buildings with a replacement cost value of $6.4 billion is exposed to the moderate erosion hazard area and 14,207 building with a replacement cost value of $14.9 billion is exposed to the low erosion hazard area in Douglas County.

Table 5-91 Building Stock Replacement Cost Value and Building Count within the Low and Moderate Erosion Susceptibility Hazard Area in Douglas County

			Estimated Building Stock Exposed							
			Low Erosion-Susceptibility Hazard Area				Moderate Erosion-Susceptibility Hazard Area			
Jurisdiction	Number of Buildings	Total Replacement Cost Value	Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total	Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total
Castle Pines (C)	3,701	$4,995,772,208	1,864	50.4%	$2,288,695,181	45.8%	692	18.7%	$726,977,612	14.6%
Castle Rock (T)	24,262	$28,003,310,038	6,312	26.0%	$6,691,280,912	23.9%	2,079	8.6%	$1,936,031,592	6.9%
Larkspur (T)	394	$135,724,576	99	25.1%	$36,213,532	26.7%	9	2.3%	$3,298,123	2.4%
Lone Tree (C)	4,190	$23,664,803,217	3	0.1%	$2,302,544	0.0%	18	0.4%	$69,543,894	0.3%
Parker (T)	17,864	$23,597,914,712	2,573	14.4%	$3,319,401,335	14.1%	294	1.6%	$1,304,265,480	5.5%
Unincorporated Douglas County	84,745	$102,018,837,713	3,356	4.0%	$2,655,672,185	2.6%	1,851	2.2%	$2,348,746,384	2.3%
Douglas County (Total)	**135,156**	**$182,416,362,464**	**14,207**	**10.5%**	**$14,993,565,690**	**8.2%**	**4,943**	**3.7%**	**$6,388,863,086**	**3.5%**

Source: Douglas County GIS, 2020, RS Means 2020, Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Impact on the Critical Facilities

It is recognized that a number of critical facilities are located in the low and moderate erosion susceptibility hazard area. Majority of the critical facilities exposed to the erosion hazard areas are potable water facilities, bridges, recreation sites, and assisted living facilities. Impact to these resources could directly impact vulnerable population over 65 or impact the ability to evacuate if critical transportation infrastructure is impacted. Table 5-92 through Table 5-93 summarize the distribution of critical facilities exposed to the erosion hazard areas by critical facility type and jurisdiction. Out of the incorporated communities in Douglas County, the Town of Castle Rock has the greatest number of critical facilities built in the low erosion susceptibility area (i.e., 40) of which 36 are lifelines. Douglas County's unincorporated area has the greatest number of critical facilities located in the moderate erosion area (i.e., 25) of which 24 are lifelines. The exposed lifelines are categorized into FEMA lifeline groupings and are summarized in

Table 5-96, the majority of which are under the “food, water, or shelter” FEMA lifeline category. Additionally, the number of critical facilities and lifelines within the soil erosion hazard areas by jurisdiction are shown in Table 5-94 and Table 5-95.

Table 5-92 Critical Facilities and Lifelines by Type in the Low Erosion-Susceptibility Hazard Area in Douglas County

Jurisdiction	Critical Facilities Exposed to the Low Erosion-Susceptibility Area																							
	Assisted Living	Bridge	Childcare	Dam	EOC	Fire Station	Food Distribution	Government Building	Hazardous Material Facility	Libraries	Medical Care	Municipal Building	Pharmacy	Police Station	Polling Sites	Post Office	Potable Water Lift station	Potable Water Tank	Potable Water Treatment Facility	Potable Well	Primary Education	Recreation Site	Shelter	Urgent Care
Castle Pines (C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Castle Rock (T)	10	0	0	2	1	4	2	6	1	1	0	0	1	1	3	1	0	0	0	0	5	0	1	1
Larkspur (T)	0	2	0	0	0	1	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Lone Tree (C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parker (T)	1	0	3	1	0	1	4	0	0	0	2	1	2	0	0	1	1	0	2	0	2	9	0	1
Unincorporated Douglas County	0	12	1	4	0	3	0	0	6	0	1	0	0	0	0	1	0	1	1	21	2	15	2	0
Douglas County (Total)	**12**	**14**	**4**	**7**	**1**	**9**	**6**	**7**	**7**	**2**	**3**	**1**	**3**	**1**	**4**	**3**	**1**	**1**	**3**	**21**	**10**	**25**	**3**	**2**

Source: Douglas County GIS 2020; Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Table 5-93 Critical Facilities and Lifelines by Type in the Moderate Erosion-Susceptibility Hazard Area in Douglas County

Jurisdiction	Critical Facilities Exposed to the Moderate Erosion-Susceptibility Area									
	Bridge	Dam	Food Distribution	Hazardous Material Facility	Medical Care	Pharmacy	Potable Well	Primary Education	Recreation Site	Urgent Care
Castle Pines (C)	0	0	0	0	0	0	0	1	1	0
Castle Rock (T)	1	0	0	0	0	0	0	2	0	1
Larkspur (T)	0	0	0	0	0	0	0	0	0	0
Lone Tree (C)	1	0	0	0	0	0	0	0	0	0
Parker (T)	0	0	0	0	2	2	0	0	0	0
Unincorporated Douglas County	8	3	1	1	2	0	9	0	1	0
Douglas County (Total)	**10**	**3**	**1**	**1**	**4**	**2**	**9**	**3**	**2**	**1**

Source: Douglas County GIS 2020; Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Table 5-94 Critical Facilities and Lifelines in the Low Erosion-Susceptibility Hazard Area in Douglas County

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Exposed to Low Erosion Hazard Area			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Castle Pines (C)	20	12	3	15.0%	2	16.7%
Castle Rock (T)	108	100	40	37.0%	36	36.0%
Larkspur (T)	15	9	6	40.0%	4	44.4%
Lone Tree (C)	54	42	0	0.0%	0	0.0%
Parker (T)	140	105	31	22.1%	19	18.1%
Unincorporated Douglas County	827	703	70	8.5%	54	7.7%
Douglas County (Total)	**1,164**	**971**	**150**	**12.9%**	**115**	**11.8%**

Source: Douglas County GIS 2020; Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Table 5-95 Critical Facilities and Lifelines in the Moderate Erosion-Susceptibility Hazard Area in Douglas County

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Exposed to Moderate Erosion Hazard Area			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Castle Pines (C)	20	12	2	10.0%	1	8.3%
Castle Rock (T)	108	100	4	3.7%	4	4.0%
Larkspur (T)	15	9	0	0.0%	0	0.0%
Lone Tree (C)	54	42	1	1.9%	1	2.4%
Parker (T)	140	105	4	2.9%	4	3.8%
Unincorporated Douglas County	827	703	25	3.0%	24	3.4%
Douglas County (Total)	**1,164**	**971**	**36**	**3.1%**	**34**	**3.5%**

Source: Douglas County GIS 2020; Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Table 5-96 Lifelines Exposed to the Erosion Hazard Areas

FEMA Lifeline Category	Number of Lifelines	Number of Lifelines Exposed to the Low Erosion-Susceptibility Hazard Area	Number of Lifelines Exposed to the Moderate Erosion Susceptibility Hazard Area
Food, Water, Shelter	428	35	10
Hazardous Material	22	7	1
Health and Medical	203	20	7
Safety and Security	239	39	6
Transportation	79	14	10
Douglas County (Total)	**971**	**115**	**70**

Source: Douglas County GIS 2020; Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Impact on the Economy

The impact of erosion on the economy and estimated dollar losses are difficult to measure. Erosion and other geological hazards can impose direct and indirect impacts on society. Direct costs include the actual damage sustained by buildings, property and infrastructure. Indirect costs, such as clean-up costs, business interruption, loss of tax revenues, reduced property values, and loss of productivity are difficult to measure (USGS 2003).

Impact on the Environment

Erosion and deposition cause ecological impacts by disrupting the normal distribution of sediment in water bodies. Excessive levels of turbidity (suspended stream sediment) can negatively impact ecosystem health, including fish, invertebrates, and aquatic vegetation. Water quality of impacted water bodies can also be adversely impacted (EPA 2020).

Cascading Impacts on Other Hazards

Erosion can be exasperated from intense flooding events. Even wildfires can impact the stability of soils and slopes. Flash flooding is particularly common after wildfires and can occur quickly and within areas that are not usually prone to flood risk. People are at a greater risk of flooding due to recent wildfire burn areas and could rain at risk for up to 5 years after a fire (Colorado Division of Homeland Security and Emergency Management, n.d.). Intense floods cause increased problems in erosion and sediment transportation. Thus, increasing risk and economic impacts to buildings, infrastructure and people after a wildfire events.

Furthermore, soil and sediment runoff can accumulate downslope potentially blocking waterways and roadways and impacting quality of streams and other water bodies. Mudflows that erode into downstream waterways can threaten the life of freshwater species (USGS 2020). The impacts of eroded landscape can travel for miles downstream into adjacent waterways and create issues for surrounding watersheds.

Future Changes that May Impact Vulnerability

Understanding future changes that affect vulnerability in the County can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development

Any areas of growth could be affected by erosion if the growth areas are within identified hazard areas. Areas targeted for potential future growth and development could be potentially impacted by erosion if they are located within areas prone to erosion. There are six new development sites located within the erosion hazard area; five within the low erosion risk area. Refer to the maps in each jurisdictional annex (Section 9 of this HMP) to view the new development project areas and their proximity to the erosion risk hazard areas.

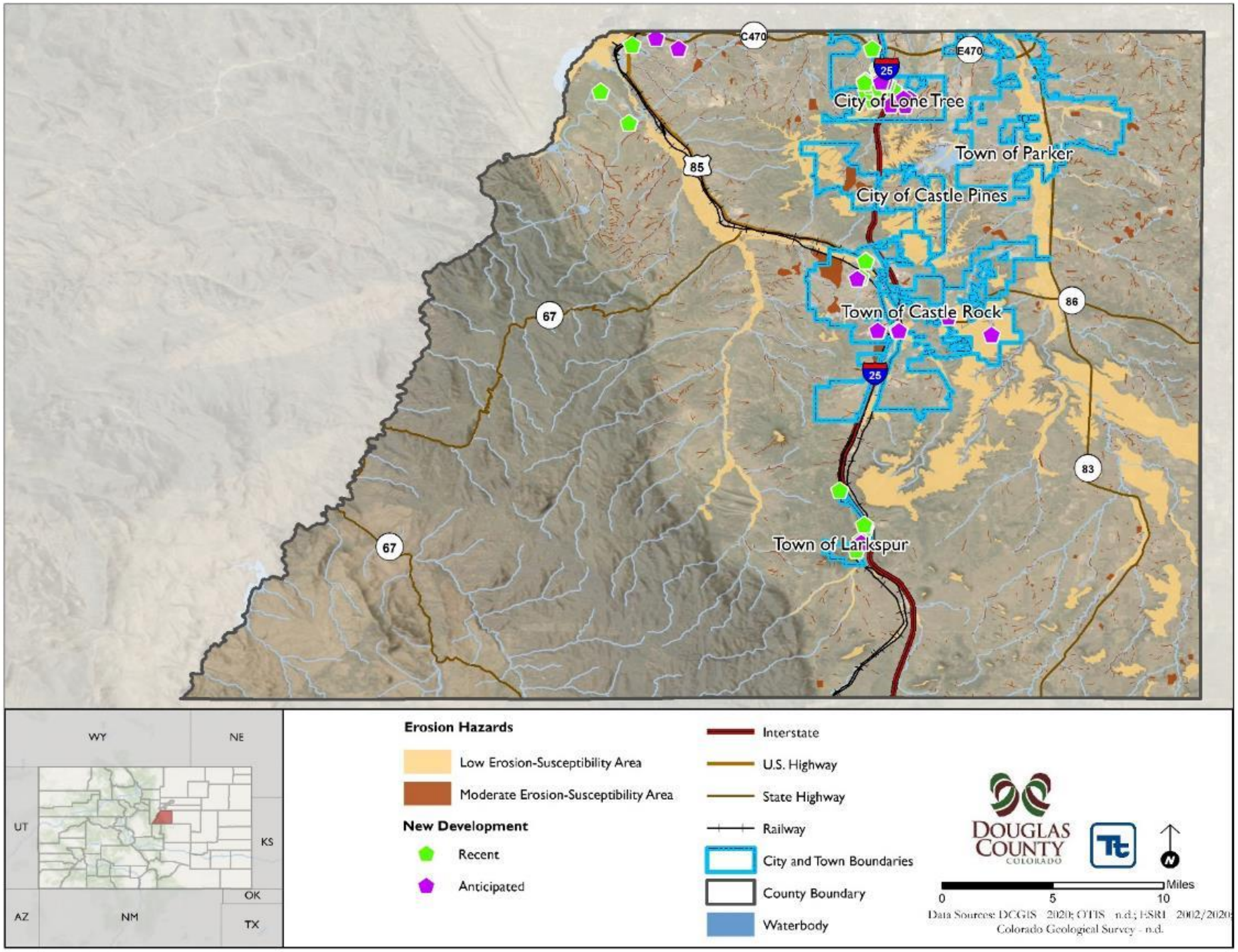
Projected Changes in Population

The County experienced an increase in population between the 2010 Census (285,465) and the estimated 2018 American Community Survey estimated population of 328,614. The population of the County is expected to increase over the next few years. As stated in the County Profile (section 4), the County is the 16th fastest growing county in the United States. The increase in population will expose more people to the erosion hazard area as residents move into these areas.

Climate Change

A direct impact of climate change on erosion is difficult to determine. Multiple secondary effects of climate change have the potential to increase the likelihood of erosion. Warming temperatures resulting in wildfires would reduce vegetative cover along steep slopes and destabilize the soils due to destruction of the root system; increased intensity of rainfall events would increase saturation of soils on steep slopes.

Figure 5-44 New Development and Erosion Risk in Douglas County



Change of Vulnerability since the 2015 HMP

For this hazard mitigation plan update, the erosion susceptibility hazard spatial layer from the Colorado Geological Survey was referenced to determine areas within Douglas County that are vulnerable to erosion. Population statistics have also been updated using the 5-Year 2014-2018 American Community Survey Population Estimates. A customized general building stock was created using RS Means 2020 replacement cost values, building footprints and tax assessor and parcel information provided by the County. Additionally, the critical facility inventory was reviewed by Douglas County. Refer to the Methodology Section (5.1) of the plan for more information about the hazard data and exposure analysis

Overall, this vulnerability assessment uses a more accurate and updated building inventory which provides more accurate estimated exposure and potential losses for Douglas County.

Identified Issues

Identified issues associated with geological hazards in the County include the following:

- Wildfire burn areas will continue to pose erosive threats for Douglas County waterways and water supplies.
- Erosion can cause negative environmental consequences, including water quality degradation.
- Impact the integrity of the levee and the properties located behind the levee system.

5.4.14 Soil Hazards: Expansive Soils and Heaving Bedrock

The following section provides the hazard profile and vulnerability assessment for the expansive soils hazard in Douglas County.

Hazard Profile

Description

Expansive soils and heaving bedrock entail movement of underlying soil and rock resulting in surface damage. Expansive soils and heaving bedrock both cause changes to the Earth's surface that result in damage to property and infrastructure. Ground deformation is localized and linear, resulting in highly variable damage (Noe and Dodson 1999). In this hazard profile, heaving/dipping bedrock is recognized as the primary type of expansive soil hazard of concern for Douglas County.

Expansive soils are soils that contain minerals, such as clays, that are capable of absorbing water. When the soils absorb water, they increase in volume. This change in volume can exert enough force on a building or structure to cause damage. Expansive soils can also shrink when they dry out. Shrinking soils can remove support from buildings or other structures and result in damages as well. Fissures (large cracks in the ground that are formed as a result of land subsidence) in the soil can also develop. These fissures can facilitate the deep penetration of water when moist conditions or runoff occurs. Over time, the cycle of swelling and shrinking soils places repetitive stress on structures and damage will worsen over time (King 2020).

Heaving bedrock is a geological hazard that is similar to expansive soils and occurs where steeply dipping sedimentary bedrock containing claystone is encountered at the ground surface. Bedrock heaves in a linear fashion and is caused by differential rebound movements or swelling within the bedrock (State of Colorado 2018).

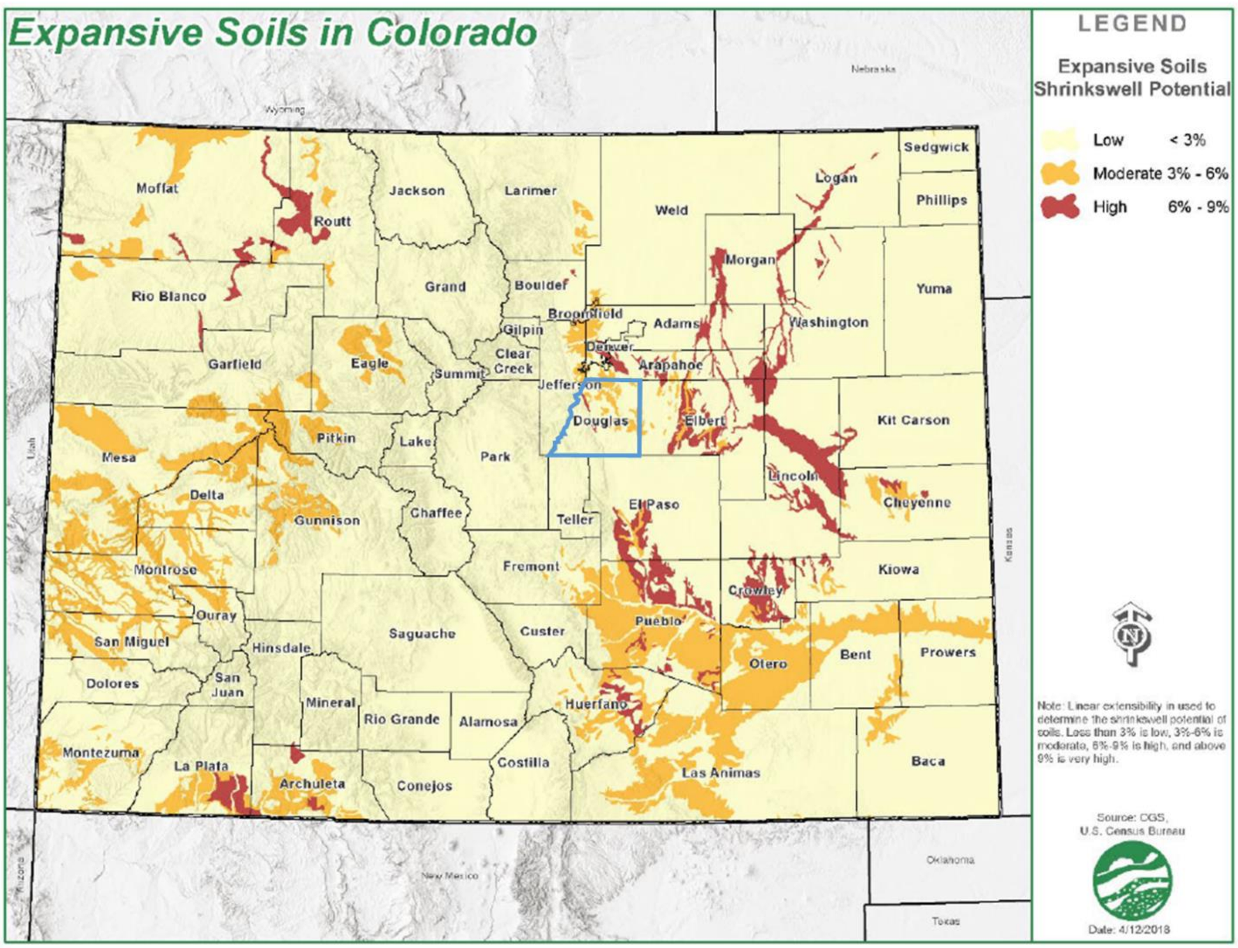
The shrink-swell potential of soils is determined by linear extensibility. Linear extensibility is the change in length of an unconfined clod (lump of earth or clay) as moisture content decreases from a moist to a dry state (State of Colorado 2018).

Extent and Location

The extent of expansive soils is determined by underlying rocks that contain swelling clay. This type of rock generally occurs in mountain valleys and plains rather than in mountainous regions. Linear extensibility determines the extent of potential damage. Expansive soils with a linear extensibility of less than three percent are considered to have a low shrink-swell potential, whereas those with linear extensibility between three and six percent are considered moderate and soils with linear extensibility greater than six percent is considered high (State of Colorado 2018)

Figure 5-45 shows areas of expansive soils in the State of Colorado. In the Front Range region, which includes Douglas County, there are small and relatively isolated areas of soils with high shrink-swell potential. The Colorado Geological Survey classifies some lands in the northern and central part of the County as having soils of moderate shrink-swell potential (between three and six percent).

Figure 5-45: Expansive Soils in Colorado

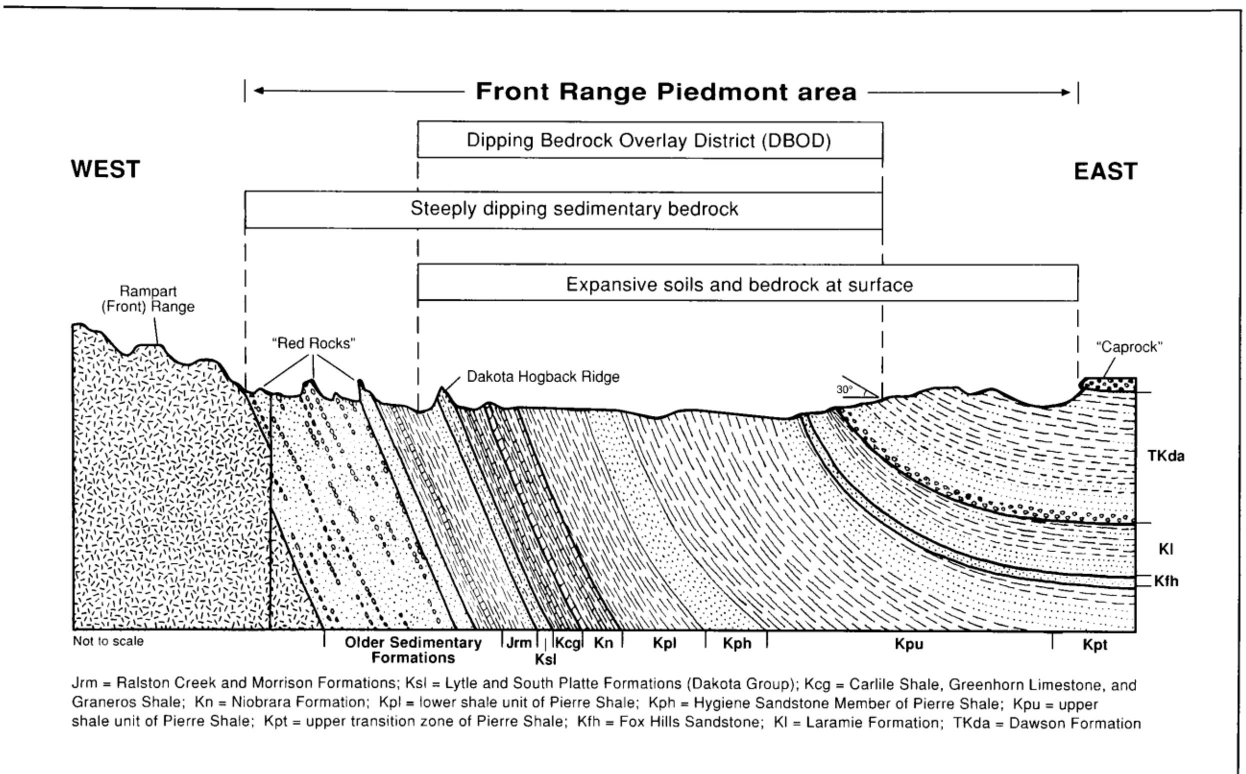


Source: *State of Colorado Hazard Mitigation Plan*
Note: *Douglas County is outlined in blue.*

Mapped areas of dipping bedrock in Douglas County are limited to Front Range piedmont found between Chatfield Reservoir and East Plum Creek at the mouth of Stone Canyon. The area impacted by dipping bedrock is approximately 23 miles long from north to south and varies between 1,000 feet and 2.5 miles wide. The area includes much of a proposed Dipping Bedrock Overlay District that was developed to revise zoning regulations to mitigate the dipping bedrock hazard.

Figure 5-46 shows a cross section of the proposed overlay district. The figure demonstrates the 30-degree angle at which bedrock dips into the ground. Figure 5-47 shows the location of dipping bedrock within Douglas County.

Figure 5-46: Schematic Geological Cross-Section of the Proposed Dipping Bedrock Overlay District



Source: Colorado Geological Survey

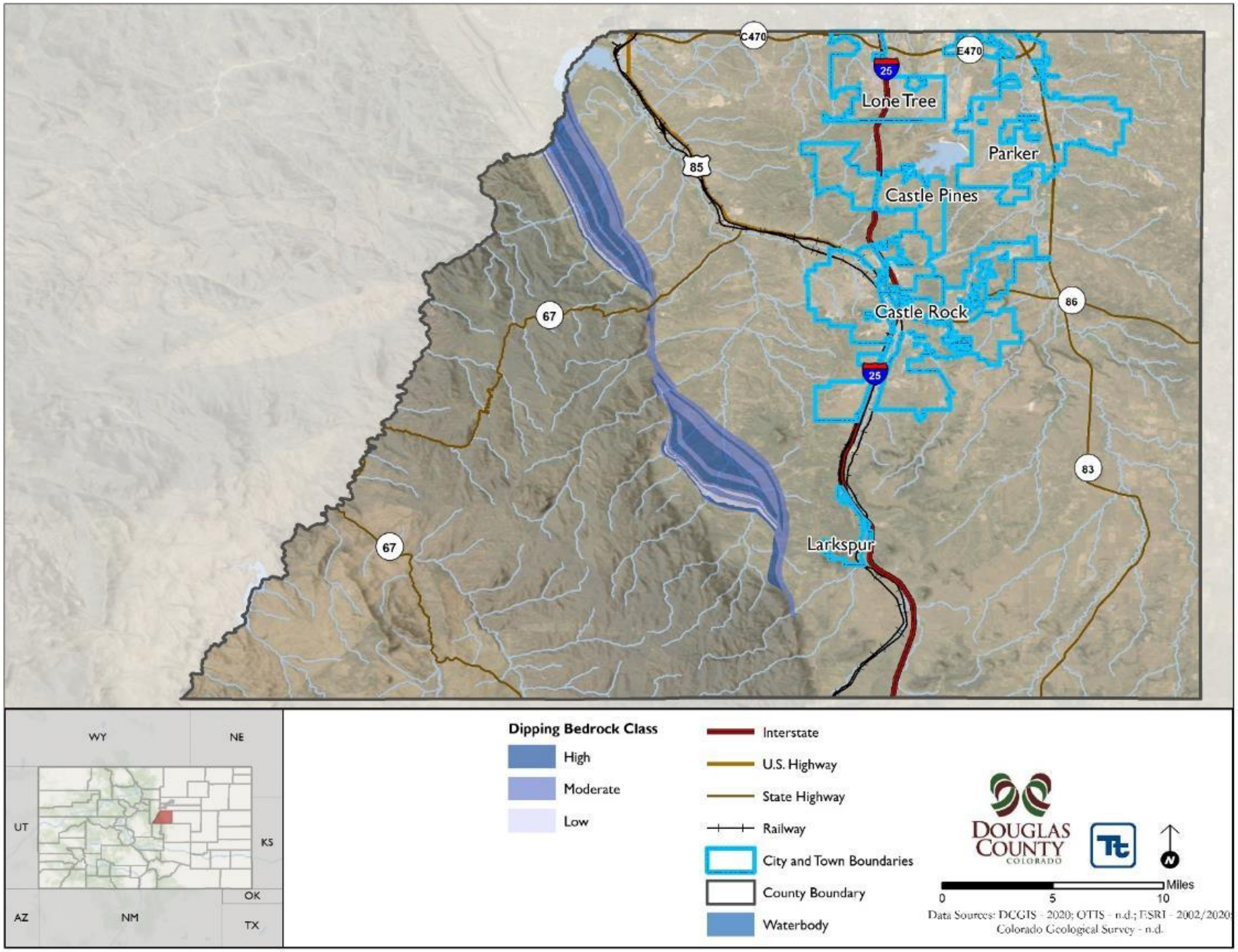
Previous Occurrences and Losses

Specific instances of occurrences of heaving bedrock and expansive soils in Douglas County were not found or reported in the 2015 Hazard Mitigation Plan Update or in the 2018 Enhanced State Hazard Mitigation Plan. However, a 1999 study by the Colorado Geological Survey noted that heaving-bedrock hazards had resulted in millions of dollars in damages to suburban-style development beginning in the 1980s (Noe and Dodson 1999).

Climate Change Projections

Climate change is not anticipated to have a direct impact on expansive soils. However, the Colorado Enhanced State Hazard Mitigation Plan notes that the projected increase in duration and frequency of droughts may increase the frequency of expansive soil events (State of Colorado 2018).

Figure 5-47 Location of Dipping Bedrock in Douglas County



Probability of Future Events

Despite the lack of recent reported damages owing to expansive soil and heaving bedrock events in Douglas County, portions of the County remain vulnerable to damage from these soil hazards. Incidences may increase as the County's climate changes, and as the County continues to build out in areas susceptible to the hazards.

Based on historical records and input from the Core Planning Team, the probability of occurrence for expansive soils and heaving bedrock events in the County is considered *occasional* (Hazard event is likely to occur within 100 years). Refer to Sections 5.1 and 5.3 for additional information on the hazard ranking methodology and probability criteria.

Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable to the identified hazard. Expansive soils and heaving/dipping bedrock may impact public safety, property, infrastructure, environmental resources and local economies. The following text evaluates and estimates the potential impact of expansive soils on Douglas County. An exposure analysis was conducted with the dipping bedrock spatial layer from the Colorado Geological Survey.

Impact on Population

Damages from expansive soils are most prevalent when periods of moderate to high rainfall are followed by drought conditions and then followed again by periods of heavy rain. Pipelines, sewer lines, and water lines that are buried in areas of expansive soils are also at risk. Since the County has only a concentrated area of dipping bedrock mainly located in the undeveloped portions of the County, the number of persons living on lands that contain expansive soils are low. Historic occurrences also indicate that the impacts to life, health and safety are minimal for expansive soils. Overall, only 2.4% of the County's population is located within the dipping bedrock hazard layer.

According to the 2018 American Community Survey (ACS) five-year estimate, Douglas County had a population of 328,614 people. Douglas County's unincorporated area has the highest number populations at risk of events caused by expansive soils, 7,175 persons or 3.8%. Refer to Figure 5-48 which illustrates the geographical extent of dipping bedrock within the County. Table 5-97 and Table 5-98 summarize the population located within the dipping bedrock hazard area.

Table 5-97 Estimated Population in the Dipping Bedrock Hazard Area (Low, Moderate, and High Class)

Jurisdiction	American Community Survey (2014-2018) Population	Estimated Population Exposed: Dipping Bedrock - High Class: Number of People	Dipping Bedrock - High Class: Percent of Total	Dipping Bedrock - Moderate Class: Number of People	Dipping Bedrock - Moderate Class: Percent of Total	Dipping Bedrock - Low Class: Number of People	Dipping Bedrock - Low Class: Percent of Total
Castle Pines (C)	10,573	0	0.0%	0	0.0%	0	0.0%
Castle Rock (T)	59,680	0	0.0%	0	0.0%	442	0.7%
Larkspur (T)	257	0	0.0%	0	0.0%	0	0.0%
Lone Tree (C)	14,209	0	0.0%	0	0.0%	152	1.1%
Parker (T)	52,563	0	0.0%	0	0.0%	56	0.1%
Unincorporated Douglas County	191,332	4,265	2.2%	2,721	1.4%	188	0.1%

Jurisdiction	American Community Survey (2014-2018) Population	Estimated Population Exposed					
		Dipping Bedrock - High Class		Dipping Bedrock - Moderate Class		Dipping Bedrock - Low Class	
		Number of People	Percent of Total	Number of People	Percent of Total	Number of People	Percent of Total
Douglas County (Total)	**328,614**	**4,265**	**1.3%**	**2,721**	**0.8%**	**839**	**0.3%**

Source: American Community Survey 2018 (ACS 2014-2018); Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Table 5-98 Estimated Population in the Dipping Bedrock Hazard Area (All Classes)

Jurisdiction	American Community Survey (2014-2018) Population	Estimated Population Exposed to Dipping Bedrock (High, Moderate, Low)	
		Number of People	Percent of Total
Castle Pines (C)	10,573	0	0.0%
Castle Rock (T)	59,680	442	0.7%
Larkspur (T)	257	0	0.0%
Lone Tree (C)	14,209	152	1.1%
Parker (T)	52,563	56	0.1%
Unincorporated Douglas County	191,332	7,175	3.8%
Douglas County (Total)	**328,614**	**7,825**	**2.4%**

Source: American Community Survey 2018 (ACS 2014-2018); Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Impact on General Building Stock

Residential structures and one-story commercial structures are more susceptible to damage by expansive soils compared to multi-story buildings because of differences in building construction. Multi-story buildings are heavier and can generally counter the swelling pressures. The exception is when multi-story buildings are built on wet clay where damage can be caused by shrinkage of the clay if moisture levels are substantially reduced from evapotranspiration or by evaporation from under heated buildings (Table 5-99 and Table 5-100 summarize the estimated number of buildings currently built on the dipping bedrock hazard areas: low, moderate, and high. Approximately 1,860 buildings or 1.4% of the structure inventory is located within the high dipping bedrock hazard area within Douglas County's unincorporated area. There are no buildings located within the incorporated cities of Douglas County built on soils that contain the high dipping bedrock hazard area. Overall, only 2.6% of the structure inventory is built on soils that contain low, moderate, or high dipping bedrock hazard areas.

Table 5-99 Estimated Building Exposure to the Dipping Bedrock Hazard Areas (All Classes)

Jurisdiction	Number of Buildings	Total Replacement Cost Value	Estimated Building Stock Exposed to Dipping Bedrock (High, Moderate, Low)			
			Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total
Castle Pines (C)	3,701	$4,995,772,208	0	0.0%	$0	0.0%
Castle Rock (T)	24,262	$28,003,310,038	170	0.7%	$168,889,761	0.6%
Larkspur (T)	394	$135,724,576	0	0.0%	$0	0.0%
Lone Tree (C)	4,190	$23,664,803,217	41	1.0%	$49,678,029	0.2%
Parker (T)	17,864	$23,597,914,712	19	0.1%	$19,091,044	0.1%

Jurisdiction	Number of Buildings	Total Replacement Cost Value	Estimated Building Stock Exposed to Dipping Bedrock (High, Moderate, Low)			
			Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total
Unincorporated Douglas County	84,745	$102,018,837,713	3,230	3.8%	$2,588,371,223	2.5%
Douglas County (Total)	**135,156**	**$182,416,362,464**	**3,460**	**2.6%**	**$2,826,030,057**	**1.5%**

Source: Douglas County GIS, 2020, RS Means 2020, Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Table 5-100 Estimated Building Exposure to the Dipping Bedrock Hazard Areas

Jurisdiction	Number of Buildings	Total Replacement Cost Value	Estimated Building Stock Exposed											
			Dipping Bedrock - High Class				Dipping Bedrock - Moderate Class				Dipping Bedrock - Low Class			
			Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total	Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total	Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total
Castle Pines (C)	3,701	$4,995,772,208	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Castle Rock (T)	24,262	$28,003,310,038	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%	170	0.7%	$168,889,761	0.6%
Larkspur (T)	394	$135,724,576	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Lone Tree (C)	4,190	$23,664,803,217	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%	41	1.0%	$49,678,029	0.2%
Parker (T)	17,864	$23,597,914,712	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%	19	0.1%	$19,091,044	0.1%
Unincorporated Douglas County	84,745	$102,018,837,713	1,860	2.2%	$1,503,965,824	1.5%	1,285	1.5%	$988,700,543	1.0%	85	0.1%	$95,704,855	0.1%
Douglas County (Total)	**135,156**	**$182,416,362,464**	**1,860**	**1.4%**	**$1,503,965,824**	**0.8%**	**1,285**	**1.0%**	**$988,700,543**	**0.5%**	**315**	**0.2%**	**$333,363,689**	**0.2%**

Source: Douglas County GIS, 2020, RS Means 2020, Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Impact on the Critical Facilities

It is recognized that a number of critical facilities are located in the dipping bedrock hazard areas. The majority of the critical facilities exposed are potable water facilities, bridges, and dams. There are two fire stations and one food distribution site within the hazard area. Impact to these resources could directly impact government agencies from providing aid during other emergencies or local residents may have trouble obtaining access to food distribution sites or may have utility failures. Table 5-101 summarizes the distribution of critical facilities exposed to the dipping bedrock hazard areas by critical facility type and jurisdiction. There are 37 critical facilities located in the hazard area in which 32 are considered lifelines. The exposed lifelines are categorized into FEMA lifeline groupings and are summarized in Table 5-103, the majority of which belong in the "food, water, or shelter" FEMA lifeline category. Additionally, number of critical facilities and lifelines within the dipping bedrock hazard areas by jurisdiction are shown in Table 5-102.

Table 5-101 Critical Facilities and Lifelines by Type in Dipping Bedrock Hazard Area in Douglas County (All Classes)

Jurisdiction	Critical Facilities Exposed to Dipping Bedrock Hazard Area (Low, Moderate, High Class)													
	Bridge	Childcare	Dam	Fire Station	Food Distribution	Medical Care	Municipal Building	Pharmacy	Police Station	Polling Sites	Potable Well	Primary Education	Recreation Site	Wastewater Treatment Facility
Castle Pines (C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Castle Rock (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Larkspur (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lone Tree (C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parker (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unincorporated Douglas County	8	1	4	2	1	1	1	1	1	1	10	2	3	1
Douglas County (Total)	**8**	**1**	**4**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**10**	**2**	**3**	**1**

Source: Douglas County GIS 2020; Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Table 5-102 Critical Facilities and Lifelines in Dipping Bedrock Hazard Area in Douglas County (All Classes)

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Exposed to Dipping Rock Hazard Area (Low, Moderate, High Class)			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Castle Pines (C)	20	12	0	0.0%	0	0.0%
Castle Rock (T)	108	100	0	0.0%	0	0.0%
Larkspur (T)	15	9	0	0.0%	0	0.0%
Lone Tree (C)	54	42	0	0.0%	0	0.0%
Parker (T)	140	105	0	0.0%	0	0.0%
Unincorporated Douglas County	827	703	37	4.5%	32	4.6%
Douglas County (Total)	**1,164**	**971**	**37**	**3.2%**	**32**	**3.3%**

Source: Douglas County GIS 2020; Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Table 5-103 Lifelines in Dipping Bedrock Hazard Area in Douglas County (All Classes)

FEMA Lifeline Category	Number of Lifelines	Number of Lifelines Exposed to Dipping Bedrock (Low, Moderate, High Class)
Food, Water, Shelter	428	12
Hazardous Material	22	0
Health and Medical	203	2

FEMA Lifeline Category	Number of Lifelines	Number of Lifelines Exposed to Dipping Bedrock (Low, Moderate, High Class)
Safety and Security	239	10
Transportation	79	8
Douglas County (Total)	**971**	**32**

Source: Douglas County GIS 2020; Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Impact on the Economy

As summarized by FEMA, the greatest damage from expansive soils is to highways and roads. Damages result from differential vertical movement that occurs as clay moisture content adjusts to the changed environment. For pavement, differential movement of 0.4 inches with a horizontal distance of 20 feet can pose an engineering problem for fast travel (FEMA 1997). Infrastructure damage is costly and can impact the local and regional economy.

Impact on the Environment

Expansive soils shrink and swell based on available water content. Absorbing available water could reduce water availability for surrounding ecosystems. Shrinking soils from a lack of water could create cracks in the ground, impacted rooted plants. The instability of this soil type may not be the most ideal habitat for species in the County.

Cascading Impacts to Other Hazards

There are no known cascading impacts expansive soils cause to other hazards of concern for the County.

Future Changes that May Impact Vulnerability

Understanding future changes that affect vulnerability in the County can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development

Any new development in terms of structures and infrastructure (e.g. highways and streets) on known expansive soils could be potentially impacted. Proper grading and building regulations/code including proper slab design and emplacement procedures can mitigate structural damage to new development in areas where expansive soils exist. In most cases, structural damage due to expansive soils is not covered by insurance (FEMA 1997).

Projected Changes in Population

The County experienced an increase in population between the 2010 Census (285,465) and the estimated 2018 Community Survey estimated population of 328,614. The population of the County is expected to increase over the next few years. Even through there are increasing population trends in the major metropolitan areas, dipping bedrock is solely located within Douglas County's unincorporated areas in areas of smaller populations. Therefore, it is not likely that as development increases there is a larger risk to expansive soils. There are no new development sites located within the low dipping bedrock hazard area. Refer to section 9 for potential new development in the County and their proximity to the dipping bedrock hazard area.

Typically, land subsidence poses a greater risk to property than to human life. The average annual damage throughout the United States from all types of subsidence is estimated to be at least $125 million. Damage consists primarily of direct structural damage and property loss and depreciation of land values. It also includes business and personal losses that accrue during periods of repair (FEMA 1997).

Climate Change

A combination of dry and wet weather leads to damages from expansive soils. As the climate changes, it could increase the risk of the severity of expansive soils.

Change of Vulnerability Since the 2015 HMP

For this hazard mitigation plan update, the dipping bedrock hazard from Colorado Geological Survey was referenced to determine areas within Douglas County that are vulnerable to expansive soils. Population statistics have also been updated using the 5-Year 2014-2018 American Community Survey Population Estimates. A customized general building stock was created using RS Means 2020 replacement cost values, building footprints and tax assessor and parcel information provided by the County. Additionally, the critical facility inventory was reviewed by Douglas County.

Overall, this vulnerability assessment uses a more accurate and updated building inventory which provides more accurate estimated exposure and potential losses for Douglas County.

Identified Issues

No issues have been identified pertaining to the expansive soils hazard. Douglas County will continue to monitor conditions as they pertain to this hazard to inform future updates to this plan.

5.4.15 Soil Hazards: Land Subsidence

The following section provides the hazard profile and vulnerability assessment for the land subsidence hazard in Douglas County.

Hazard Profile

Description

Ground subsidence entails the settlement of native low-density soils or the sinking of land over voids that could be underground or manmade. Subsidence can be caused by natural sediment compaction, sinkholes, settling of mines, or the melting of permafrost. Subsidence can occur slowly or suddenly, and in Colorado subsidence occurs most frequently in sedimentary rocks underlain by coal, clay mines, and hard rock. Hydro-compaction can also occur when settling or collapsing soils are wettened or subjected to weight. Subsidence can also occur due to withdrawn water from underground (State of Colorado HMP 2018).

Land subsidence is one of the most varied forms of ground failure affecting the United States, ranging from broad regional lowering of land surfaces to local collapses. Regional lowering may aggravate the flood potential or permanently inundate an area, particularly in coastal or riverine settings. Local collapse may damage or destroy buildings, roads, and utilities (FEMA 1997; National Research Council Commission on Engineering and Technical Systems 1991). Other impacts of subsidence include, but are not limited to changes in elevation and slope of streams, canals, and drains; damage to bridges, roads, railroads, storm drains, sanitary sewers, canals, and levees; damage to private and public buildings; and failure of well casings from forces generated by compaction of fine-grained materials in aquifer systems. In some coastal areas, subsidence has resulted in tides moving into low-lying areas that were once above high-tide levels (Leake 2004).

Extent

To determine the extent of the subsidence hazard, the affected areas need to be identified and the probability of the subsidence occurring within some time period needs to be assessed. Natural variables that contribute to the overall extent of potential subsidence activity in any particular area include soil properties, and underlaying geologic feature. Predicting subsidence is difficult, even under ideal conditions. As a result, the subsidence hazard is often represented by presence of evaporite or carbonate rock.

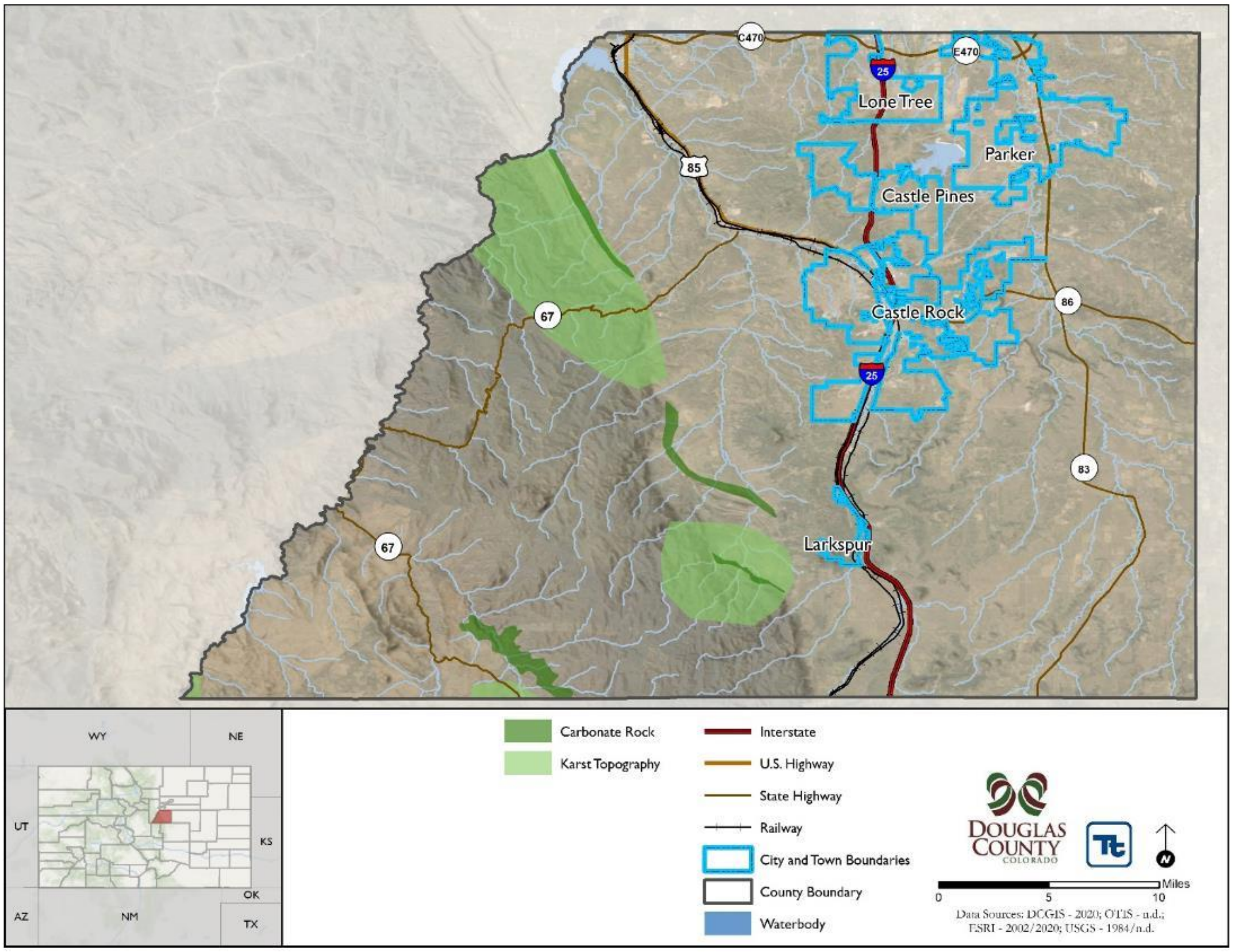
Location

Land subsidence occurs throughout the United States. More than 17,000 square miles in 45 states have been directly impacted by subsidence (USGS 2020). Areas underlain by carbonate bedrock are the most susceptible to land subsidence and sinkhole incidents. Areas of limestone, carbonate rock, salt beds, or rocks that can naturally be dissolved by groundwater are more prone to sinkholes. As the rock dissolves, spaces and caverns develop underground, leading to sinkholes (USGS 2018).

In Colorado, subsidence due to withdrawn water and mining is less common than in other western states (State of Colorado 2018). According to the Colorado Geological Survey, the northwestern section of Douglas County is underlain by inactive coal mines that pose subsidence risks (State of Colorado 2018). In addition to this area, various portions of Douglas County are underlain by carbonate rock and Karst topography. This includes a large area stretching from the County boundary southeast across Highway 67 to Garber Creek and east to Roxborough State Park. Much of this area is underlain by Karst topography, with carbonate rock comprising the sliver along Roxborough State Park. Other narrow bands of carbonate rock stretch northwest from Larkspur towards Garber Creek, along the foothills near Starr Canyon, and along Trout Creek. Other areas of Karst topography include the area in the confluence of West Plum Creek and Gove Creek, and the area southwest of the Rainbow Falls Riding Area in Pike National Forest.

Though the State Hazard Mitigation Plan and the County Comprehensive Plan do not reference the subsidence hazard in Douglas County, instances of subsidence were reported in the 2015 Douglas County Hazard Mitigation Plan in the Castle Meadows area resulting from abandoned clay mines. The Class 3 Hazards map in the County’s Comprehensive Plan additionally notes subsidence areas in the vicinity of Castle Rock, including Douglas County High School, the vicinity of the Reserve at Castle Highlands Apartments, and near the intersection of 5th Street and 5th Place. Please refer to Figure 5-48 to see carbonate rock and karst topography located within Douglas County.

Figure 5-48 Karst Topography and Carbonate Rock in Douglas County



Previous Occurrences and Losses

Douglas County has experienced occasional subsidence issues. The 2015 Hazard Mitigation plan noted isolated incidents in Castle Meadows associated with abandoned clay mines. Northern Douglas County has been reported as susceptible to collapsible soils (White and Greenman 2008).

Climate Change Projections

Climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration. Increase in global temperature could affect the snowpack and its ability to hold and store water. Warming temperatures also could increase the occurrence and duration of droughts, which would increase the probability of wildfire, reducing the vegetation that helps to support steep slopes. All of these factors would increase the probability for erosion, including land subsidence, to occur.

Probability of Future Events

Land subsidence may continue to develop from other types of below-ground withdrawals or from natural or man-made forces. The State of Colorado identifies evaporative karst subsidence, abandoned land mines, and collapsible soils as the likely sources of future subsidence events. Land subsidence related to abandoned mines and collapsible soils result, in part, from increasing population and development trends lead to varying groundwater withdrawals, and this can lead to more incidences of land subsidence/sinkholes (State of Colorado HMP 2018).

Based on historical records and input from the Core Planning Team, the probability of occurrence for land subsidence events in the County is considered *occasional* (Hazard event is likely to occur within 100 years). Refer to Sections 5.1 and 5.3 for additional information on the hazard ranking methodology and probability criteria.

Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable to the identified hazard. Land subsidence may impact public safety, property, infrastructure, environmental resources and local economies. The following text evaluates and estimates the potential impact of land subsidence on Douglas County. A spatial analysis was conducted using the United States Geological Survey karst topography and carbonate hazard area overlaid over the population. general building stock, and critical facility spatial layers to calculate impacts to the population and the economy.

Impact on Life, Health, and Safety

Table 5-104 summarizes the population located in the karst topography hazard area and the carbonate rock hazard area. There is no impact to Douglas County's incorporated cities. Approximately 3.4-percent of Douglas County's population within unincorporated areas are living on lands that contain karst topography and 1-percent of the unincorporated population is living on lands that contain the carbonate rock hazard area. Overall, there are approximately 8,448 persons exposed to the land subsidence hazard areas.

Table 5-104 Estimated Population Located in the Karst Topography and Carbonate Rock Hazard Area in Douglas County

Jurisdiction	American Community Survey (2014-2018) Population	Estimated Population Exposed to Karst Topography Hazard Area		Estimated Population Exposed to Carbonate Rock Hazard Area	
		Number of People	Percent of Total	Number of People	Percent of Total
Castle Pines (C)	10,573	0	0.0%	0	0.0%
Castle Rock (T)	59,680	0	0.0%	0	0.0%
Larkspur (T)	257	0	0.0%	0	0.0%
Lone Tree (C)	14,209	0	0.0%	0	0.0%
Parker (T)	52,563	0	0.0%	0	0.0%
Unincorporated Douglas County	191,332	6,501	3.4%	1,947	1.0%
Douglas County (Total)	**328,614**	**6,501**	**2.0%**	**1,947**	**0.6%**

Source: American Community Survey 2018 (ACS 2014-2018); United States Geological Survey, n.d./1984
Notes: C=City; T = Town

Impact on General Building Stock

In general, the built environment located in the land subsidence area and the population, structures and infrastructure located downslope are vulnerable to this hazard. There are 2,885 buildings with a replacement cost value of approximately $2.2 billion located in the karst topography hazard area countywide and 828 buildings with a replacement cost value of approximately $620 million located in the carbonate rock hazard area. Table 5-105 and Table 5-106 summarizes the exposed building stock located in the land subsidence area throughout the county by jurisdiction.

Table 5-105 Building Stock Replacement Cost Value and Building Count within Karst Topography Hazard Area in Douglas County

Jurisdiction	Number of Buildings	Total Replacement Cost Value	Estimated Building Stock Exposed to Karst Topography Hazard Area			
			Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total
Castle Pines (C)	3,701	$4,995,772,208	0	0.0%	$0	0.0%
Castle Rock (T)	24,262	$28,003,310,038	0	0.0%	$0	0.0%
Larkspur (T)	394	$135,724,576	0	0.0%	$0	0.0%
Lone Tree (C)	4,190	$23,664,803,217	0	0.0%	$0	0.0%
Parker (T)	17,864	$23,597,914,712	0	0.0%	$0	0.0%
Unincorporated Douglas County	84,745	$102,018,837,713	2,885	3.4%	$2,160,421,157	2.1%
Douglas County (Total)	**135,156**	**$182,416,362,464**	**2,885**	2.1%	**$2,160,421,157**	1.2%

Source: Douglas County GIS, 2020, RS Means 2020, United States Geological Survey, n.d.
Notes: C=City; T = Town

Table 5-106 Building Stock Replacement Cost Value and Building Count within Carbonate Rock Hazard Area in Douglas County

Jurisdiction	Number of Buildings	Total Replacement Cost Value	Estimated Building Stock Exposed to Carbonate Rock Hazard Area			
			Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total
Castle Pines (C)	3,701	$4,995,772,208	0	0.0%	$0	0.0%
Castle Rock (T)	24,262	$28,003,310,038	0	0.0%	$0	0.0%
Larkspur (T)	394	$135,724,576	0	0.0%	$0	0.0%
Lone Tree (C)	4,190	$23,664,803,217	0	0.0%	$0	0.0%
Parker (T)	17,864	$23,597,914,712	0	0.0%	$0	0.0%
Unincorporated Douglas County	84,745	$102,018,837,713	828	1.0%	$620,357,854	0.6%
Douglas County (Total)	**135,156**	**$182,416,362,464**	**828**	0.6%	**$620,357,854**	0.3%

Source: Douglas County GIS, 2020; RS Means 2020; United Stated Geological Survey, n.d., 1984.
Notes: C=City; T = Town

Impact on the Critical Facilities

It is recognized that a number of critical facilities are located in the karst topography and carbonate rock hazard areas. The majority of the critical facilities exposed to land subsidence hazard areas are potable water facilities, recreation sites and dams. Impact to these resources could cause utility failure or flood control issues if there are any breaches to dams. Table 5-107 through Table 5-110 summarize the distribution of critical facilities exposed to the subsidence hazard areas by critical facility type and jurisdiction. Douglas County's unincorporated area has the greatest number of critical facilities located in the subsidence hazard areas. The exposed lifelines are categorized into FEMA lifeline groupings and are summarized in Table 5-111, the majority of which are under the "food, water, or shelter" FEMA lifeline category. Additionally, the number of critical facilities and lifelines within the subsidence hazard areas by jurisdiction are shown in Table 5-107 and Table 5-108.

Table 5-107 Critical Facilities and Lifelines by Type in the Karst Topography Hazard Area in Douglas County

Jurisdiction	Critical Facilities Exposed to Karst Topography				
	Bridge	Dam	Fire Station	Potable Well	Recreation Site
Castle Pines (C)	0	0	0	0	0
Castle Rock (T)	0	0	0	0	0
Larkspur (T)	0	0	0	0	0
Lone Tree (C)	0	0	0	0	0
Parker (T)	0	0	0	0	0
Unincorporated Douglas County	2	5	2	15	10
Douglas County (Total)	**2**	**5**	**2**	**15**	**10**

Source: Douglas County GIS, 2020, United Stated Geological Survey, n.d.
Notes: C=City; T = Town

Table 5-108 Critical Facilities and Lifelines by Type in the Carbonate Rock Hazard Area in Douglas County

Jurisdiction	Critical Facilities Exposed to the Carbonate Rock Hazard Area		
	Bridge	Dam	Potable Well
Castle Pines (C)	0	0	0
Castle Rock (T)	0	0	0
Larkspur (T)	0	0	0
Lone Tree (C)	0	0	0
Parker (T)	0	0	0
Unincorporated Douglas County	2	2	2
Douglas County (Total)	**2**	**2**	**2**

Source: Douglas County GIS, 2020, United Stated Geological Survey, 1984
Notes: C=City; T = Town

Table 5-109 Critical Facilities and Lifelines by Type in the Karst Topography Hazard Area in Douglas County

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Exposed to Karst Topography			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Castle Pines (C)	20	12	0	0.0%	0	0.0%
Castle Rock (T)	108	100	0	0.0%	0	0.0%
Larkspur (T)	15	9	0	0.0%	0	0.0%
Lone Tree (C)	54	42	0	0.0%	0	0.0%

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Exposed to Karst Topography			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Parker (T)	140	105	0	0.0%	0	0.0%
Unincorporated Douglas County	827	703	34	4.1%	24	3.4%
Douglas County (Total)	**1,164**	**971**	**34**	**2.9%**	**24**	**2.5%**

Source: Douglas County GIS, 2020, United Stated Geological Survey, n.d.
Notes: C=City; T = Town

Table 5-110 Critical Facilities and Lifelines by Type in the Carbonate Rock Hazard Area in Douglas County

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Exposed to Carbonate Rock Hazard Area			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Castle Pines (C)	20	12	0	0.0%	0	0.0%
Castle Rock (T)	108	100	0	0.0%	0	0.0%
Larkspur (T)	15	9	0	0.0%	0	0.0%
Lone Tree (C)	54	42	0	0.0%	0	0.0%
Parker (T)	140	105	0	0.0%	0	0.0%
Unincorporated Douglas County	827	703	6	0.7%	6	0.9%
Douglas County (Total)	**1,164**	**971**	**6**	**0.5%**	**6**	**0.6%**

Source: Douglas County GIS, 2020, United Stated Geological Survey, 1984
Notes: C=City; T = Town

Table 5-111 Lifelines Exposed to the Karst Topography and Carbonate Rock Hazard Area Douglas County

FEMA Lifeline Category	Number of Lifelines	Number of Lifelines Exposed to Karst Topography	Number of Lifelines Exposed to the Carbonate Rock Hazard Area
Food, Water, Shelter	428	15	2
Hazardous Material	22	0	0
Health and Medical	203	0	0
Safety and Security	239	7	2
Transportation	79	2	2
Douglas County (Total)	**971**	**24**	**6**

Source: Douglas County GIS, 2020, United Stated Geological Survey, n.d./1984
Notes: C=City; T = Town

Impact on the Economy

Geological hazards such as land subsidence can impose direct and indirect impacts on society. Direct costs include the actual damage sustained by buildings, property and infrastructure. Indirect costs, such as clean-up costs, business interruption, loss of tax revenues, reduced property values, and loss of productivity are difficult to measure (USGS, 2003). Additionally, subsidence can cause damages to buildings and decrease property value as saltwater encroachment increases in coastal areas.

Impact on the Environment

A landslide or sinkhole/subsidence event will alter the landscape. In addition to changes in topography, vegetation and wildlife habitats may be damaged or destroyed, and soil and sediment runoff will accumulate downslope potentially blocking waterways and roadways and impacting quality of streams and other water bodies. Additional environmental impacts include loss of forest productivity.

Furthermore, soil and sediment runoff can accumulate downslope potentially blocking waterways and roadways and impacting quality of streams and other water bodies. Mudflows that erode into downstream waterways can threaten the life of freshwater species (USGS 2020). The impacts of eroded landscape can travel for miles downstream into adjacent waterways and create issues for surrounding watersheds.

Cascading Impacts on Other Hazards

Landslide events can have cascading impacts on soil erosion. Landslides can alter topography, uproot vegetation and disturb soil stability. This could lead to potential impacts to erosion susceptibility and debris flow. Additionally, landslide events can cause transport of material possibly distributing contaminants from contained sites to other areas. More information about slope failures can be found in Section 5.4.16.

Future Changes that May Impact Vulnerability

Understanding future changes that affect vulnerability in the County can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development

Due the lack of exposure and impacts from these hazards, future development in the County is not likely to be impacted by land subsidence in the short term. However, as a changing climate continues to influence the frequency, severity and magnitude of hazard events, there could be impacts on future development. Future updates to this plan will have to measure those possibilities as it assesses land subsidence. There are no new development sites located within the landslide hazard area. Refer to the maps in each jurisdictional annex (Section 9 of this HMP) to view the new development project areas and their proximity to the carbonate rock and karst topography areas.

Projected Changes in Population

The County experienced an increase in population between the 2010 Census (285,465) and the estimated 2018 Community Survey estimated population of 328,614. The population of the County is expected to increase over the next few years. Increasing population trends in the major metropolitan areas will lead to increasing groundwater withdrawals from surface aquifers, and this can lead to more incidences of land subsidence/sinkholes.

Climate Change

More frequent and severe rainfall events, as is predicted for the region, will alter the hydrologic conditions and stability of the soil through increased erosion and changes in soil saturation. With increases in extreme temperatures and precipitation more landslide events are likely to occur with greater magnitudes (Huggel, C., Khabarov, N., Korup, O., & Obersteiner, M., 2012).

Change of Vulnerability Since the 2015 HMP

For this hazard mitigation plan update, the carbonate rock and karst topography hazard spatial layer from the United States Geological Survey was referenced to determine areas within Douglas County that are vulnerable to land subsidence. Population statistics have also been updated using the 5-Year 2014-2018 American Community Survey Population Estimates. A customized general building stock was created using RS Means 2020 replacement cost values, building footprints and tax assessor and parcel information provided by the County. Additionally, the critical facility inventory was reviewed by Douglas County.

Overall, this vulnerability assessment uses a more accurate and updated building inventory which provides more accurate estimated exposure and potential losses for Douglas County.

Identified Issues

Identified issues pertaining to land subsidence include the following:

- According to existing geological data, subsidence is most likely to occur in portions of the County that are sparsely populated. However, subsidence still poses a threat to infrastructure, people, and property in these areas.
- The Douglas County Comprehensive Master Plan 2040 maps small areas of subsidence on its Class 3 hazards plan. However, the Comprehensive Plan itself and the State Hazard Mitigation Plan do not mention collapsible soil or subsidence areas in the County.

5.4.16 Soil Hazards: Slope Failure

The following section provides the hazard profile and vulnerability assessment for the slope failure and debris flow hazard in Douglas County.

Hazard Profile

Description

Landslides, slope failures and debris flows include several types of soil hazards that result in abrupt movements of rock and soil. Landslides include processes that result in the outward and downward movement of slope-forming materials that include, but are not limited to, artificial fill, soil, and rock. Slope failures include movements by sliding, spreading, flowing, toppling, and falling. There are different types of landslides, as seen in Figure 5-49. In Douglas County, the more common slope failures include landslides, mud/debris flows, and rockfalls. Landslides occur in all 50 states and are estimated to cause between 25 and 50 deaths and result in more than $1 billion in damage annually. Though slope failures are singular events, they can have multiple causes and variables impacting the extent and severity of the hazard.

Figure 5-49 Types of Landslides

Type of movement		Type of material		
		Bedrock	Engineering soils	
			Predominantly coarse	Predominantly fine
Falls		Rock fall	Debris fall	Earth fall
Topples		Rock topple	Debris topple	Earth topple
Slides	Rotational	Rock slide	Debris slide	Earth slide
	Translational			
Lateral Spreads		Rock spread	Debris spread	Earth spread
Flows		Rock flow (deep creep)	Debris flow	Earth flow
			Soil creep	
Complex		Combination of two or more principal types of movement		

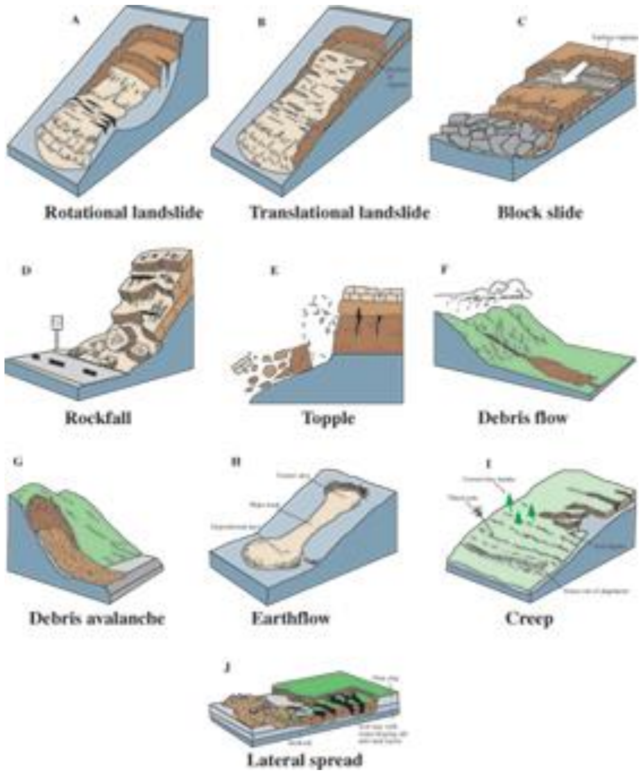
Source: USGS

Landslides are the downward and outward movement of slopes composed of one or a combination of natural rock, soils, and artificial fills. Common types of landslides include slump, rockslide, debris slide, lateral spreading, debris avalanche, earth flow, and soil creep (State of Colorado HMP 2018). Figure 5-50 illustrates these different types of landslides.

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, this event is called a debris flow (State of Colorado HMP 2018). They are similar to flash floods and can occur suddenly without time for adequate warning. When the drainage channel eventually becomes less steep, the liquid mass spreads out and slows down to form a part of a debris fan or a mud flow deposit. In the steep channel itself, erosion is the dominant process as the flow picks up more solid material (Douglas County HMP 2015). Of particular concern to Douglas County are post-wildfire debris-flows. Rains in the wake of wildfire events can cause debris flows due to root decay and the loss of soil strength. Post-fire debris flows can move very quickly and with little warning, causing drainage blockage, structure damages, and further strip vegetation. Additionally, wildfires can further de-stabilize pre-existing deep-seated landslides over a long period of time.

Rockfalls are the fastest type of landslide and occur most frequently in mountains or steep areas during early spring. Rockfalls are caused by the loss of support from underneath or detachment from a larger rock mass. Ice wedging, root growth, or ground shaking, as well as a loss of support through erosion or chemical weathering may start the fall (Douglas County HMP 2015).

Figure 5-50 Types of Landslides (Illustrated)



Source: USGS

Extent

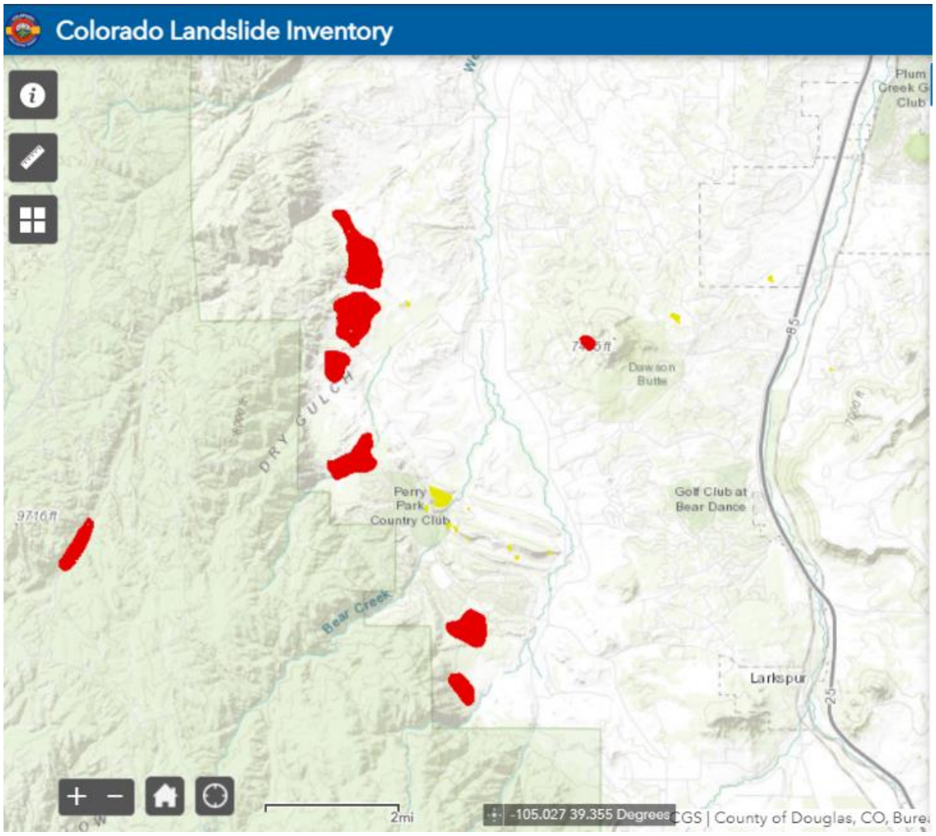
Landslides are difficult to predict on an individual basis. However, landslides can be anticipated through an understanding of an area's underlying geologic and soil conditions, the known occurrence of past landslide events, high topographic relief, and precipitation events. The occurrence of disruptive human activities such as large-scale excavation can also affect the extent of a slope failure event. The extent of a wildfire burn area can also inform the extent of slope failures due to changes in vegetation and soil strength.

Location

According to the US Geological Survey, landslides in Colorado typically occur along the Front Range, central mountains, and western part of the State where there are significant slopes. Slope failures typically occur in mountainous regions, such as those of Pike National Forest found in the western portion of Douglas County. However, slope failures can also occur in low-relief areas in the form of river buff failures, lateral landslides, collapse of mine-waste piles, and cut-and-fill failures.

According to the Colorado Landslide Inventory, landslides have been limited in their occurrence to the vicinity of Larkspur in the southwestern section of the County. One cluster of landslides has been reported at Dawson Butte and the area to the southeast of Castle Rock. Another cluster of landslides was recorded at the vicinity of the Perry Park Country Club, along Dry Gulch, and along Jackson Creek near Devils Head in the Rampart Range. Figure 5-51 shows the historic occurrences of landslides in Douglas County.

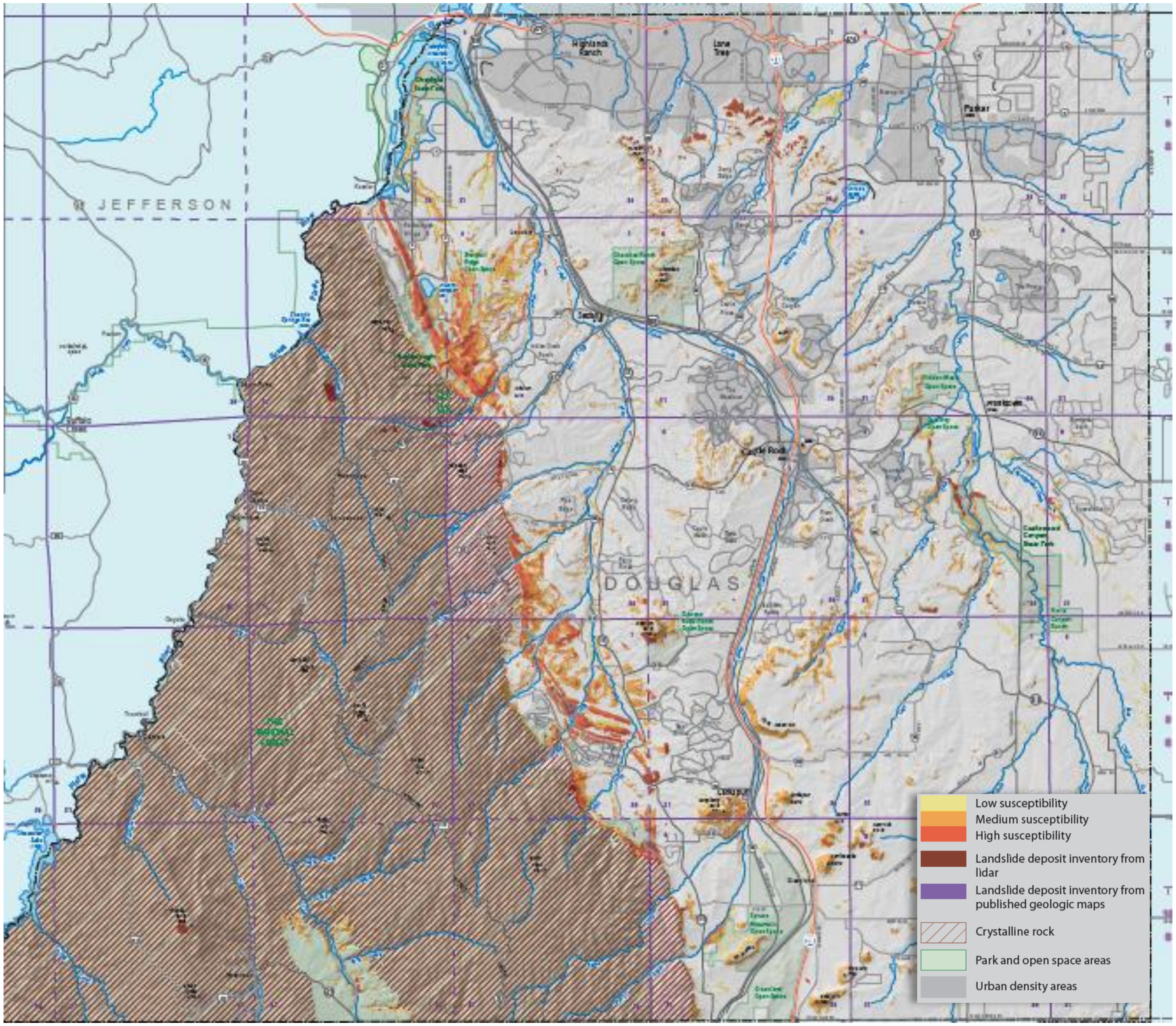
Figure 5-51 Landslide Occurrences in Douglas County



Source: Colorado Landslide Inventory

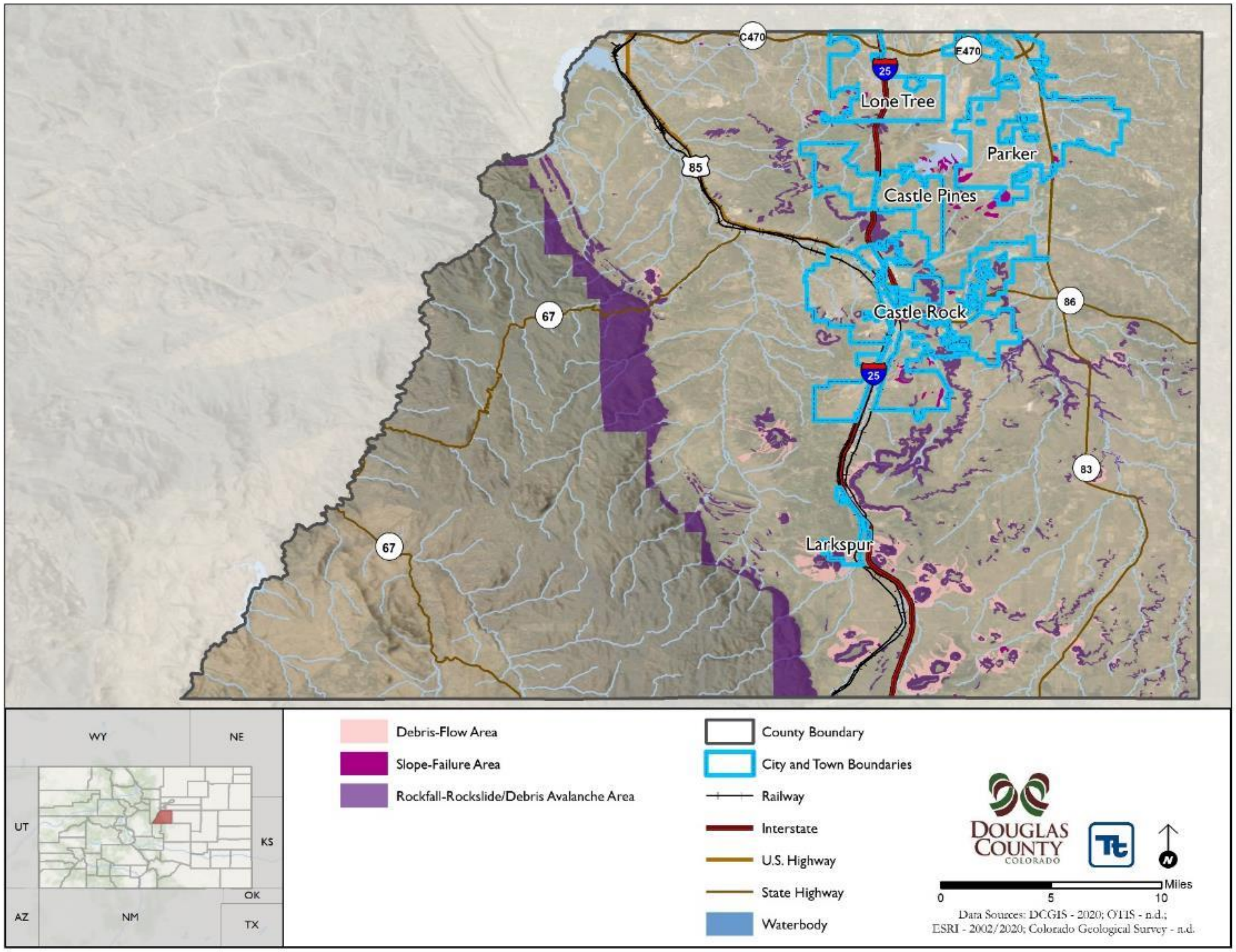
The Colorado Geological Survey has mapped landslide susceptibility in Douglas County using factors such as relief, slope classes, and geologic rock unit. The Geological Survey also identified landslide deposits from LIDAR and published geologic maps. Landslide deposits were found in scattered locations across the County, such as between Lone Tree and Castle Pines North, Castlewood Canyon State Park, and Roxborough State Park. Areas of medium and high susceptibility to landslides are found along the County's buttes and mountain ridges, particularly along the Pike National Forest boundary. Figure 5-52 shows landslide susceptibility in Douglas County.

Figure 5-52 Landslide Susceptibility Map of Douglas County, Colorado



Source: Colorado Geological Survey

Figure 5-53 Debris Flow, Slope Failure, and Rockfall-Rockslide/Debris Avalanche Hazard Area in Douglas County



Previous Occurrences and Losses

Douglas County has not experienced landslide events since the 2015 Hazard Mitigation Plan. The 2015 plan reports two past occurrences of landslides in 2004 and 2007 resulting from localized flash flooding in the Hayman burn area. In the August 2004 landslide incident, the Westcreek subdivision and several roads were damaged by floodwaters that reached eight inches deep. The July 2007 rock and mudslide event occurred near Trout Ranch Road. The Hayman Creek burn area stretches from Trout Creek to the County line and may be the location of future landslides or unrecorded landslides occurring since the fire.

Climate Change Projections

Climate change is anticipated to cause more intense precipitation events along with more frequent and intense droughts and wildfires. The combination of these meteorological and climatological impacts will make conditions for slope failures more favorable and frequent.

Probability of Future Events

The underlying geologic causes of slope failures will continue to remain in Douglas County. Though slope failures are relatively rare events, the potential for future events to occur remains and may increase due to human activity and meteorological conditions. Climate change will likely increase the frequency of slope failures occurring in Douglas County.

Based on historical records and input from the Planning Team, the probability of occurrence for slope failure events in the County is considered *occasional* (likely to occur in 100 years). Refer to Sections 5.1 and 5.2 for additional information on the hazard ranking methodology and probability criteria.

Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable to the identified hazard. Slope failure and debris flows may impact public safety, property, infrastructure, environmental resources and local economies. The following text evaluates and estimates the potential impact of rockfall and slope failure on Douglas County. An exposure analysis was conducted with the geological hazard spatial layers from the Colorado Geological Survey.

Impact on Population

Landslides occur in all 50 states and are estimated to cause between 25 and 50 deaths and result in more than $1 billion in damage annually. Though slope failures are singular events, they can have multiple causes and variables impacting the extent and severity of the hazard. Based on previous occurrences and severity, impacts to life, health and safety are minimal for landslide events.

According to the 2018 ACS annual estimate, Douglas County had a population of 328,614 people. The City of Castle Pines has the highest percentage of persons exposed to the rockfall-rockslide/debris avalanche area, 2.7-percent and 281 persons. Overall, Douglas county has a low percentage of population exposed to the slope-failure hazard area and the rockfall-rockslide/debris avalanche area, 0.3-percent and 1.6-percent respectively. Refer to Figure 5-52 which illustrates the geographical location of slope-failure and rockfall-rockslide/debris hazard area within the County. Table 5-112 summarizes the population located within the slope failure and rockfall hazard area.

The Town of Larkspur has the greatest percentage of persons living in the debris-flow hazard area, 52.7-percent or 136 persons. Refer to Table 5-112 for the estimated population living in the debris-flow hazard area.

Table 5-112 Estimated Population Located in the Debris Flow Hazard Area in Douglas County

Jurisdiction	American Community Survey (2014-2018) Population	Estimated Population Exposed to the Debris Flow Hazard Area	
		Number of People	Percent of Total
Castle Pines (C)	10,573	0	0.0%
Castle Rock (T)	59,680	18	<0.1%
Larkspur (T)	257	136	52.7%
Lone Tree (C)	14,209	0	0.0%
Parker (T)	52,563	0	0.0%
Unincorporated Douglas County	191,332	699	0.4%
Douglas County (Total)	**328,614**	**852**	**0.3%**

Source: American Community Survey 2018 (ACS 2014-2018); Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Table 5-113 Estimated Population in the Slope-Failure Hazard Area and the Rockfall-Rockslide/Debris Avalanche Hazard Area

Jurisdiction	American Community Survey (2014-2018) Population	Estimated Population Exposed to the Slope-Failure Hazard Area		Estimated Population Exposed to the Rockfall-Rockslide/Debris Avalanche Hazard Area	
		Persons Exposed	Percent of Total	Persons Exposed	Percent of Total
Castle Pines (C)	10,573	0	0.0%	281	2.7%
Castle Rock (T)	59,680	442	0.7%	1,501	2.5%
Larkspur (T)	257	0	0.0%	2	0.9%
Lone Tree (C)	14,209	152	1.1%	0	0.0%
Parker (T)	52,563	56	0.1%	0	0.0%
Unincorporated Douglas County	191,332	188	0.1%	3,620	1.9%
Douglas County (Total)	**328,614**	**839**	**0.3%**	**5,405**	**1.6%**

Source: American Community Survey 2018 (ACS 2014-2018); Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Impact on Life, Health, and Safety

Generally, a landslide event would be an isolated incidents and impact the populations within the immediate area of the incident. Specifically, the population located downslope of the landslide hazard areas are particularly vulnerable to this hazard. In addition to causing damages to residential buildings and displacing residents, landslide events can block off or damage major roadways and inhibit travel for emergency responders or populations trying to evacuate the area.

Impact on General Building Stock

Table 5-114 and Table 5-115 summarizes the estimated number of buildings currently built within the slope failure hazard and the rockfall hazard area. The Town of Castle Rock has the largest number of buildings

(170) located within the slope failure hazard area with an estimated replacement cost values of $168 million. Furthermore, the City of Castle Pines has the highest percentage (2.6%) of buildings located in the rockfall hazard area, whereas Unincorporated Douglas County has the largest number of buildings in the rockfall hazard area. Overall, impacts from slope-failure are low for the County; 0.2% of the structure inventory is located within the slope failure hazard area and 1.7-percent is located within the rockfall hazard area. Additionally, 557 buildings are located in the debris flow area with a replacement cost value of $270 million.

Table 5-114 Estimated Building Exposure to the Slope-Failure Hazard Area

Jurisdiction	Number of Buildings	Total Replacement Cost Value	Estimated Building Stock Exposed to the Slope-Failure Hazard Area			
			Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total
Castle Pines (C)	3,701	$4,995,772,208	0	0.0%	$0	0.0%
Castle Rock (T)	24,262	$28,003,310,038	170	0.7%	$168,889,761	0.6%
Larkspur (T)	394	$135,724,576	0	0.0%	$0	0.0%
Lone Tree (C)	4,190	$23,664,803,217	41	1.0%	$49,678,029	0.2%
Parker (T)	17,864	$23,597,914,712	19	0.1%	$19,091,044	0.1%
Unincorporated Douglas County	84,745	$102,018,837,713	85	0.1%	$95,704,855	0.1%
Douglas County (Total)	**135,156**	**$182,416,362,464**	**315**	**0.2%**	**$333,363,689**	**0.2%**

Source: Douglas County GIS, 2020, RS Means 2020, Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Table 5-115 Estimated Building Exposure to the Rockfall-Rockslide/Debris Avalanche Hazard Area

Jurisdiction	Number of Buildings	Total Replacement Cost Value	Estimated Building Stock Exposed to the Rockfall-Rockslide/Debris Avalanche Area			
			Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total
Castle Pines (C)	3,701	$4,995,772,208	97	2.6%	$154,658,985	3.1%
Castle Rock (T)	24,262	$28,003,310,038	590	2.4%	$604,488,757	2.2%
Larkspur (T)	394	$135,724,576	7	1.8%	$1,188,219	0.9%
Lone Tree (C)	4,190	$23,664,803,217	1	<0.1%	$25,906,834	0.1%
Parker (T)	17,864	$23,597,914,712	0	0.0%	$0	0.0%
Unincorporated Douglas County	84,745	$102,018,837,713	1,631	1.9%	$1,226,678,761	1.2%
Douglas County (Total)	**135,156**	**$182,416,362,464**	**2,326**	**1.7%**	**$2,012,921,555**	**1.1%**

Source: Douglas County GIS, 2020, RS Means 2020, Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Table 5-116 Building Stock Replacement Cost Value and Building Count within the Debris Flow Hazard Area in Douglas County

Jurisdiction	Number of Buildings	Total Replacement Cost Value	Estimated Building Stock Exposed to the Debris Flow Hazard Area			
			Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total
Castle Pines (C)	3,701	$4,995,772,208	0	0.0%	$0	0.0%
Castle Rock (T)	24,262	$28,003,310,038	7	<0.1%	$7,823,267	<0.1%
Larkspur (T)	394	$135,724,576	185	47.0%	$45,357,554	33.4%
Lone Tree (C)	4,190	$23,664,803,217	0	0.0%	$0	0.0%
Parker (T)	17,864	$23,597,914,712	0	0.0%	$0	0.0%
Unincorporated Douglas County	84,745	$102,018,837,713	365	0.4%	$217,249,684	0.2%
Douglas County (Total)	**135,156**	**$182,416,362,464**	**557**	**0.4%**	**$270,430,506**	**0.1%**

Source: Douglas County GIS, 2020, RS Means 2020, Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Impact on the Critical Facilities

It is recognized that a number of critical facilities are located in the slope failure or rockfall hazard area. Some of the critical facilities exposed to the hazard areas are potable water facilities dams, assisted living, and medical facilities. Impact to these resources could directly impact vulnerable population over 65 or impact the ability to evacuate if medical centers and assisted living facilities are disrupted. Table 5-117 and Table 5-118 summarize the distribution of critical facilities exposed to the geological hazard areas by critical facility type and jurisdiction. Overall, the County has 34 lifelines located within the slope failure or rockfall hazard area. The exposed lifelines are categorized into FEMA lifeline groupings and are summarized in Table 5-119, the majority of which are under the “food, water, or shelter” FEMA lifeline category. Table 5-120 and Table 5-121 show impacts on critical facilities and lifelines for debris flow hazard areas in Douglas County.

Table 5-117 Critical Facilities and Lifelines by Type in Slope-Failure Hazard Area in Douglas County

Jurisdiction	Critical Facilities Exposed to the Slope-Failure Hazard Area		
	Bridge	Municipal Building	Potable Well
Castle Pines (C)	0	0	0
Castle Rock (T)	0	0	0
Larkspur (T)	0	0	0
Lone Tree (C)	0	0	0
Parker (T)	0	0	0
Unincorporated Douglas County	1	1	2
Douglas County (Total)	**1**	**1**	**2**

Table 5-118 Critical Facilities and Lifelines in Rockfall-Rockslide/Debris Avalanche Hazard Area in Douglas County

Jurisdiction	Critical Facilities Exposed to the Rockfall-Rockslide/Debris Avalanche Hazard Area								
	Assisted Living	Bridge	Dam	Fire Station	Medical Care	Potable Water Tank	Potable Well	Primary Education	Recreation Site
Castle Pines (C)	0	0	0	0	0	0	0	0	0
Castle Rock (T)	2	0	0	0	0	0	0	0	0
Larkspur (T)	0	0	0	0	0	3	0	0	0
Lone Tree (C)	0	0	0	0	0	0	0	0	0
Parker (T)	0	0	0	0	0	0	0	0	0
Unincorporated Douglas County	1	1	5	1	2	0	14	1	2
Douglas County (Total)	**3**	**1**	**5**	**1**	**2**	**3**	**14**	**1**	**2**

Source: Douglas County GIS 2020; Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Table 5-119 Lifelines in the Rockfall-Rockslide/Debris Avalanche and Slope-Failure Hazard Area in Douglas County

FEMA Lifeline Category	Number of Lifelines	Number of Lifelines Exposed to the Rockfall-Rockslide/Debris Avalanche Hazard Area	Number of Lifelines Exposed to the Slope-Failure Hazard Area
Food, Water, Shelter	428	17	2
Hazardous Material	22	0	0
Health and Medical	203	5	0
Safety and Security	239	7	1
Transportation	79	1	1
Douglas County (Total)	**971**	**30**	**4**

Source: Douglas County GIS 2020; Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Table 5-120 Critical Facilities and Lifelines by Type in the Debris Flow Hazard Area in Douglas County

Jurisdiction	Critical Facilities Exposed to the Debris Flow Hazard Area						
	Bridge	Dam	Fire Station	Major Business	Potable Water Treatment Facility	Potable Well	Recreation Site
Castle Pines (C)	0	0	0	0	0	0	0
Castle Rock (T)	0	0	0	0	0	0	0
Larkspur (T)	0	0	0	1	1	0	0

Jurisdiction	Critical Facilities Exposed to the Debris Flow Hazard Area						
	Bridge	Dam	Fire Station	Major Business	Potable Water Treatment Facility	Potable Well	Recreation Site
Lone Tree (C)	0	0	0	0	0	0	0
Parker (T)	0	0	0	0	0	0	0
Unincorporated Douglas County	1	3	1	0	0	4	2
Douglas County (Total)	**1**	**3**	**1**	**1**	**1**	**4**	**2**

Source: Douglas County GIS 2020; Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Table 5-121 Critical Facilities and Lifelines in the Debris Flow Hazard Area in Douglas County

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Exposed to Debris Flow Hazard Area			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Castle Pines (C)	20	12	0	0.0%	0	0.0%
Castle Rock (T)	108	100	0	0.0%	0	0.0%
Larkspur (T)	15	9	2	13.3%	1	11.1%
Lone Tree (C)	54	42	0	0.0%	0	0.0%
Parker (T)	140	105	0	0.0%	0	0.0%
Unincorporated Douglas County	827	703	11	1.3%	9	1.3%
Douglas County (Total)	**1,164**	**971**	**13**	**1.1%**	**10**	**1.0%**

Source: Douglas County GIS 2020; Colorado Geological Survey, n.d.
Notes: C=City; T = Town

Impact on the Economy

The slope failure and debris flow areas mapped for this hazard occur in predominantly lightly-developed or undeveloped portions of Douglas County. Damage from slope failure and debris flows can impact infrastructure that supports economic activity in these areas.

Impact on the Environment

Geological hazards can impose direct and indirect impacts on society. Direct costs include the actual damage sustained by buildings, property and infrastructure. Indirect costs, such as clean-up costs, business interruption, loss of tax revenues, reduced property values, and loss of productivity are difficult to measure (USGS, 2003).

Cascading Impacts to Other Hazards

As stated earlier, slope failures include movements by sliding, spreading, flowing, toppling, and falling. In addition to changes in topography, vegetation and wildlife habitats may be damaged or destroyed, and soil and sediment runoff will accumulate downslope potentially blocking waterways and roadways and impacting quality of streams and other water bodies. Additional environmental impacts include loss of forest productivity.

Some of the largest debris-flow events happen during the first post-fire storm season. It takes less rainfall to trigger debris in areas that were burned than in areas that were not affected by fires (USGS 2020). Fires reduce the rate in which water can permeate the soil triggering debris flow occurrence can by surface erosion and land sliding caused by steep slopes (USGS 2020). To learn more about flooding and wildfire hazards refer to section 5.4.6 and 5.4.17 respectively.

Future Changes that May Impact Vulnerability

Understanding future changes that affect vulnerability in the County can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development

Any new development in terms of structures and infrastructure (e.g. highways and streets) in debris flow and slope failure areas could be potentially impacted. Proper grading and building regulations/code including proper slab design and emplacement procedures can mitigate structural damage to new development in areas where these hazard areas exist.

Projected Changes in Population

The County experienced an increase in population between the 2010 Census (285,465) and the estimated 2018 Community Survey estimated population of 328,614. The population of the County is expected to increase over the next few years. Increasing population trends in the major metropolitan areas will lead to an increase in development and construction could occur in areas of slope failure or rockfall hazard areas. There is one new development site located within the slope failure hazard area and no new development sites located within the rockfall hazard area. Refer to section 9 for potential new development in the County and their proximity to the geological hazards.

Climate Change

A combination of dry and wet weather leads to damages from slope-failure and debris flows/rockfall. As the climate changes, it could increase the risk of the severity of these hazards. In particular, the increase of non-snow precipitation can impact

Change of Vulnerability Since the 2015 HMP

For this hazard mitigation plan update, the slope-failure and rockfall spatial layer from the Colorado Geological Survey was referenced to determine areas within Douglas County that are vulnerable to slope failure. Population statistics have also been updated using the 5-Year 2014-2018 American Community Survey Population Estimates. A customized general building stock was created using RS Means 2020 replacement cost values, building footprints and tax assessor and parcel information provided by the County. Additionally, the critical facility inventory was reviewed by Douglas County.

Overall, this vulnerability assessment uses a more accurate and updated building inventory which provides more accurate estimated exposure and potential losses for Douglas County.

Identified Issues

The following issues were identified for the Slope Failure hazard:

- Slope failures triggered by meteorological events may increase due to climate change impacts resulting in increased precipitation.
- Slope failures in Douglas County can disrupt roadways and infrastructure, thereby creating challenges for emergency response in the event that a slope failure occurs.

5.4.17 Wildfire

This section provides the hazard profile and vulnerability assessment for the wildfire hazard for Douglas County.

Profile

Hazard Description

A wildfire is an unplanned fire that burns natural areas such as forests, grasslands, or prairies. They can threaten lives and property if not contained. Wildfires can be defined as wildland, interface or intermix, catastrophic, and prescribed fires. Wildfires are fueled almost exclusively by natural vegetation while interface or intermix fires are urban/wildland fires in which vegetation and the built environment provide the fuel. Wildfires can occur anytime of the year in the State of Colorado (State of Colorado HMP 2018). In Douglas County, wildfires are an ongoing concern, especially fires that occur in the wildland/urban interface (Douglas County HMP 2015).

Figure 5-54. Fire Burning in Parker, October 13, 2016

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. 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 (State of Colorado HMP 2018).

Extent

Colorado Wildfire Risk Assessment Portal (CO-WRAP) is the primary tool used by the Colorado Forest Atlas to deploy risk information and create awareness about wildfire issues across the State of Colorado. CO-WRAP provides Characteristic Fire Intensity Scale (FIS). The FIS determines potential fire intensity based on high to extreme weather conditions, fuels, and topography where there are five classes: Lowest to

Highest Intensity. Table 5-122 shows the distribution of the FIS in Douglas County (Colorado Forest Atlas, 2019).

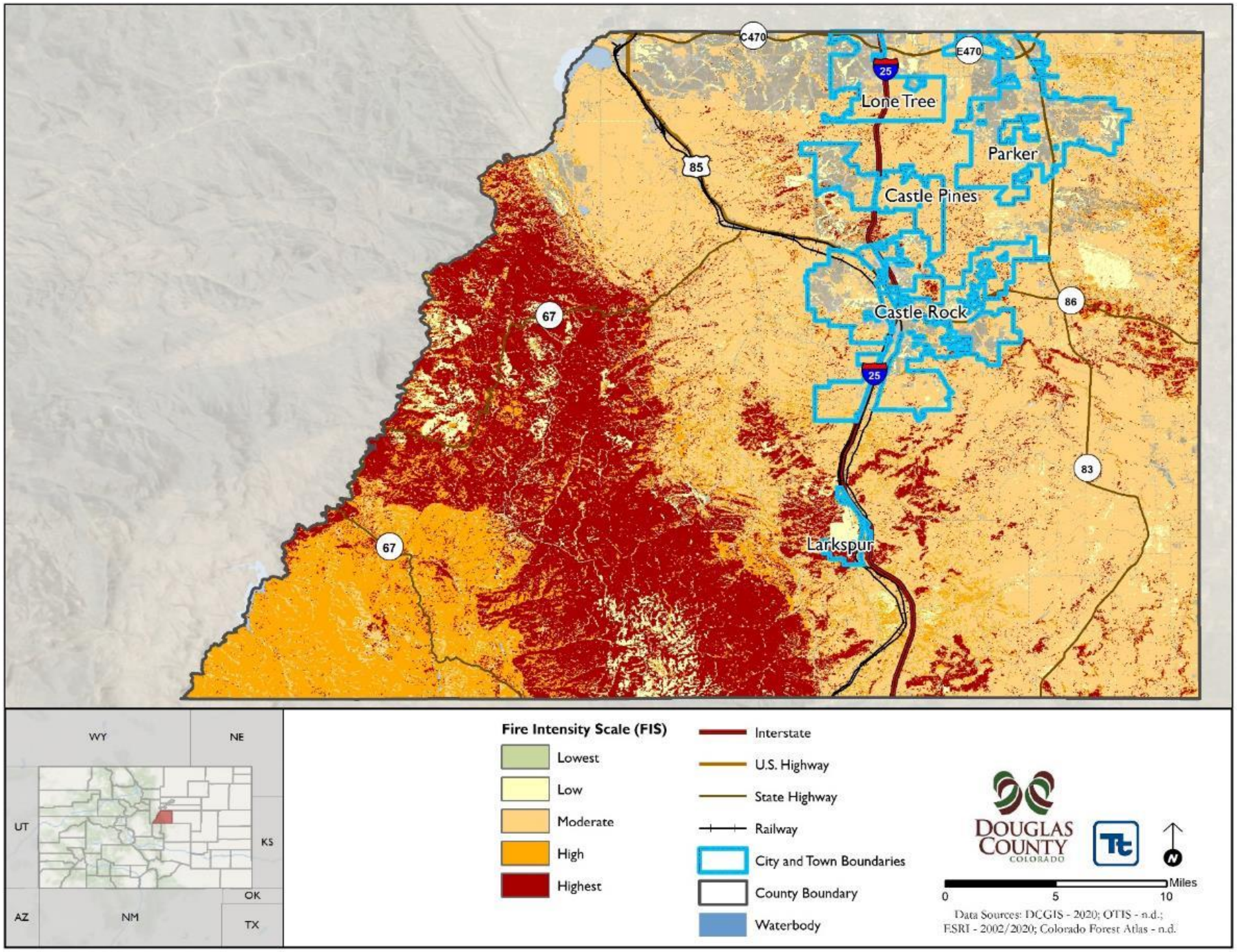
Wildfire risk ranges from lowest, low, moderate, high, and highest risk areas; 38.1-percent of the County is located in the moderate risk area and 32.5-percent of the County is located in the high-risk area. Table 5-122 summarizes the acres exposed to the wildfire risk areas in Douglas County.

Table 5-122 Land Acres exposed to Wildfire Risk Hazard Areas in Douglas County

Hazard Area Type	Acres Exposed to Wildfire Hazard Areas	Percent of Total
Highest Wildfire Risk Area	31,369	5.8%
High Wildfire Risk Area	174,788	32.5%
Moderate Wildfire Risk Area	205,045	38.1%
Low Wildfire Risk Area	40,492	7.5%
Lowest Wildfire Risk Area	36,322	6.8%
Douglas County (Total)	**537,585**	

Source: USGS National Land Cover Data 2016; Colorado Forest Atlas, 2017
Notes: C=City; T = Town; Water areas were not included in acreage totals

Figure 5-55 CO-WRAP Fire Intensity Scale for Douglas County



Wildfire events can range in size and intensity; much of which depends on weather and human activity.

Wildfire Behavior and Fire Ecology

Fire behavior is defined as the manner in which fuel ignites, flame develops, and fire spreads, which depend on interactions among fuel, weather, and topography. Fire behavior is one of the most important aspects of wildfires because almost all actions in response to a fire depend on how it behaves. Potential for wildfire and its subsequent development (growth) and severity are controlled by the three principal factors of topography, fuel, and weather, described as follows:

Topography **–** Topography can powerfully influence wildfire behavior. Movement of air over the terrain tends to direct a fire's course. A gulch or canyon can funnel air and act as a chimney, intensifying fire behavior and inducing faster spread. Saddles on ridgetops tend to offer lower resistance to passage of air and draw fires. Solar heating of drier, south-facing slopes produces upslope thermal winds that can complicate behavior. Slope is an important factor. If the percentage of uphill slope doubles, the rate the wildfire spreads will most likely double as well. Terrain can inhibit wildfires: fire travels downslope much more slowly than it does upslope, and ridgetops often mark the end of a wildfire's rapid spread (FEMA 1997).

Fuel **–** Fuels are classified by weight or volume (fuel loading) and by type. Fuel loading is used to describe the amount of vegetative material available. If this amount doubles, energy released can also double. Each fuel type is given a burn index—an estimate of amount of potential energy that may be released, effort required to ignite a fire in a given fuel and expected flame length. Different fuels have different burn qualities, and some burn more easily than others. Grass fires release relatively little energy but can sustain very high rates of spread (FEMA 1997). According to the U.S. Forest Service (USFS), a forest stand may consist of several layers of live and dead vegetation in the understory (surface fuels), midstory (ladder fuels), and overstory (crown fuels):

- Surface fuels consist of grasses, shrubs, litter, and woody material lying on the ground. Surface fires burn low vegetation, woody debris, and litter. Under the right conditions, surface fires reduce likelihood that future wildfires will grow into crown fires.
- Ladder fuels consist of live and dead small trees and shrubs; live and dead lower branches from larger trees, needles, vines, lichens, mosses; and any other combustible biomass between the top of surface fuels and bottom of overstory tree crowns.
- Crown fuels are suspended above the ground in treetops or other vegetation and consist mostly of live and dead fine material. When historically low-density forests become overcrowded, tree crowns may merge and form a closed canopy. Tree canopies constitute the primary fuel layer in a forest crown fire (USFS 2003).

Fire behavior is strongly influenced by these fuels.

Weather / Air Mass **–** Weather is the most important factor influencing fire behavior, but it is always changing. Air mass, defined by the National Weather Service (NWS) as a body of air covering a relatively wide area and exhibiting horizontally uniform properties, can affect wildfire through climatic factors that include temperature and relative humidity, local wind speed and direction, cloud cover, precipitation amount and duration, and stability of the atmosphere at the time of the fire (NWS 2009). Extreme weather leads to extreme events, and often a subsidence of severe weather marks the end of a wildfire's growth and the beginning of successful containment. High temperatures and low humidity can produce vigorous fire activity. Fronts and thunderstorms can produce winds that radically and suddenly change in speed and direction, causing similar changes in fire activity. The rate of spread of a fire varies directly with wind velocity. Winds may play a dominant role in directing the course of a fire. The most damaging firestorms are typically marked by high winds (FEMA 1997).

Several tools are available to estimate fire potential, extent, danger, and growth, including, but not limited to, the following:

The ***Colorado State Forest Service's Wildfire Risk Public Viewer*** contains mapped wildfire data that includes historical occurrences, burn probability, fire intensity, and social vulnerability.

The ***Wildland Fire Assessment System (WFAS)*** is an internet-based information system that provides a national view of weather and fire potential, including national fires danger, weather maps, and satellite-derived "greenness" maps (USFS, No Date [n.d.]).

The ***Fire Potential Index (FPI)*** is derived by combining information on daily weather and vegetation condition and can identify areas most susceptible to fire ignition (Burgan et al. 2000).

Fuel Moisture (FM) content is quantity of water in a fuel particle expressed as a percent of oven-dry weight of the fuel particle and is an expression of cumulative effects of past and present weather events, to help evaluate the effects of current or future weather on fire potential (Burgan et al. 2000).

The ***Keetch-Byram Drought Index (KBDI)*** is designed for fire potential assessment and is a number representing the net effect of evapotranspiration and precipitation in producing cumulative moisture deficiency in deep duff and upper soil layers (USFS n.d.).

The ***Haines Index***, also known as the Lower Atmosphere Stability Index, is a fire weather index based on stability and moisture content of the lower atmosphere that measures potential for existing fires to become large fires (USFS n.d.).

The ***Buildup Index (BUI)*** is a number that reflects combined cumulative effects of daily drying and precipitation in fuels with a 10-day time lag constant (North Carolina Forest Service 2007).

Location

The Wildland-Urban Interface (WUI) definition in the Federal Register was developed to identify communities as risk in the vicinity of public lands; the area where houses meet or intermingle with undeveloped vegetation. The entire County can expect to experience wildfires in the future; especially the areas of the County located within the WUI area. The intensity and severity of the wildfire may vary within the County due to variations in wildland vegetation, defensible space, weather conditions and fuel sources.

According to the Wildland-Urban Interface Risk Index created by the Colorado State Forest Service, 45% of Douglas County residents live in areas with an index of 2, indicating nearly half of residents live in an area characterized as having between a low and least negative impact for wildfire risk. The proportion of residents at no risk who do not live within the Wildland-Urban Interface is 18%, whereas the proportion of those who live in the area with the highest negative impact is 14%.

In addition to the WUI, Colorado Forest Atlas created a wildfire risk spatial layer that calculates the probability of loss or harm from a wildfire by combining burn probability and fire effects. Areas affected are weighted by population, forest assets, riparian assets, and drinking water importance values (Colorado

State Forest Service, 2018). Approximately 35.5-percent of the County's population is located within the wildfire risk area and 50,760 buildings are exposed to the wildfire risk area. Figure 5-56 through Figure 5-60 shows the wildfire risk area in Douglas County.

Figure 5-56 Wildfire Risk in Douglas County

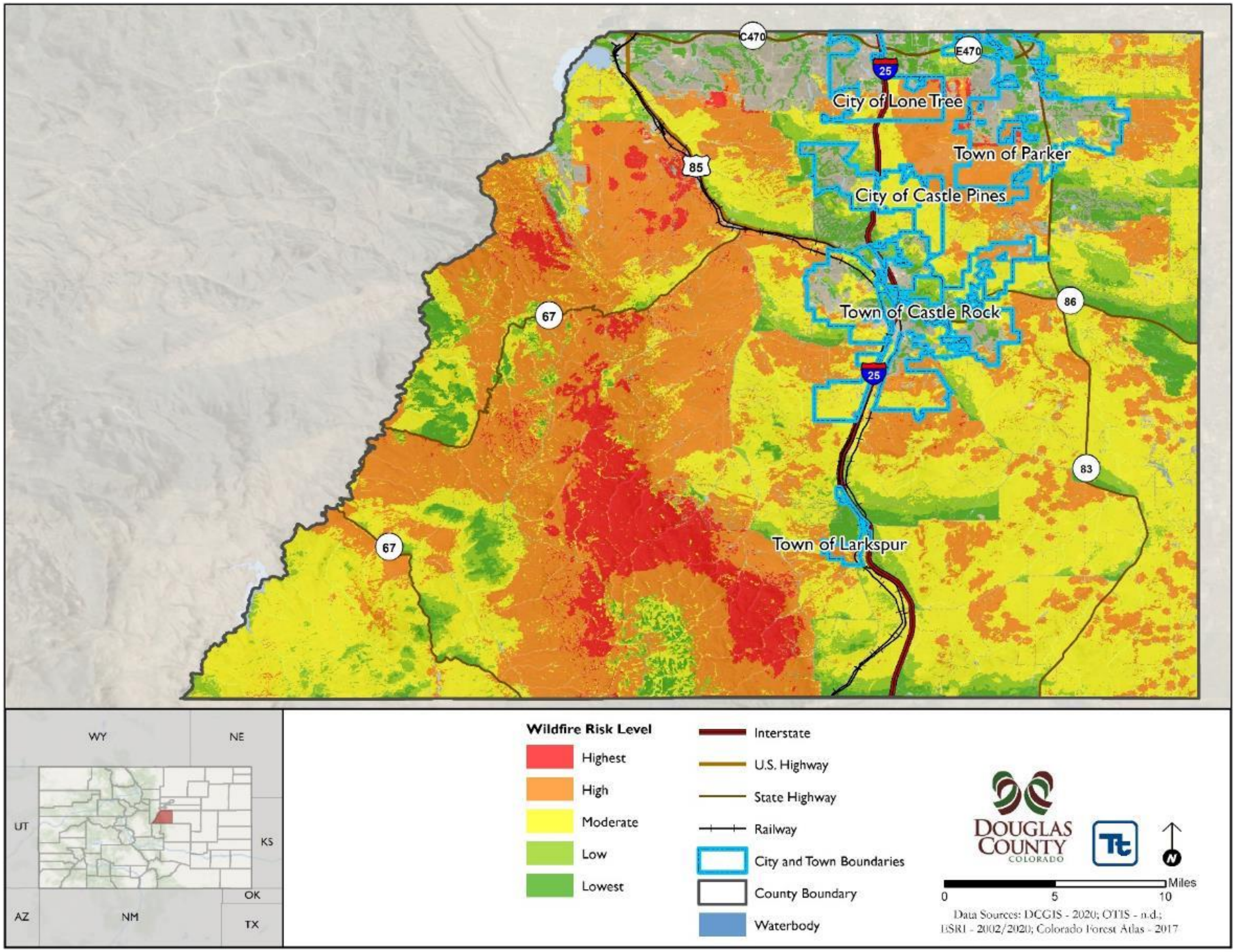


Figure 5-57 Wildfire Risk in Douglas County (Northwest)

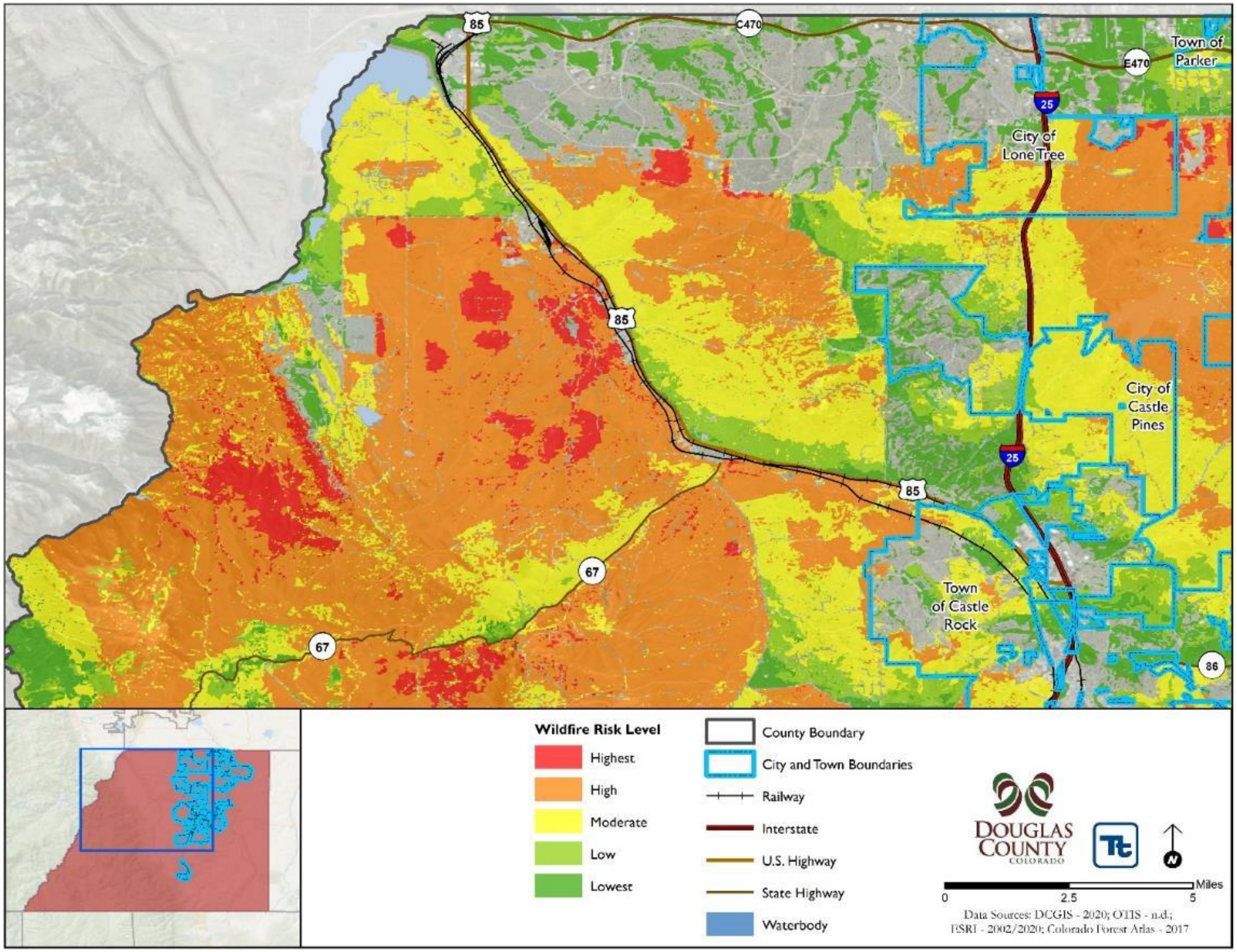


Figure 5-58 Wildfire Risk in Douglas County (Northeast)

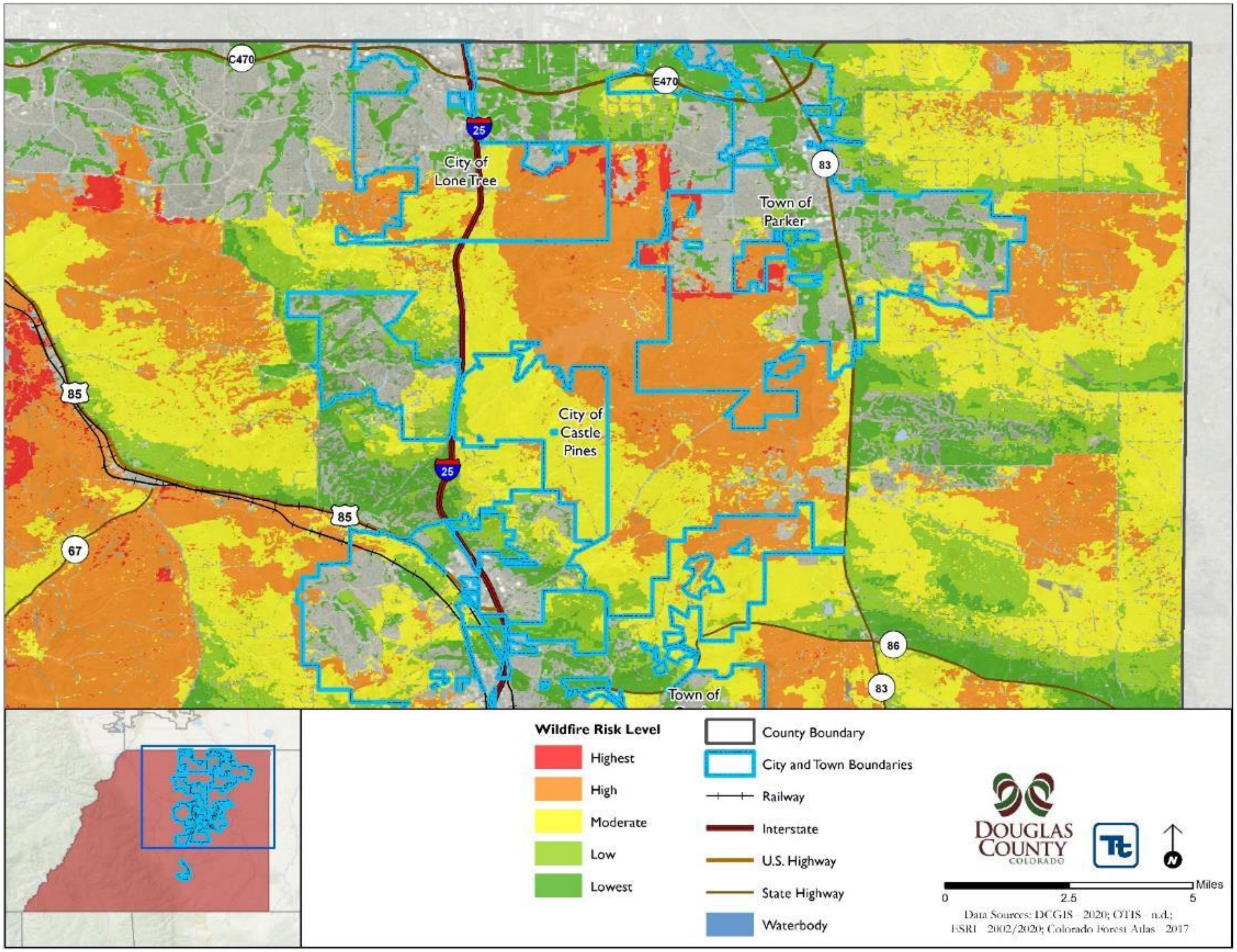


Figure 5-59 Wildfire Risk in Douglas County (Southwest)

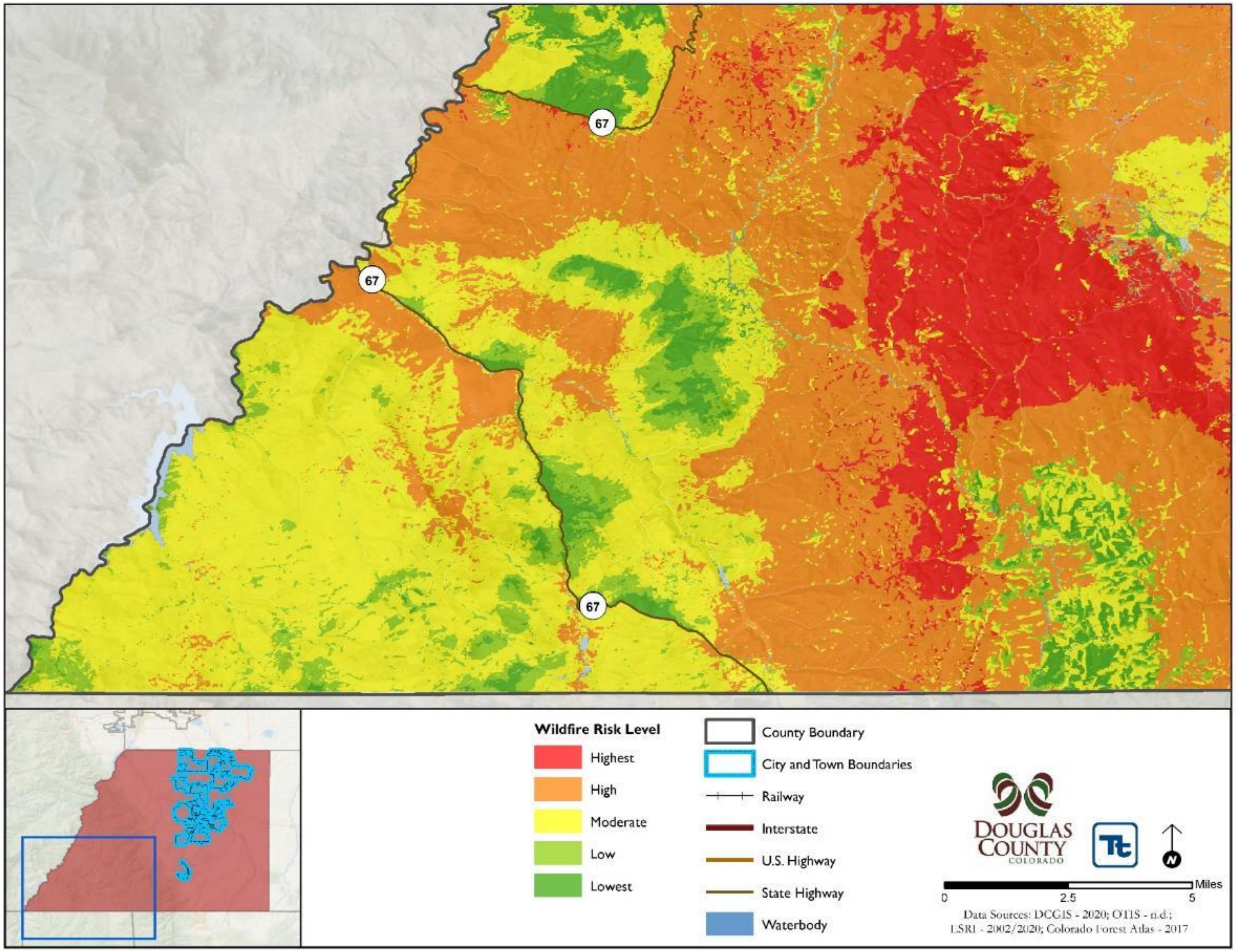
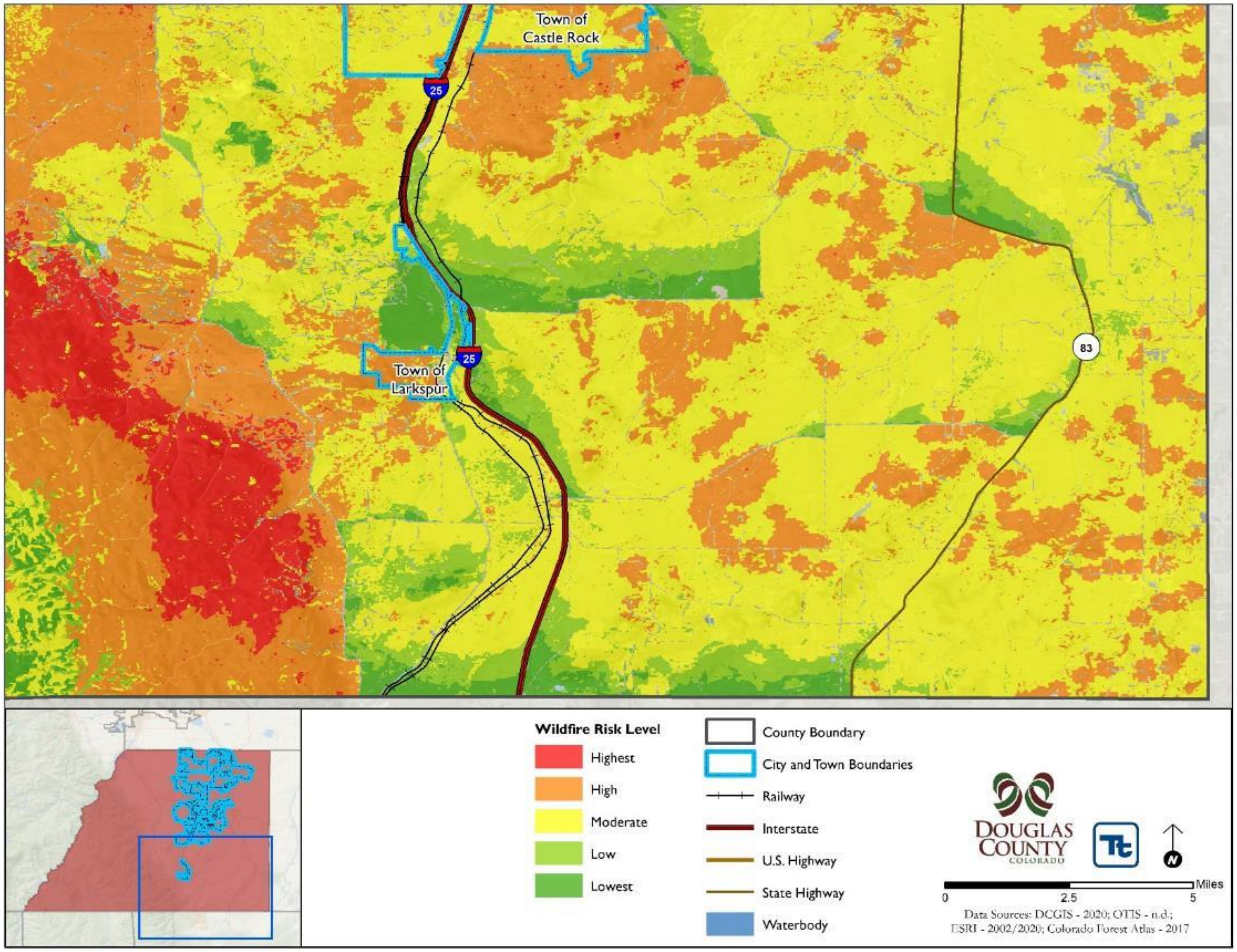


Figure 5-60 Wildfire Risk in Douglas County (Southeast)



Previous Occurrences and Losses

Between 1953 and January 2021, FEMA included the State of Colorado in 71 fire-related major disaster (DR), emergency (EM), or fire management assistance (FM) declarations. Generally, these disasters cover a wide region of the state; therefore, they may have impacted many counties. Douglas County was included in three fire-related FEMA declarations.

Table 5-123 Wildfire-Related FEMA Declarations for Douglas County, 1953 to 2020

FEMA Declaration Number	Date(s) of Event	Incident Type	Incident Title
DR-1421	June 19, 2002	Fire	Hayman Fire
FS-2407	May 23, 2002	Fire	Schoonover Fire
FM-2510	October 29, 2003	Fire	Cherokee Ranch Wildfire

Source: FEMA 2020, USDA 2020

According to the NOAA-NCEI Storm Events Database, there was one recorded wildfire impacting Douglas County from 1996 to 2020. According to the National Interagency Fire Center, there have been six reports of wildfires within Douglas County from 2003 to 2020 (NIFC 2020). Lastly, the USGS Federal Wildland Fire Occurrence Map Viewer was queried for any wildfires in Douglas County. From 1980 to 2020, the map showed a number of wildfire events in the County. Major wildfire events are discussed in the following table.

Table 5-124 Previous Wildfire Events in Douglas County, 2002 to 2020

Date(s) of Event	Incident Title	FEMA Declaration Number	County Designated?	Description
May 23, 2002	Schoonover Fire	FS-2407	Yes	Nearly 3,500 acres of Pike National Forest in southwestern Douglas County burned near Spring Gulch.
June 19, 2002	Hayman Fire	DR-1421	Yes	Until recently, the Hayman Fire was the most damaging in the State's history. Douglas County evacuated 19 neighborhood and saw $8 million in property damage.
October 29, 2003	Cherokee Ranch Wildfire	FM-2510	Yes	The Cherokee Ranch fire burned 1,042 acres near Daniels Park
March 24, 2011	Burning Tree Fire	N/A	N/A	Approximately 1,662 acres burned in Bayou Gulch. The area burned stretched from Bayou Gulch Regional Park to East Burning Tree Lane.
April 26, 2012	Illinois Gulch Fire (Incident 332)	N/A	N/A	Approximately 85 acres burned near Illinois Gulch near Turkey Track.
June 24, 2012	Trout Creek	N/A	N/A	A 40 acre fire burned near Trout Creek.
August 26, 2015	Greenland Open Space Fire	N/A	N/A	A small brush fire burned at the Greenland Rangeland near Larkspur.
February 6, 2017	South Lake Gulch Road Fire	N/A	N/A	An electrical transformer was suspected of generating a 70-acre brush fire in the vicinity of South Lake Gulch Road south of Castle Rock. No structures were damaged and the fire occurred on private property.
April 13, 2017	Turkey Track 7	N/A	N/A	A wildfire resulting from visitor activity burned 40 acres near a shooting range in Pike National Forest west of state Highway 67.

Source: Douglas County Sheriff; NIFC

Climate Change Projections

The size and number of western forest fires has increased significantly since 1985. Droughts and higher temperatures are anticipated to increase the extent, frequency, and severity of wildfires in Colorado. According to the Colorado State Forest Service, Colorado's climate has warmed by two degrees over the past 30 years. Further warming is expected by another 2.5 to 6.5 degrees by 2050 based on global climate models. Continued warming will reduce snowpack levels, resulting in lower runoff and water availability for ecosystems. The US Forest Service anticipates that more fire is expected in rangelands and western forests due to the prevalence of ecosystem types in which drought is correlated with burned area.

Probability of Future Occurrences

In Douglas County, wildfire events will continue to occur. The likelihood of one of those fires attaining significant size and intensity cannot be predicted and is highly dependent on environmental conditions and firefighting response. Climate change is also likely to increase the probability of future wildfires. Prolonged periods of drought caused by climate change can potentially increase the length of the wildfire season and provide a more favorable climate for ignition.

Colorado experiences nearly 2,500 wildfires annually, the vast majority of which are contained under 100 acres. Douglas County has seen six significant wildfires during the last decade and will continue to be at risk for future fires owing to its wildland-urban interface, vast forests in Pike National Forest, and climatic conditions (State of Colorado 2018).

In Section 5.3, the ranking of identified hazards of concern for Douglas County is provided. The probability of occurrence, or likelihood of the event, is one parameter used for ranking hazards. Based on historical records and input from the Planning Committee, the probability of occurrence for wildfire in the county is considered 'frequent' (hazard event is likely to occur within 25 years).

Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed and vulnerable in the identified hazard area. A spatial analysis was conducted using the 2017 wildfire risk spatial layer from the Colorado Forest Atlas. For the purposes of the assessment, an asset (population, structures, critical facilities, and lifelines) is considered exposed and potentially vulnerable to the wildfire hazard if it is located in the wildfire risk hazard area. The wildfire risk spatial layer calculates the probability of loss or harm from a wildfire by combining burn probability and fire effects. Areas affected are weighted by population, forest assets, riparian assets, and drinking water importance values (Colorado State Forest Service, 2018).

Impact on Life, Health and Safety

Potential losses from wildfire include human health and life of residents and responders, structures, infrastructure and natural resources. The most vulnerable populations include emergency responders and those within a short distance of the interface between the built environment and the wildland environment. Based on the spatial analysis, 116,499 individuals, or 35.5- percent of the County's population, are located in the wildfire risk area. Refer to Table 5-125 which summarizes the estimated population living in the hazard area.

Of the population exposed, the most vulnerable include the economically disadvantaged and the population over age 65. In Douglas County, there are 11,333 persons in poverty and 35,801 persons over 65 years old (American Community Survey 2018). Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on net economic impacts on their families. The population over age 65 is also more vulnerable because they are more likely to seek or need medical attention that may not be available due to isolation during a wildfire event, and they may have more difficulty evacuating. Smoke and air pollution from wildfires can be a severe health hazard, especially for sensitive populations, including children, the elderly, and those with respiratory and cardiovascular diseases. Smoke generated by wildfire consists of visible and invisible emissions that contain particulate matter (soot, tar, water vapor, and minerals), gases (carbon monoxide, carbon dioxide, nitrogen oxides), and toxics (formaldehyde, benzene). Emissions from wildfires depend on the type of fuel, the moisture content of the fuel, the efficiency (or temperature) of combustion, and the weather. Public health impacts associated with wildfire include difficulty in breathing, odor, and reduction in visibility.

Based on the analysis, an estimated 116,499 residents, or approximately 35.5-percent of the County's population, are located in the wildfire risk hazard area. The Town of Castle Rock has 34.9-percent or 20,800 individuals located in the wildfire risk area and Douglas County's unincorporated area has 42.2-percent or 80,737 individuals located in the wildfire risk area.

Table 5-125 Estimated Population Located in the Wildfire Risk Hazard Areas in Douglas County

Jurisdiction	American Community Survey (2014-2018) Population	Estimated Population Exposed to the Wildfire Risk Areas											
		Highest Wildfire Risk Area		High Wildfire Risk Area		Moderate Wildfire Risk Area		Low Wildfire Risk Area		Lowest Wildfire Risk Area		All Wildfire Risk Areas	
		Number of People	Percent of Total	Number of People	Percent of Total	Number of People	Percent of Total	Number of People	Percent of Total	Number of People	Percent of Total	Number of People	Percent of Total
Castle Pines (C)	10,573	0	0.0%	0	0.0%	586	5.5%	135	1.3%	920	8.7%	1,640	15.5%
Castle Rock (T)	59,680	8	<0.1%	6,507	10.9%	6,491	10.9%	2,482	4.2%	5,313	8.9%	20,800	34.9%
Larkspur (T)	257	0	0.0%	118	45.8%	48	18.8%	10	3.9%	7	2.7%	183	71.2%
Lone Tree (C)	14,209	0	0.0%	689	4.9%	159	1.1%	11	0.1%	1,123	7.9%	1,982	14.0%
Parker (T)	52,563	1,349	2.6%	2,423	4.6%	2,598	4.9%	1,221	2.3%	3,565	6.8%	11,156	21.2%
Unincorporated Douglas County	191,332	5,309	2.8%	29,193	15.3%	25,448	13.3%	6,833	3.6%	13,954	7.3%	80,737	42.2%
Douglas County (Total)	**328,614**	**6,665**	**2.0%**	**38,930**	**11.8%**	**35,331**	**10.8%**	**10,692**	**3.3%**	**24,881**	**7.6%**	**116,499**	**35.5%**

Source: American Community Survey 2018 (ACS 2014-2018); Colorado Forest Atlas, 2017
Notes: C=City; T = Town

Impact on General Building Stock

The most vulnerable structures to wildfire events are those within wildfire risk hazard area. Buildings constructed of wood or vinyl siding are generally more likely to be impacted by the fire hazard than buildings constructed of brick or concrete. To estimate the buildings exposed to the wildfire hazard, wildfire risk hazard areas were overlaid upon the updated building inventory at the structure level. The replacement cost value of the structures with their center in the wildfire risk hazard areas were totaled (refer to Table 5-126, Table 5-127, and Table 5-128 for the distribution of estimated exposure within the high, high, moderate, low, and lowest wildfire risk areas). Overall, 50,760 buildings with a replacement cost value of $55.8 billion are exposed to the wildfire risk hazard area in Douglas County.

Table 5-126 Building Stock Replacement Cost Value and Building Count within the Wildfire Risk Hazard Area in Douglas County (All Risk Areas)

			Estimated Building Stock Exposed to Wildfire Risk Areas Highest, High, Moderate, Low, Lowest Wildfire Risk Area			
Jurisdiction	Number of Buildings	Total Replacement Cost Value (RCV)	Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total
Castle Pines (C)	3,701	$4,995,772,208	593	16.0%	$936,182,189	18.7%
Castle Rock (T)	24,262	$28,003,310,038	8,318	34.3%	$10,019,034,981	35.8%
Larkspur (T)	394	$135,724,576	279	70.8%	$80,876,628	59.6%
Lone Tree (C)	4,190	$23,664,803,217	572	13.7%	$3,346,930,260	14.1%
Parker (T)	17,864	$23,597,914,712	3,838	21.5%	$5,783,119,895	24.5%
Unincorporated Douglas County	84,745	$102,018,837,713	37,160	43.8%	$35,588,600,017	34.9%
Douglas County (Total)	**135,156**	**$182,416,362,464**	**50,760**	**37.6%**	**$55,754,743,970**	**30.6%**

Source: Douglas County GIS 2020; Colorado Forest Atlas, 2017

Notes: C=City; T = Town

Table 5-127 Building Stock Replacement Cost Value and Building Count within the Wildfire Risk Hazard Area in Douglas County (Highest, High, and Moderate Risk Areas)

			Estimated Building Stock Exposed to Wildfire Risk Areas											
			Highest Wildfire Risk Area				High Wildfire Risk Area				Moderate Wildfire Risk Area			
Jurisdiction	Number of Buildings	Total Replacement Cost Value (RCV)	Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total	Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total	Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total
Castle Pines (C)	3,701	$4,995,772,208	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%	213	5.8%	$223,843,532	4.5%
Castle Rock (T)	24,262	$28,003,310,038	4	<0.1%	$3,109,077	<0.1%	2,533	10.4%	$2,397,992,336	8.6%	2,601	10.7%	$3,495,197,936	12.5%
Larkspur (T)	394	$135,724,576	0	0.0%	$0	0.0%	162	41.1%	$34,929,551	25.7%	79	20.1%	$25,085,506	18.5%
Lone Tree (C)	4,190	$23,664,803,217	1	<0.1%	$2,224,056	<0.1%	194	4.6%	$234,541,678	1.0%	47	1.1%	$403,511,476	1.7%
Parker (T)	17,864	$23,597,914,712	436	2.4%	$456,320,686	1.9%	800	4.5%	$854,095,276	3.6%	868	4.9%	$1,055,340,083	4.5%
Unincorporated Douglas County	84,745	$102,018,837,713	2,309	2.7%	$2,116,932,019	2.1%	13,520	16.0%	$11,273,604,704	11.1%	11,955	14.1%	$8,340,916,002	8.2%
Douglas County (Total)	**135,156**	**$182,416,362,464**	**2,750**	**2.0%**	**$2,578,585,838**	**1.4%**	**17,209**	**12.7%**	**$14,795,163,546**	**8.1%**	**15,763**	**11.7%**	**$13,543,894,534**	**7.4%**

Source: Douglas County GIS 2020; Colorado Forest Atlas, 2017

Notes: C=City; T = Town

Table 5-128 Building Stock Replacement Cost Value and Building Count within the Wildfire Risk Hazard Area in Douglas County (Low, Lowest, Risk Areas)

Jurisdiction	Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Exposed to Wildfire Risk Areas							
			Low Wildfire Risk Area				Lowest Wildfire Risk Area			
			Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total	Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total
Castle Pines (C)	3,701	$4,995,772,208	52	1.4%	$62,062,087	1.2%	328	8.9%	$650,276,570	13.0%
Castle Rock (T)	24,262	$28,003,310,038	991	4.1%	$1,173,882,972	4.2%	2,189	9.0%	$2,948,852,660	10.5%
Larkspur (T)	394	$135,724,576	26	6.6%	$13,759,356	10.1%	12	3.0%	$7,102,215	5.2%
Lone Tree (C)	4,190	$23,664,803,217	4	0.1%	$5,559,588	0.0%	326	7.8%	$2,701,093,463	11.4%
Parker (T)	17,864	$23,597,914,712	430	2.4%	$516,935,575	2.2%	1,304	7.3%	$2,900,428,275	12.3%
Unincorporated Douglas County	84,745	$102,018,837,713	3,134	3.7%	$2,398,656,212	2.4%	6,242	7.4%	$11,458,491,080	11.2%
Douglas County (Total)	**135,156**	**$182,416,362,464**	**4,637**	**3.4%**	**$4,170,855,789**	**2.3%**	**10,401**	**7.7%**	**$20,666,244,264**	**11.3%**

Source: Douglas County GIS 2020; Colorado Forest Atlas, 2017
Notes: C=City; T = Town

Impact on Critical Facilities

It is recognized that a number of critical facilities are located in the wildfire hazard area and are also vulnerable to the threat of wildfire. A majority of the critical facilities exposed to the wildfire risk hazard areas are potable water facilities, recreation sites, dams, and medical care facilities. Table 5-129 through Table 5-139 summarize the distribution of critical facilities exposed to the wildfire risk hazard area by critical facility type and jurisdiction. 129 critical facilities are exposed to the highest and high wildfire risk areas, the majority of which are potable wells, recreation sites, and bridges. Douglas County's unincorporated area has the greatest number of critical facilities built in the wildfire risk hazard areas (i.e., 426) of which 365 are lifelines. The exposed lifelines are categorized into FEMA lifeline groupings and are summarized in Table 5-141. Additionally, the number of critical facilities and lifelines within the wildfire hazard areas by jurisdiction are shown in Table 5-129 through Table 5-140.

Table 5-129 Critical Facilities and Lifelines in the Highest Wildfire Risk Hazard Areas in Douglas County

Jurisdiction	Critical Facilities Exposed to the Highest Wildfire Risk Area			
	Assisted Living	Hazardous Material Facility	Potable Well	Recreation Site
Castle Pines (C)	0	0	0	0
Castle Rock (T)	0	0	0	0
Larkspur (T)	0	0	0	0
Lone Tree (C)	0	0	0	0
Parker (T)	2	0	0	0
Unincorporated Douglas County	1	1	5	1
Douglas County (Total)	**3**	**1**	**5**	**1**

Source: Douglas County GIS 2020; Colorado Forest Atlas, 2017
Notes: C=City; T = Town

Table 5-130 Critical Facilities and Lifelines in the High Wildfire Risk Hazard Areas in Douglas County

Jurisdiction	Critical Facilities Exposed to High Wildfire Risk Area													
	Assisted Living	Bridge	Dam	Fire Station	Government Building	Major Business	Medical Care	Municipal Building	Potable Water Lift station	Potable Water Tank	Potable Water Treatment Facility	Potable Well	Primary Education	Recreation Site
Castle Pines (C)	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Castle Rock (T)	1	0	1	1	0	0	0	0	0	0	0	0	0	0
Larkspur (T)	0	0	0	0	0	1	0	0	0	3	1	0	0	0
Lone Tree (C)	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Parker (T)	0	0	0	1	0	0	1	1	0	0	0	0	1	0
Unincorporated Douglas County	1	11	8	4	1	0	2	0	1	2	1	59	2	13
Douglas County (Total)	**2**	**12**	**9**	**6**	**1**	**1**	**3**	**1**	**2**	**5**	**2**	**59**	**3**	**13**

Source: Douglas County GIS 2020; Colorado Forest Atlas, 2017
Notes: C=City; T = Town

Table 5-131 Critical Facilities and Lifelines in the Moderate Wildfire Risk Hazard Areas in Douglas County

Jurisdiction	Critical Facilities Exposed to Moderate Wildfire Risk Area													
	Assisted Living	Bridge	Dam	Fire Station	Light Rail Station	Medical Care	Polling Sites	Potable Water Lift station	Potable Water Tank	Potable Well	Primary Education	Recreation Site	Shelter	Wastewater Treatment Facility
Castle Pines (C)	0	0	0	0	0	0	1	1	0	0	0	1	0	0
Castle Rock (T)	1	0	0	1	0	1	0	0	0	0	4	0	1	0
Larkspur (T)	0	0	0	0	0	0	0	0	0	0	0	3	0	0
Lone Tree (C)	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Parker (T)	0	0	0	0	0	1	0	0	0	0	1	0	0	0
Unincorporated Douglas County	0	3	24	5	0	6	0	0	2	124	4	31	1	1
Douglas County (Total)	**1**	**3**	**24**	**6**	**2**	**8**	**1**	**1**	**2**	**124**	**9**	**35**	**2**	**1**

Source: Douglas County GIS 2020; Colorado Forest Atlas, 2017
Notes: C=City; T = Town

Table 5-132 Critical Facilities and Lifelines in the Low Wildfire Risk Hazard Areas in Douglas County

Jurisdiction	Critical Facilities Exposed to Low Wildfire Risk Area														
	Assisted Living	Bridge	Dam	Fire Station	Hazardous Material Facility	Hospital	Medical Care	Pharmacy	Police Station	Potable Water Treatment Facility	Potable Well	Primary Education	Recreation Site	Urgent Care	Wastewater Treatment Facility
Castle Pines (C)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Castle Rock (T)	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0
Larkspur (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lone Tree (C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parker (T)	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0
Unincorporated Douglas County	2	4	2	1	1	1	0	0	1	2	24	2	4	0	1
Douglas County (Total)	**3**	**4**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**25**	**3**	**5**	**1**	**1**

Source: Douglas County GIS 2020; Colorado Forest Atlas, 2017
Notes: C=City; T = Town

Table 5-133 Critical Facilities and Lifelines in the Lowest Wildfire Risk Hazard Areas in Douglas County

Jurisdiction	Critical Facilities Exposed to the Lowest Wildfire Risk Area																					
	Airport	Assisted Living	Bridge	Bus Facility	Childcare	Dam	Fire Station	Government Building	Hospital	Libraries	Light Rail Station	Medical Care	Pharmacy	Police Station	Polling Sites	Potable Water Lift station	Potable Well	Primary Education	Recreation Site	Secondary Education	Shelter	Wastewater Pump Station
Castle Pines (C)	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Castle Rock (T)	0	2	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
Larkspur (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lone Tree (C)	0	2	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Parker (T)	0	1	0	0	2	1	0	0	0	1	0	2	0	0	0	2	1	4	8	1	0	0
Unincorporated Douglas County	1	5	1	1	0	9	1	2	1	1	0	5	0	1	1	0	21	5	9	0	1	1
Douglas County (Total)	**1**	**12**	**1**	**1**	**3**	**11**	**1**	**2**	**1**	**3**	**1**	**7**	**1**	**1**	**1**	**2**	**22**	**10**	**20**	**1**	**1**	**1**

Source: Douglas County GIS 2020; Colorado Forest Atlas, 2017
Notes: C=City; T = Town

Table 5-134 Critical Facilities and Lifelines in the Wildfire Risk Hazard Areas in Douglas County (Highest, High, Moderate, Low, Lowest Areas)

Jurisdiction	**Critical Facilities Exposed to the Lowest Wildfire Risk Area**																												
	Airport	**Assisted Living**	**Bridge**	**Bus Facility**	**Childcare**	**Dam**	**Fire Station**	**Government Building**	**Hazardous Material Facility**	**Hospital**	**Libraries**	**Light Rail Station**	**Major Business**	**Medical Care**	**Municipal Building**	**Pharmacy**	**Police Station**	**Polling Sites**	**Potable Water Lift station**	**Potable Water Tank**	**Potable Water Treatment Facility**	**Potable Well**	**Primary Education**	**Recreation Site**	**Secondary Education**	**Shelter**	**Urgent Care**	**Wastewater Pump Station**	**Wastewater Treatment Facility**
Castle Pines (C)	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	5	0	0	0	0	0
Castle Rock (T)	0	5	0	0	0	2	2	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	6	0	0	1	0	0	0
Larkspur (T)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	1	0	0	3	0	0	0	0	0

Jurisdiction	Critical Facilities Exposed to the Lowest Wildfire Risk Area																												
	Airport	Assisted Living	Bridge	Bus Facility	Childcare	Dam	Fire Station	Government Building	Hazardous Material Facility	Hospital	Libraries	Light Rail Station	Major Business	Medical Care	Municipal Building	Pharmacy	Police Station	Polling Sites	Potable Water Lift station	Potable Water Tank	Potable Water Treatment Facility	Potable Well	Primary Education	Recreation Site	Secondary Education	Shelter	Urgent Care	Wastewater Pump Station	Wastewater Treatment Facility
Lone Tree (C)	0	2	1	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parker (T)	0	3	0	0	2	1	1	0	0	0	1	0	0	5	1	0	0	0	2	0	0	2	6	8	1	0	1	0	0
Unincorporated Douglas County	1	9	19	1	0	43	11	3	2	2	1	0	0	13	0	0	2	1	1	4	3	233	13	58	0	2	0	1	2
Douglas County (Total)	**1**	**21**	**20**	**1**	**3**	**46**	**14**	**3**	**2**	**2**	**3**	**3**	**1**	**19**	**1**	**2**	**2**	**2**	**5**	**7**	**4**	**235**	**25**	**74**	**1**	**3**	**1**	**1**	**2**

Source: Douglas County GIS 2020; Colorado Forest Atlas, 2017
Notes: C=City; T = Town

Table 5-135 Critical Facilities and Lifelines in the Highest Wildfire Risk Hazard Areas in Douglas County

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Exposed to Wildfire Risk Area - Highest			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Castle Pines (C)	20	12	0	0.0%	0	0.0%
Castle Rock (T)	108	100	0	0.0%	0	0.0%
Larkspur (T)	15	9	0	0.0%	0	0.0%
Lone Tree (C)	54	42	0	0.0%	0	0.0%
Parker (T)	140	105	2	1.4%	2	1.9%
Unincorporated Douglas County	827	703	8	1.0%	7	1.0%
Douglas County (Total)	**1,164**	**971**	**10**	**0.9%**	**9**	**0.9%**

Source: Douglas County GIS 2020; Colorado Forest Atlas, 2017
Notes: C=City; T = Town

Table 5-136 Critical Facilities and Lifelines in the High Wildfire Risk Hazard Areas in Douglas County

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Exposed to Wildfire Risk Area -High			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Castle Pines (C)	20	12	1	5.0%	1	8.3%
Castle Rock (T)	108	100	3	2.8%	3	3.0%
Larkspur (T)	15	9	5	33.3%	4	44.4%
Lone Tree (C)	54	42	1	1.9%	1	2.4%
Parker (T)	140	105	4	2.9%	4	3.8%
Unincorporated Douglas County	827	703	105	12.7%	92	13.1%
Douglas County (Total)	**1,164**	**971**	**119**	**10.2%**	**105**	**10.8%**

Source: Douglas County GIS 2020; Colorado Forest Atlas, 2017
Notes: C=City; T = Town

Table 5-137 Critical Facilities and Lifelines in the Moderate Wildfire Risk Hazard Areas in Douglas County

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Exposed to Wildfire Risk Area -Moderate			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Castle Pines (C)	20	12	3	15.0%	1	8.3%
Castle Rock (T)	108	100	8	7.4%	8	8.0%
Larkspur (T)	15	9	3	20.0%	0	0.0%
Lone Tree (C)	54	42	2	3.7%	2	4.8%
Parker (T)	140	105	2	1.4%	2	1.9%
Unincorporated Douglas County	827	703	201	24.3%	170	24.2%
Douglas County (Total)	**1,164**	**971**	**219**	**18.8%**	**183**	**18.8%**

Source: Douglas County GIS 2020; Colorado Forest Atlas, 2017
Notes: C=City; T = Town

Table 5-138 Critical Facilities and Lifelines in the Low Wildfire Risk Hazard Areas in Douglas County

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Exposed to Wildfire Risk Area -Low			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Castle Pines (C)	20	12	1	5.0%	0	0.0%
Castle Rock (T)	108	100	3	2.8%	3	3.0%
Larkspur (T)	15	9	0	0.0%	0	0.0%
Lone Tree (C)	54	42	0	0.0%	0	0.0%
Parker (T)	140	105	3	2.1%	3	2.9%
Unincorporated Douglas County	827	703	45	5.4%	41	5.8%
Douglas County (Total)	**1,164**	**971**	**52**	**4.5%**	**47**	**4.8%**

Source: Douglas County GIS 2020; Colorado Forest Atlas, 2017
Notes: C=City; T = Town

Table 5-139 Critical Facilities and Lifelines in the Lowest Wildfire Risk Hazard Areas in Douglas County

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Exposed to Wildfire Risk Area -Lowest			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Castle Pines (C)	20	12	6	30.0%	2	16.7%
Castle Rock (T)	108	100	5	4.6%	5	5.0%
Larkspur (T)	15	9	0	0.0%	0	0.0%
Lone Tree (C)	54	42	4	7.4%	3	7.1%
Parker (T)	140	105	23	16.4%	12	11.4%
Unincorporated Douglas County	827	703	66	8.0%	55	7.8%
Douglas County (Total)	**1,164**	**971**	**104**	**8.9%**	**77**	**7.9%**

Source: Douglas County GIS 2020; Colorado Forest Atlas, 2017
Notes: C=City; T = Town

Table 5-140 Critical Facilities and Lifelines in the Wildfire Risk Hazard Areas in Douglas County (High, Highest, Moderate, Low, Lowest Areas)

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Exposed to Wildfire Risk Area			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Castle Pines (C)	20	12	11	55.0%	4	33.3%
Castle Rock (T)	108	100	19	17.6%	19	19.0%
Larkspur (T)	15	9	8	53.3%	4	44.4%
Lone Tree (C)	54	42	7	13.0%	6	14.3%
Parker (T)	140	105	34	24.3%	23	21.9%
Unincorporated Douglas County	827	703	425	51.4%	365	51.9%
Douglas County (Total)	**1,164**	**971**	**504**	**43.3%**	**421**	**43.4%**

Source: Douglas County GIS 2020; Colorado Forest Atlas, 2017
Notes: C=City; T = Town

Table 5-141 Lifelines Exposed to the Wildfire Risk Hazard Areas

FEMA Lifeline Category	Total Number of Lifelines	Estimated Lifeline Exposed to Wildfire Risk Areas: Highest Wildfire Risk Area Number of Lifelines	High Wildfire Risk Area Number of Lifelines	Moderate Wildfire Risk Area Number of Lifelines	Low Wildfire Risk Area Number of Lifelines	Lowest Wildfire Risk Area Number of Lifelines	All Wildfire Risk Areas Number of Lifelines
Food, Water, Shelter	428	5	68	130	28	26	257
Hazardous Material	22	1	0	0	1	0	2
Health and Medical	203	3	5	9	7	21	45
Safety and Security	239	0	20	39	7	26	92
Transportation	79	0	12	5	4	4	25
Douglas County (Total)	**971**	**9**	**105**	**183**	**47**	**77**	**421**

Source: Douglas County GIS 2020; Colorado Forest Atlas, 2017
Notes: C=City; T = Town

Impact on Economy

Wildfire events can have major economic impacts on a community from the initial loss of structures and the subsequent loss of revenue from destroyed business and decrease in tourism. Wildfires can cost thousands of taxpayer dollars to suppress and control and can involve hundreds of operating hours on fire apparatus and thousands of volunteer man hours from the volunteer firefighters. There are also many direct and indirect costs to local businesses that excuse volunteers from working to fight these fires.

Impact on the Environment

According to the USGS, post-fire runoff polluted with debris and contaminates can be extremely harmful to ecosystem and aquatic life (USFS 2020). Studies show that urban fires in particular are more harmful to the environment compared to forest fires (USFS 2020). The age and density of infrastructure within Douglas County can exacerbate consequences of fires on the environment because of the increased amount of chemicals and contaminates that would be released from burning infrastructure. These chemicals, such as iron lead, and zinc, may leach into the storm water, contaminate nearby streams, and impair aquatic life.

Cascading Impacts on Other Hazards

Wildfires result in the uncontrolled destruction of forests, brush, field crops, grasslands, real estate, and personal property, and have secondary impacts on other hazards such as flooding, by removing vegetation and destroying watersheds. Flash flooding is particularly common after wildfires and can occur quickly and within areas that are not usually prone to flood risk. People are at a greater risk of flooding due to recent wildfire burn areas and could remain at risk for up to 5 years after a fire (Colorado Division of Homeland Security and Emergency Management, 2020). Intense floods cause increased problems in erosion and sediment transportation, thus increasing risk and economic impacts to buildings, infrastructure and people after a wildfire events. Some of the largest debris-flow events happen during the first post-fire storm season. It takes less rainfall to trigger debris in areas that were burned than in areas that were not affected by fires (USGS, 2020). Fires reduce the rate in which water can permeate the soil triggering debris flow occurrence can by surface erosion and land sliding caused by steep slopes (USGS, 2020). To learn more about flooding and geological hazards refer to section 5.4.6 and 5.4.13 through 5.4.16.

Future Changes that May Impact Vulnerability

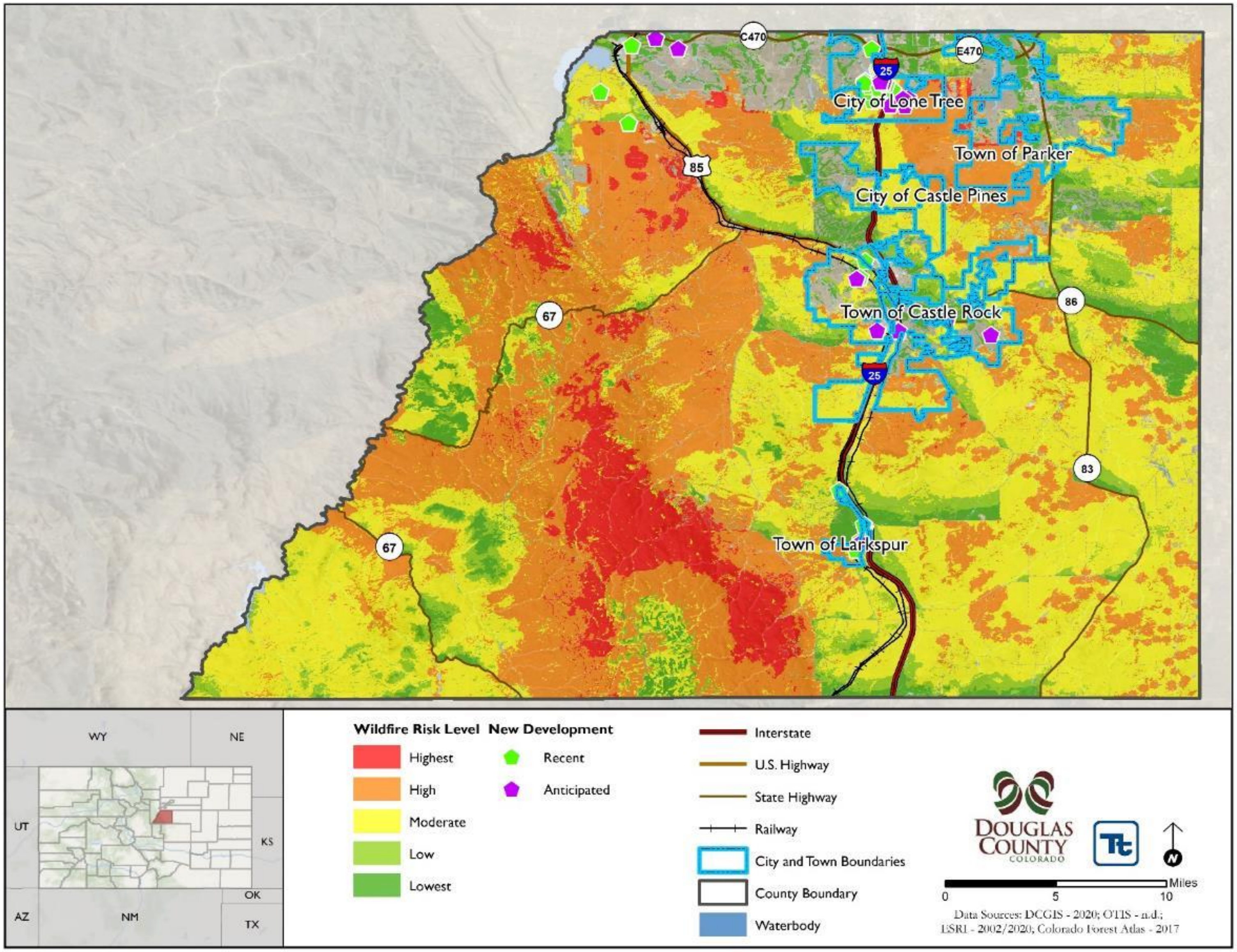
Understanding future changes that impact vulnerability in the County can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development

As discussed in Section 4, areas targeted for future growth and development have been identified across the County. Any areas of growth located in the wildfire risk hazard areas could be at risk. Refer to the maps in each jurisdictional annex (Section 9 of this HMP) to view the new development project areas and their proximity to the wildfire risk hazard areas. There are 33 new development sites located within the wildfire risk hazard area; 9 within the high-risk area, 8 within the moderate risk area and 16 within the low risk area. Refer to Figure 5-61 for potential new development in the County and their proximity to the wildfire risk area.

Figure 5-61 Potential New Development in the Wildfire Risk Area



Projected Changes in Population

The County experienced an increase in population between the 2010 Census (320,500) and the estimated 2018 Community Survey estimated population of 328,614. The population of the County is expected to increase over the next few years. The increase in population will expose more people to the wildfire hazard as residents move into the wildfire risk areas.

Climate Change

Climate change has the potential to affect multiple elements of the wildfire system: fire behavior, ignitions, fire management, and vegetation fuels. Hot dry spells create the highest fire risk. Increased temperatures may intensify wildfire danger by warming and drying out vegetation. Changes in climate patterns may impact the distribution and perseverance of insect outbreaks that create dead trees (increase fuel). Fire interacts with climate and vegetation (fuel) in predictable ways. Understanding the climate/fire/vegetation interactions is essential for addressing issues associated with climate change that include:

- Effects on regional circulation and other atmospheric patterns that affect fire weather
- Effects of changing fire regimes on the carbon cycle, forest structure, and species composition, and
- Complications from land use change, invasive species and an increasing wildland-urban interface (USFS 2020).

It is projected that higher summer temperatures will likely increase the high fire risk by 10- to 30-percent. Fire occurrence and/or area burned could increase across the U.S. due to the increase of lightning activity, the frequency of surface pressure and associated circulation patterns conductive to surface drying, and fire-weather conditions, in general, which is conductive to severe wildfires. Warmer temperatures will also increase the effects of drought and increase the number of days each year with flammable fuels and extending fire seasons and areas burned (USFS 2020).

Future changes in fire frequency and severity are difficult to predict. Global and regional climate changes associated with elevated greenhouse gas concentrations could alter large weather patterns, thereby affecting fire-weather conducive to extreme fire behavior (USFS 2020).

Change of Vulnerability Since the 2015 HMP

For this hazard mitigation plan update, the wildfire risk hazard spatial layer from the Colorado Forest Atlas was referenced to determine areas within Douglas County that are vulnerable to wildfires. Population statistics have also been updated using the 5-Year 2014-2018 American Community Survey Population Estimates. A customized general building stock was created using RS Means 2020 replacement cost values, building footprints and tax assessor and parcel information provided by the County. Additionally, the critical facility inventory was reviewed by Douglas County.

Overall, this vulnerability assessment uses a more accurate and updated building inventory which provides more accurate estimated exposure and potential losses for Douglas County.

Identified Issues

- A significant portion of Douglas County's western section is within Pike National Forest. Pike National Forest has been significantly impacted by Douglas-fir beetle, resulting in a large number of standing dead trees.

- Development in the wildfire risk areas should be managed or measures taken to implement preventative measures to mitigate impacts on these assets.
- Climate change could affect the wildfire hazard as increased frequency of drought events could affect water supply and prolonged heat waves could support increased risk of wildfire events.
- Local fire departments should continue to train on wildland-urban interface events and wildfire risk areas.
- Public education and outreach to people living in or near the fire hazard zones should include information about and assistance with mitigation activities such as defensible space, and advance identification of evacuation routes and safe zones.
- Residents and visitors must know the current fire restrictions and bans posted on the county's website and communicated through partner websites and social media notifications.
- Wildfires could cause landslides as a secondary natural hazard because vegetation is removed.
- Climate change could affect the wildfire hazard.
- Area fire districts need to continue to train on WUI fire events.
- Vegetation management activities should continue and be evaluated for additional needs.
- Both the natural and human-caused conditions that contribute to the wildland fire hazard are tending to exacerbate through time.
- Conservative forestry management practices have resulted in congested forests prone to fire and disease.
- The continued migration of residents to remote areas of the county increases the probability of human-caused ignitions from vehicles, grills, campfires, and electrical devices.

SECTION 6 MITIGATION STRATEGY

This section presents mitigation strategies for Douglas County to reduce potential exposure and losses identified as concerns in the Risk Assessment portion of this plan. The Local Planning Committee reviewed the Risk Assessment to identify and develop these mitigation actions, which are presented herein.

6.1 Background and Past Mitigation Accomplishments

***Hazard mitigation* -** reduces the potential impacts of, and costs associated with, emergency and disaster-related events. Mitigation actions address a range of impacts, including impacts on the population, property, the economy, and the environment.

***Mitigation actions* -** can include activities such as revisions to land-use planning, training and education, and structural and nonstructural safety measures.

In accordance with the requirements of the Disaster Mitigation Act of 2000, detailed on Page 1-1 in Section 1 (Introduction), a discussion regarding past mitigation activities and an overview of past efforts is provided as a foundation for understanding the mitigation goals, objectives, and activities outlined in this plan update. Douglas County, through previous and ongoing hazard mitigation activities, has demonstrated that it is proactive in protecting its physical assets and citizens against losses from natural hazards. Examples of previous and ongoing actions and projects include the following:

- The County facilitated the development of the 2021 Douglas County Local Natural Hazard Mitigation Plan. The current planning process represents the regulatory five-year update process, which includes participation of the County, five municipalities, three special purpose districts, and key county and regional stakeholders.
- Reports, plans, and studies relating to or including information on natural hazards or natural hazard policies affecting Douglas County have been reviewed and incorporated into this plan update as appropriate, as discussed in Section 3 (Planning Process and References).

6.2 General Mitigation Planning Approach

The overall approach used to update the County and local hazard mitigation strategies are based on FEMA and Colorado regulations and guidance regarding local mitigation plan development, including the following:

- DMA 2000 regulations, specifically 44 CFR 201.6 (local mitigation planning).
- FEMA *Local Mitigation Planning Handbook*, March 2013.
- FEMA *Local Mitigation Plan Review Guide*, October 1, 2011.
- FEMA *Integrating Hazard Mitigation into Local Planning*, March 1, 2013.
- FEMA *Plan Integration: Linking Local Planning Efforts*, July 2015.
- FEMA *Mitigation Planning How-To Guide #3, Identifying Mitigation Actions and Implementing Strategies* (FEMA 386-3), April 2003.
- FEMA *Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards*, January 2013.

The mitigation strategy update approach includes the following steps that are further detailed in later subsections:

- Section 6.3 – Identification of Strengths, Weaknesses, Obstacles and Opportunities
- Section 6.4 - Review and update mitigation goals and objectives.
- Section 6.5 (Jurisdiction Specific Annex Section 9) - Identify mitigation capabilities and evaluate their capacity and effectiveness to mitigate and manage hazard risk.
- Section 6.6 (Jurisdiction Specific Annex Section 9) - Prepare an implementation strategy, including:
    - Identify progress on previous County and jurisdictional mitigation strategies.
    - Develop updated County and jurisdictional mitigation strategies.
    - Prioritize projects and initiatives in the updated mitigation strategy.

6.3 Strengths, Weaknesses, Obstacles, and Opportunities exercise

The Local Planning Committee participated in an online Strengths Weaknesses Obstacles and Opportunities (SWOO) survey in September 2020, focusing on the 11 hazards being included in the 2021 update. The survey focused on the hazards of concern and what the County's strengths, weaknesses, obstacles, and opportunities are for each hazard. The results were compiled and presented to the planning partnership at the risk assessment presentation. The results were also used by the participants to help identify capabilities and potential mitigation actions. The following provides a summary of strengths, weaknesses, obstacles, and opportunities identified by the Local Planning Committee:

- Strengths – coordination between various agencies (county and local), planning, flood warning systems, codes and standards, emergency response capabilities, and public outreach.
- Weaknesses – existing structures located in hazard areas, ability to incentivize homeowners to mitigate their properties, lack of warning systems for all hazards, limited resources for large-scale events, and potential dam failures and other potential impacts from catastrophic events.
- Obstacles – availability of shelters, climate change, mitigating private properties, community complacency, continuity of operations, data collection, funding, resources, and education and outreach.
- Opportunities – outreach and education, planning, grant funding, training, reviewing codes and ordinances, data collection, local awareness training and programs, and enhance notification systems.

6.4 Review and Update of Mitigation Goals and Objectives

This section documents the County's efforts to develop hazard mitigation goals and objectives that are established to reduce or avoid long-term vulnerabilities to the identified hazards.

6.4.1 Guiding Principle

Per FEMA guidance (386-1), a mission statement or guiding principle describes the overall duty and purpose of the planning process and serves to identify the principle message of the plan. It focuses or constrains the range of goals and objectives identified. This is not a goal because it does not describe outcomes, rather it is broad in scope, and provides a direction for the HMP update.

As part the of the 2021 HMP update process, the Douglas County Local Planning Committee reviewed and updated the 2015 HMP guiding statement as noted below:

"The purpose of this plan update is to guide hazard mitigation planning, implement projects, and prioritize resources to better protect the people and property of the County from the effects of hazards. This plan demonstrates the community's commitment to reducing risks from hazards and serves as a tool to help decision makers direct mitigation activities and resources. This plan was also developed to ensure Douglas County and participating jurisdictions' continued eligibility for federal, state, and local disaster assistance including but not limited to the FEMA HMGP, BRIC, and FMA; and HUD CDBG-MIT. Completion also earns credits for the National Flood Insurance Program's CRS which provides for lower flood insurance premiums in CRS communities."

6.4.2 Goals and Objectives

According to CFR 201.6(c)(3)(i): "The hazard mitigation strategy shall include a description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards." The mitigation goals were developed based on the risk assessment results, discussions, research, and input from the committee, existing authorities, polices, programs, resources, stakeholders, and the public.

For the purposes of this plan, goals and objectives are defined as follows:

Goals are general guidelines that explain what is to be achieved. They are broad, long-term, policy-type statements that represent global visions. Goals help define the benefits that the plan is trying to achieve. The success of the plan, once implemented, should be measured by the degree to which its goals have been met (that is, by the actual benefits in terms of hazard mitigation).

Objectives are short-term aims, which when combined form a strategy or course of action to meet a goal. Unlike goals, objectives are specific and measurable.

FEMA defines ***Goals*** as general guidelines that explain what should be achieved. Goals are usually broad, long-term, policy statements, and represent a global vision.

FEMA defines ***Objectives*** as strategies or implementation steps to attain mitigation goals. Unlike goals, objectives are specific and measurable, where feasible.

FEMA defines ***Mitigation Actions*** as specific actions that help to achieve the mitigation goals and objectives.

During the 2021 plan update process, the Local Planning Committee reviewed the goals and objectives established in the 2015 HMP in consideration of the hazard events and losses since the 2015 plan, the updated hazard profiles and vulnerability assessment, the goals and objectives established in the State of Colorado 2018 Hazard Mitigation Plan, and county and local plans. The update incorporates direct input for how the County and municipalities need to move forward to best manage their hazard risk. Amendments include additions and edits to goals and objectives to express the planning partnership's interests in integrating this plan with other planning mechanisms/programs and to support mitigation through the protection and preservation of natural systems, including particular reference to certain goals and objectives in the State of Colorado 2018 Hazard Mitigation Plan update, as identified below.

As a result of this review process, the goals and objectives for the 2021 update were amended as presented in below. Objectives identified meet multiple goals, as demonstrated in Table 6-1.

Goals

- Goal 1 – Warning - Enhance predictive measure including the expansion and protection of warning systems and supporting technologies.

- Goal 2 – Data Collection - Enhance the quality of assessments, analysis and planning through the development and collection of data.
- Goal 3 – Outreach and Education - Increase public awareness of hazards and their mitigation.
- Goal 4 - Mitigate Structures and Protect Lives - Reduce impacts, costs, and damages from hazard events to people, property, local government and private assets, economy, and natural and cultural resources.
- Goal 5 - Planning - Coordinate and integrate hazard mitigation activities with local land development planning activities and emergency operations planning to consider resiliency.
- Goal 6 - Codes & Standards - Review, update, adopt and enforce local, state and federal plans, codes and regulations to reduce the impacts of natural hazards.
- Goal 7 - Entity Coordination - Strengthen communication and coordination among public entities, non-governmental organizations (NGOs), businesses and private citizens.
- Goal 8 - Continuity of Operations - Support continuity of operations pre-, during, and post- hazard events including the support of community lifelines.

Objectives

- Objective 1 - Improve systems that provide warning and emergency communications.
- Objective 2 - Increase public awareness of risk.
- Objective 3 - Research, develop, and promote adoption of cost-effective building and development laws, regulations, and ordinances.
- Objective 4 - Improve hazard information databases and maps and increase accessibility to those resources.
- Objective 5 - Develop and provide updated information about threats, hazards, vulnerabilities, and mitigation strategies to state, regional, and local agencies, as well as private sector groups.
- Objective 6 - Manage development in geologically hazardous areas and floodplains to protect life and property.
- Objective 7 - Incorporate risk reduction considerations in new and updated infrastructure and development plans to reduce the impacts of natural hazards.
- Objective 8 - Establish and maintain partnerships among all levels of government, private sector, community groups, and institutions of higher learning that improve and implement methods to protect life and property.
- Objective 9 - Improve understanding of the locations, potential impacts, and linkages among threats, hazards, vulnerability, and measures needed to protect life safety and health.
- Objective 10 - Consider risk reduction in long-term planning.
- Objective 11 - Minimize impacts of hazard events to key employers.
- Objective 12 - Identify projects that simultaneously reduce risk while increasing operational area resilience and sustainability.
- Objective 13 - Establish a partnership among all levels of government and the business community to improve and implement methods to protect property.
- Objective 14 - Reduce risks that may impact critical business operations.
- Objective 15 - Promote and enhance outreach and education efforts by state, regional and local agencies with hazard mitigation plans and programs to actively encourage engagement of stakeholder groups such as homeowners, private sector businesses, and nonprofit community organizations.

- Objective 16 - Inform the public on the risk exposure to natural hazards and ways to increase the public's capability to prepare, respond, recover and mitigate the impacts of these events.
- Objective 17 - Modify structures, as necessary, to meet life safety standards.
- Objective 18 - Encourage the incorporation of mitigation measures into repairs, major alterations, new development, and redevelopment practices, especially in areas subject to substantial hazard risk.
- Objective 19 - Retrofit, purchase, or relocate structures in high hazard areas, especially those known to be repetitively damaged.
- Objective 20 - Encourage hazard mitigation measures that promote and enhance natural processes and minimize adverse impacts on the ecosystem.
- Objective 21 - Promote enforcement of relevant state regulations and local ordinances that significantly reduce life loss and injuries.
- Objective 22 - Strengthen local building code enforcement.
- Objective 23 - Ensure continuity of operations of essential county government services.
- Objective 24 - Protect rare, endangered, unusual, or educationally important natural resources. Objective 25 - Provide incentives for development and land use techniques that reduce risks.

Table 6-1 Douglas County Hazard Mitigation Plan Goals and Objectives

Objective #	Objective Statement	Goal 1 – Warning	Goal 2 – Data Collection	Goal 3 – Outreach and Education	Goal 4 - Mitigate Structures and Protect Lives	Goal 5 – Planning	Goal 6 – Codes and Standards	Goal 7 – Entity Coordination	Goal 8 - Continuity of Operations
1	Improve systems that provide warning and emergency communications.	X							
2	Increase public awareness of risk.	X	X	X				X	
3	Research, develop, and promote adoption of cost-effective building and development laws, regulations, and ordinances.		X		X		X		
4	Improve hazard information databases and maps and increase accessibility to those resources.	X	X	X				X	X
5	Develop and provide updated information about threats, hazards, vulnerabilities, and mitigation strategies to state, regional, and local agencies, as well as private sector groups.	X	X	X	X	X		X	X
6	Manage development in geologically hazardous areas and floodplains to protect life and property.						X	X	
7	Incorporate risk reduction considerations in new and updated infrastructure and development plans to reduce the impacts of natural hazards.		X		X	X	X	X	
8	Establish and maintain partnerships among all levels of government, private sector, community groups, and institutions of higher learning that improve and implement methods to protect life and property.	X	X	X	X	X		X	X
9	Improve understanding of the locations, potential impacts, and linkages among threats, hazards, vulnerability, and measures needed to protect life safety and health.		X	X	X	X		X	
10	Consider risk reduction in long-term planning.		X		X		X	X	
11	Minimize impacts of hazard events to key employers.	X	X	X	X	X		X	X
12	Identify projects that simultaneously reduce risk while increasing operational area resilience and sustainability.	X	X	X	X	X	X	X	X
13	Establish a partnership among all levels of government and the business community to improve and implement methods to protect property.		X	X	X	X		X	X
14	Reduce risks that may impact critical business operations.	X	X	X	X	X		X	X
15	Promote and enhance outreach and education efforts by state, regional and local agencies with hazard mitigation plans and programs to actively encourage engagement of stakeholder groups such as homeowners, private sector businesses, and nonprofit community organizations.		X	X	X	X		X	X
16	Inform the public on the risk exposure to natural hazards and ways to increase the public's capability to prepare, respond, recover and mitigate the impacts of these events.	X	X	X	X	X	X	X	X
17	Modify structures, as necessary, to meet life safety standards.			X	X		X	X	X

Objective #	Objective Statement	Goal 1 – Warning	Goal 2 – Data Collection	Goal 3 – Outreach and Education	Goal 4 - Mitigate Structures and Protect Lives	Goal 5 – Planning	Goal 6 – Codes and Standards	Goal 7 – Entity Coordination	Goal 8 - Continuity of Operations
18	Encourage the incorporation of mitigation measures into repairs, major alterations, new development, and redevelopment practices, especially in areas subject to substantial hazard risk.		X	X	X	X	X	X	
19	Retrofit, purchase, or relocate structures in high hazard areas, especially those known to be repetitively damaged.		X	X	X	X	X	X	
20	Encourage hazard mitigation measures that promote and enhance natural processes and minimize adverse impacts on the ecosystem.		X	X	X	X	X	X	
21	Promote enforcement of relevant state regulations and local ordinances that significantly reduce life loss and injuries.		X	X	X	X	X	X	
22	Strengthen local building code enforcement.		X	X	X		X	X	
23	Ensure continuity of operations of essential county government services.		X	X	X	X		X	X
24	Protect rare, endangered, unusual, or educationally important natural resources.		X	X		X	X	X	
25	Provide incentives for development and land use techniques that reduce risks.		X	X	X	X	X	X	

6.5 CAPABILITY ASSESSMENT

As part of the HMP update process, the planning team performed an inventory and analysis of existing authorities and capabilities called a "capability assessment." A capability assessment creates an inventory of a jurisdictions' mission, programs and policies, and evaluates its capacity to carry them out. Each participating jurisdictional annex (Section 9) reflects the jurisdictional analysis of their respective (1) administrative and technical capabilities, (2) administrative fiscal capabilities, and (3) legal/regulatory capabilities. Specifically each annex displays the following:

- The Jurisdiction's Capability Assessment — reviewed to identify capabilities that the jurisdiction does not currently have but should consider pursuing or capabilities that should be revisited and updated to include best available information; also reviewed to determine how existing capabilities can be leveraged to increase or improve hazard mitigation in the jurisdiction.
- The Jurisdiction's National Flood Insurance Program Compliance Table — reviewed to identify opportunities to increase floodplain management capabilities.
- The Jurisdiction's Identified Opportunities for Future Integration — reviewed to identify specific integration actions to be included in the mitigation strategy.
- Jurisdiction-Specific Vulnerabilities — reviewed to identify actions that will help reduce known vulnerabilities.
- The Mitigation Best Practices Catalog — reviewed to identify actions that the jurisdiction should consider including in its action plan.
- Public Input — reviewed to identify potential actions and community priorities.

6.5.1 Mitigation Best Practices

Catalogs of hazard mitigation best management practices based on practical examples from across the country were provided and discussed to present a broad range of alternatives to be considered for use in the planning area, in compliance with 44 CFR (Section 201.6(c)(3)(ii)). One catalog was developed for each hazard of concern evaluated in this HMP update, which is relevant to most of the hazards of concern in this HMP update. The catalogs for each hazard are listed in Table 6-2 through Table 6-9.

These catalogs were provided to the planning partnership as a resource to support the identification and development of mitigation actions for this plan. Hazard mitigation initiatives recommended in this HMP were selected from among the alternatives presented in the catalogs. The catalogs provide a baseline of mitigation alternatives that are backed by a planning process, are consistent with the established goals and objectives, and are within the capabilities of the jurisdictions to implement.

Table 6-2. Catalog of Potential Mitigation Actions for the Dam Failure Hazard

Government-Scale
Manipulate the hazard: ❖ Remove dams ❖ Harden dams **Reduce exposure to the hazard:** ❖ Replace earthen dams with hardened structures ❖ Relocate critical facilities out of dam inundation areas ❖ Consider open space land use in designated dam inundation areas **Reduce vulnerability to the hazard:** ❖ Adopt higher floodplain standards in mapped dam inundation areas

Government-Scale
❖ Retrofit critical facilities within dam inundation areas
Build local capacity to respond to or prepare for the hazard:
❖ Map dam failure inundation areas
❖ Enhance emergency operations plan to include a dam failure component
❖ Institute monthly communications checks with dam operators
❖ Inform the public on risk reduction techniques
❖ Adopt real-estate disclosure requirements for the re-sale of property located within dam failure inundation areas
❖ Consider the probable impacts of climate change in assessing the risk associated with the dam failure hazard
❖ Establish early warning capability downstream of listed high hazard dams
❖ Consider the residual risk associated with protection provided by dams in future land use decisions

Table 6-3. Catalog of Potential Mitigation Actions for the Drought Hazard*

Government-Scale
Manipulate the hazard:
❖ Groundwater recharge through stormwater management
❖ Develop a water recycling program
❖ Increase “above-the-dam” regional natural water storage systems
Reduce exposure to the hazard:
❖ Identify and create groundwater backup sources
Reduce vulnerability to the hazard:
❖ Water use conflict regulations
❖ Reduce water system losses
❖ Distribute water saving kits
❖ Increase conventional storage that is filled during high-flow periods
Build local capacity to respond to or prepare for the hazard:
❖ Public education on drought resistance
❖ Identify alternative water supplies for times of drought; mutual aid agreements with alternative suppliers
❖ Develop drought contingency plan
❖ Develop criteria “triggers” for drought-related actions
❖ Improve accuracy of water supply forecasts
❖ Modify rate structure to influence active water conservation techniques
❖ Consider the probable impacts of climate change on the risk associated with the drought hazard

**Addressed with the Severe Weather Hazard*

Table 6-4. Catalog of Potential Mitigation Actions for the Earthquake Hazard

Government-Scale
Manipulate the hazard:
❖ None
Reduce exposure to the hazard:
❖ Locate critical facilities or functions outside hazard area where possible
Reduce vulnerability to the hazard:
❖ Harden infrastructure
❖ Provide redundancy for critical functions

Government-Scale
❖ Adopt higher regulatory standards **Build local capacity to respond to or prepare for the hazard:** ❖ Provide better hazard maps ❖ Provide technical information and guidance ❖ Enact tools to help manage development in hazard areas (e.g., tax incentives, information) ❖ Include retrofitting and replacement of critical system elements in capital improvement plan ❖ Develop strategy to take advantage of post-disaster opportunities ❖ Warehouse critical infrastructure components such as pipe, power line, and road repair materials ❖ Develop and adopt a continuity of operations plan ❖ Initiate triggers guiding improvements (such as <50% substantial damage or improvements) ❖ Further enhance seismic risk assessment to target high hazard buildings for mitigation opportunities. ❖ Develop a post-disaster action plan that includes grant funding and debris removal components.

Table 6-5 Catalog of Potential Mitigation Actions for the Flood Hazard

Government-Scale	
Manipulate the hazard: ❖ Maintain drainage system ❖ Institute low-impact development techniques on property ❖ Dredging, levee construction, and providing regional retention areas ❖ Structural flood control, levees, channelization, or revetments. ❖ Stormwater management regulations and master planning ❖ Acquire vacant land or promote open space uses in developing watersheds to control increases in runoff **Reduce exposure to the hazard:** ❖ Locate or relocate critical facilities outside of hazard area ❖ Acquire or relocate identified repetitive loss properties ❖ Promote open space uses in identified high hazard areas via techniques such as: planned unit developments, easements, setbacks, greenways, sensitive area tracks. ❖ Adopt land development criteria such as planned unit developments, density transfers, clustering ❖ Institute low impact development techniques on property ❖ Acquire vacant land or promote open space uses in developing watersheds to control increases in runoff	❖ Facilitate managed retreat from, or upgrade of, the most at-risk areas ❖ Require accounting of sea level rise in all applications for new development in shoreline areas ❖ Implement Assembly Bill 162 (2007) requiring flood hazard information in local general plans **Build local capacity to respond to or prepare for the hazard:** ❖ Produce better hazard maps ❖ Provide technical information and guidance ❖ Enact tools to help manage development in hazard areas (stronger controls, tax incentives, and information) ❖ Incorporate retrofitting or replacement of critical system elements in capital improvement plan ❖ Develop strategy to take advantage of post-disaster opportunities ❖ Warehouse critical infrastructure components ❖ Develop and adopt a continuity of operations plan ❖ Consider participation in the Community Rating System ❖ Maintain and collect data to define risks and vulnerability ❖ Train emergency responders ❖ Create an elevation inventory of structures in the floodplain

Government-Scale	
❖ Preserve undeveloped and vulnerable shoreline ❖ Restore existing flood control and riparian corridors **Reduce vulnerability to the hazard:** ❖ Harden infrastructure, bridge replacement program ❖ Provide redundancy for critical functions and infrastructure ❖ Adopt regulatory standards such as freeboard standards, cumulative substantial improvement or damage, lower substantial damage threshold; compensatory storage, non-conversion deed restrictions. ❖ Stormwater management regulations and master planning. ❖ Adopt “no-adverse impact” floodplain management policies that strive to not increase the flood risk on downstream communities	❖ Develop and implement a public information strategy ❖ Charge a hazard mitigation fee ❖ Integrate floodplain management policies into other planning mechanisms within the planning area. ❖ Consider the probable impacts of climate change on the risk associated with the flood hazard ❖ Consider the residual risk associated with structural flood control in future land use decisions ❖ Enforce National Flood Insurance Program requirements ❖ Adopt a Stormwater Management Master Plan ❖ Develop an adaptive management plan to address the long-term impacts of sea level rise

Table 6-6 Catalog of Potential Mitigation Actions for the Landslide Hazard

Government-Scale
Manipulate the hazard: ❖ Stabilize slope (dewater, armor toe) ❖ Reduce weight on top of slope **Reduce exposure to the hazard:** ❖ Acquire properties in high-risk landslide areas. ❖ Adopt land use policies that prohibit the placement of habitable structures in high-risk landslide areas. **Reduce vulnerability to the hazard:** ❖ Adopt higher regulatory standards for new development within unstable slope areas. ❖ Armor/retrofit critical infrastructure against the impact of landslides. **Build local capacity to respond to or prepare for the hazard:** ❖ Produce better hazard maps ❖ Provide technical information and guidance ❖ Enact tools to help manage development in hazard areas: better land controls, tax incentives, information ❖ Develop strategy to take advantage of post-disaster opportunities ❖ Warehouse critical infrastructure components ❖ Develop and adopt a continuity of operations plan ❖ Educate the public on the landslide hazard and appropriate risk reduction alternatives. ❖ Consider the probable impacts of climate change on the risk associated with the landslide hazard

Table 6-7 Catalog of Potential Mitigation Actions for the Severe Weather Hazard

Government-Scale

- **Manipulate the hazard:**
  - ❖ None
- **Reduce exposure to the hazard:**
  - ❖ Develop an urban heat island reduction program that includes an urban forest program or plan
- **Reduce vulnerability to the hazard:**
  - ❖ Harden infrastructure such as locating utilities underground
  - ❖ Trim trees back from power lines
  - ❖ Designate snow routes and strengthen critical road sections and bridges
- **Build local capacity to respond to or be prepared for the hazard:**
  - ❖ Support programs such as "Tree Watch" that proactively manage problem areas through use of selective removal of hazardous trees, tree replacement, etc.
  - ❖ Establish and enforce building codes that require all roofs to withstand snow loads
  - ❖ Increase communication alternatives
  - ❖ Modify land use and environmental regulations to support vegetation management activities that improve reliability in utility corridors.
  - ❖ Modify landscape and other ordinances to encourage appropriate planting near overhead power, cable, and phone lines
  - ❖ Provide NOAA weather radios to the public
  - ❖ Consider the probable impacts of climate change on the risk associated with the severe weather hazard
  - ❖ Review and update heat response plan in light of climate change (heat events) projections

Table 6-8 Catalog of Potential Mitigation Actions for the Severe Winter Weather Hazard

Government-Scale

- **Manipulate the hazard:**
  - ❖ None
- **Reduce exposure to the hazard:**
  - ❖ Develop an urban heat island reduction program that includes an urban forest program or plan
- **Reduce vulnerability to the hazard:**
  - ❖ Harden infrastructure such as locating utilities underground
  - ❖ Trim trees back from power lines
  - ❖ Designate snow routes and strengthen critical road sections and bridges
- **Build local capacity to respond to or be prepared for the hazard:**
  - ❖ Support programs such as "Tree Watch" that proactively manage problem areas through use of selective removal of hazardous trees, tree replacement, etc.
  - ❖ Establish and enforce building codes that require all roofs to withstand snow loads
  - ❖ Increase communication alternatives
  - ❖ Modify land use and environmental regulations to support vegetation management activities that improve reliability in utility corridors.
  - ❖ Modify landscape and other ordinances to encourage appropriate planting near overhead power, cable, and phone lines
  - ❖ Provide NOAA weather radios to the public
  - ❖ Consider the probable impacts of climate change on the risk associated with the severe weather hazard
  - ❖ Review and update heat response plan in light of climate change (heat events) projections

Table 6-9 Catalog of Potential Mitigation Actions for the Wildfire Hazard

Government-Scale
Manipulate the hazard: ❖ Clear potential fuels on property such as dry underbrush and diseased trees ❖ Implement best management practices on public lands **Reduce exposure to the hazard:** ❖ Create and maintain defensible space around structures and infrastructure ❖ Locate outside of hazard area ❖ Enhance building code to include use of fire resistant materials in high hazard area. **Reduce vulnerability to the hazard:** ❖ Create and maintain defensible space around structures and infrastructure ❖ Use fire-resistant building materials ❖ Use fire-resistant plantings in buffer areas of high wildfire threat. ❖ Consider higher regulatory standards (such as Class A roofing) ❖ Establish biomass reclamation initiatives ❖ Reintroduce fire (controlled or prescribed burns) to fire-prone ecosystems ❖ Manage fuel load through thinning and brush removal ❖ Establish integrated performance standards for new development to harden homes. **Build local capacity to respond to or prepare for the hazard:** ❖ More public outreach and education efforts, including an active Firewise USA program ❖ Possible weapons of mass destruction funds available to enhance fire capability in high-risk areas ❖ Identify fire response and alternative evacuation routes and establish where needed ❖ Seek alternative water supplies ❖ Become a Firewise USA community ❖ Use academia to study impacts/solutions to wildfire risk ❖ Establish/maintain mutual aid agreements between fire service agencies ❖ Develop, adopt, and implement integrated plans for mitigating wildfire impacts in wildland areas bordering on development ❖ Consider the probable impacts of climate change on the risk associated with the wildfire hazard in future land use decisions ❖ Establish a management program to track forest and rangeland health ❖ Provide incentives to for existing structures to be hardened against wildfire.

6.6 IMPLEMENTATION STRATEGY

6.6.1 Selection of Recommended Actions

The selection of mitigation actions was based on the risk assessment of identified hazards of concern and the defined hazard mitigation goals and objectives. Each annex lists the recommended hazard mitigation actions that make up the action plan. The timeframe indicated in the tables is defined as follows:

- Short Term = to be completed in 1 to 5 years
- Long Term = to be completed in greater than 5 years
- Ongoing = currently being funded and implemented under existing programs.

6.6.2 Action Prioritization

44 CFR requires actions identified in the Plan to be prioritized (Sections 201.6(c)(3)(iii)). The planning team developed a methodology for prioritizing the action plans that meets the needs of the partnership and the requirements of 44 CFR. All identified actions were prioritized in two categories — implementation and grant pursuit — as defined by the following criteria:

Implementation priority

- High Priority — an action that meets multiple objectives, has benefits that exceed costs, and has a secured source of funding. Action can be completed in the short term (1 to 5 years).
- Medium Priority — an action that meets multiple objectives, has benefits that exceed costs, and is eligible for funding though no funding has yet been secured for it. Action can be completed in the short term (1 to 5 years) once funding is secured. Medium-priority actions become high-priority actions once funding is secured.
- Low Priority — an action that will mitigate the risk of a hazard, has benefits that do not exceed the costs or are difficult to quantify, has no secured source of funding, and is not eligible for any known grant funding. Action can be completed in the long term (1 to 10 years). Low-priority actions are generally "wish-list" actions. They may be eligible for grant funding from programs that have not yet been identified.

Grant pursuit priority

- High Priority — an action that meets identified grant eligibility requirements, has high benefits, and is listed as high or medium implementation priority; local funding options are unavailable or available local funds could be used instead for actions that are not eligible for grant funding.
- Medium Priority — an action that meets identified grant eligibility requirements, has medium or low benefits, and is listed as medium or low implementation priority; local funding options are unavailable.
- Low Priority — an action that has not been identified as meeting any grant eligibility requirements.

These priority definitions are dynamic and can change from one category to another based on changes to a parameter such as availability of funding. For example, a project might be assigned a medium priority because of the uncertainty of a funding source, but be changed to high priority once a funding source has been identified. The prioritization schedule for this plan will be reviewed and updated as needed annually through the plan maintenance strategy.

6.6.3 Benefit/Cost Review

44 CFR requires the prioritization of the action plan to emphasize a benefit/cost analysis of the proposed actions. Because some actions may not be implemented for up to 10 years, benefit/cost analysis was qualitative and not of the detail required by FEMA for project grant eligibility under the Hazard Mitigation Assistance (HMA) grant program. A review of the apparent benefits versus the apparent cost of each project was performed. Parameters were established for assigning subjective ratings (high, medium, and low) to benefits and costs as follows:

Benefit ratings:

- High — the action will have an immediate impact on the reduction of risk exposure to life and property.
- Medium — the action will have a long-term impact on the reduction of risk exposure to life and property or will provide an immediate reduction in the risk exposure to property.
- Low — long-term benefits of the action are difficult to quantify in the short-term.

Cost ratings:

- High — existing funding levels are not adequate to cover the costs of the proposed action; implementation would require an increase in revenue through an alternative source (for example, bonds, grants, and fee increases).

- Medium — the action could be implemented with existing funding but would require a reapportionment of the budget or a budget amendment, or the cost of the action would have to be spread over multiple years.
- Low — the action could be funded under the existing budget. The action is part of or can be part of an existing, ongoing program.

Using this approach, projects with positive benefit versus cost ratios (such as high over high, high over medium, medium over low, etc.) are considered cost-beneficial and are prioritized accordingly. For many of the strategies identified in this action plan, funding might be sought under FEMA's HMA program. This program requires detailed benefit/cost analysis as part of the application process. These analyses will be performed on projects at the time of application preparation. The FEMA benefit-cost model will be used to perform this review. For projects not seeking financial assistance from grant programs that require this sort of analysis, the planning partners reserve the right to define "benefits" according to parameters that meet their needs and the goals and objectives of this plan.

6.6.4 Analysis of Mitigation Actions

All planning partners reviewed their recommended actions to classify each action based on the hazard it addresses and the type of mitigation it involves. Mitigation types used for this categorization are as follows:

- Prevention — government, administrative or regulatory actions that influence the way land and buildings are developed to reduce hazard losses. Includes planning and zoning, floodplain laws, capital improvement programs, open space preservation, and stormwater management regulations.
- Property Protection — modification of buildings or structures to protect them from a hazard or removal of structures from a hazard area. Includes acquisition, elevation, relocation, structural retrofit, storm shutters, and shatter-resistant glass.
- Public Education and Awareness — actions to inform citizens and elected officials about hazards and ways to mitigate them. Includes outreach projects, real estate disclosure, hazard information centers, and school-age and adult education.
- Natural Resource Protection — actions that minimize hazard loss and preserve or restore the functions of natural systems. Includes sediment and erosion control, stream corridor restoration, watershed management, forest and vegetation management, and wetland restoration and preservation.
- Emergency Services — actions that protect people and property during and immediately after a hazard event. Includes warning systems, emergency response services, and the protection of essential facilities.
- Structural Projects — actions that involve the construction of structures to reduce the impact of a hazard. Includes dams, setback levees, floodwalls, retaining walls, and safe rooms.
- Community Capacity Building — actions that increase or enhance local capabilities to adjust to potential damage, to take advantage of opportunities, or to respond to consequences. Includes staff training, memorandums of understanding, development of plans and studies, and monitoring programs.

These categories include categories identified in the Community Rating System (CRS) 2017 CRS Coordinators Manual (OMB No. 1660-0022, Figure 510-4). The CRS categories expand on the four categories in FEMA's 2013 Local Mitigation Handbook. They provide a more comprehensive range of options, thus increasing integration opportunities.

SECTION 7 PLAN MAINTENANCE PROCEDURES

This section details the formal process that will ensure that the HMP remains an active and relevant document and that the Planning Partnership maintains their eligibility for applicable funding sources. The plan maintenance process includes a schedule for monitoring and evaluating the plan annually and producing an updated plan every five years. In addition, this section describes how public participation will be integrated throughout the plan maintenance and implementation process. It explains how the mitigation strategies outlined in this plan update will be incorporated into existing planning mechanisms and programs, such as comprehensive land use planning processes, capital improvement planning, and building code enforcement and implementation. The plan's format allows sections to be reviewed and updated when new data become available, resulting in a plan that will remain current and relevant.

The below checklist provides a guide for key activities to address plan maintenance.

Annual Mitigation Plan Maintenance Checklist

- ✓ Month 1: Document municipal and special district adoption resolutions and confirm ongoing Planning Partnership membership contact information
- ✓ Month 11: Preparation of status updates and action implementation tracking as part of submission for Annual Progress Report.
- ✓ Month 11: In order for integration of mitigation principles action to become an organic part of the ongoing county, municipal and special district activities, the county will incorporate the distribution of the safe growth worksheet (see 7.1.2 below) for annual review and update by all participating jurisdictions.
- ✓ Ongoing – Months 1-12: Review the status of previous actions as submitted by the monitoring task lead and support to assess the effectiveness of the plan.
- ✓ Month 12: Generate and finalize the Annual Progress Report.
- ✓ Month 12: Distribute Annual Progress Report to all participating communities to document project implementation successes.
- ✓ Month 36 from initial plan approval position for funding of plan update including application for grant funding.

The plan maintenance matrix shown in Table 7-1 provides a synopsis of responsibilities for plan monitoring, evaluation, and update, which are discussed in further detail in the sections below.

Table 7-1 Plan Maintenance Matrix

Task	Approach	Timeline	Lead Responsibility	Support Responsibility
Monitoring	Preparation of status updates and action implementation tracking as part of submission for Annual Progress Report.	[April] or upon major update to Comprehensive Plan or major disaster	Jurisdictional points of contact identified in Section 8 (Planning Partnership) and Section 9 (Jurisdictional Annexes)	Jurisdictional implementation lead identified in Section 8 (Planning Partnership) and Section 9 (Jurisdictional Annexes)
Integration	In order for integration of mitigation principles action to	[April] each year with interim email	HMP Coordinator and jurisdictional points of	HMP Coordinator

Task	Approach	Timeline	Lead Responsibility	Support Responsibility
	become an organic part of the ongoing county, municipal and special district activities, the county will incorporate the distribution of the safe growth worksheet (see 7.1.2 below) for annual review and update by all participating jurisdictions.	reminders to address integration in county, municipal, and special district activities.	contact identified in Section 8 (Planning Partnership) and Section 9 (Jurisdictional Annexes)	
Evaluation	Review the status of previous actions as submitted by the monitoring task lead and support to assess the effectiveness of the plan; compile and finalize the Annual Progress Report	Finalized progress report completed by April of each year	Steering Committee; Plan Maintenance element	Jurisdictional points of contacts identified in Section 9 (Jurisdictional Annexes)
Update	Reconvene the planning partners, at a minimum, every 5 years to guide a comprehensive update to review and revise the plan.	Every 5 years or upon major update to Comprehensive Plan or major disaster	Douglas County HMP Coordinator	Jurisdictional points of contacts identified in Section 9 (Jurisdictional Annexes)

7.1 Monitoring, Evaluating and Updating the Plan

The procedures for monitoring, evaluating, and updating the plan are provided below.

The HMP Coordinator is assigned to manage the maintenance and update of the plan during its performance period. The HMP Coordinator will chair the Planning Committee and be the prime point of contact for questions regarding the plan and its implementation as well as to coordinate incorporation of additional information into the plan.

The Planning Committee shall fulfill the monitoring, evaluation and updating responsibilities identified in this section which is comprised of a representative from each participating jurisdiction. Each jurisdiction is expected to maintain a representative on the Planning Committee throughout the plan performance period (five years from the date of plan adoption). As of the date of this plan, primary and secondary mitigation planning representatives (points-of-contact) are identified in each jurisdictional annex in Section 9 (Jurisdictional Annexes).

Regarding the composition of the committee, it is recognized that individual commitments change over time, and it shall be the responsibility of each jurisdiction and its representatives to inform the HMP Coordinator of any changes in representation. The HMP Coordinator will strive to keep the committee makeup as a uniform representation of planning partners and stakeholders within the planning area.

Currently, the Douglas County HMP Coordinator is designated as:

Tim Johnson, Director
Douglas County Office of Emergency Management
4000 Justice Way
Castle Rock, CO 80109
(303) 660-7589

Email: tmjohnso@dcsheriff.net

7.1.1 Monitoring

The Planning Committee shall be responsible for monitoring progress on, and evaluating the effectiveness of, the plan, and documenting annual progress. Each year, beginning one year after plan development, Douglas County and local Planning Committee representatives will collect and process information from the departments, agencies and organizations involved in implementing mitigation projects or activities identified in their jurisdictional annexes (Section 9) of this plan, by contacting persons responsible for initiating and/or overseeing the mitigation projects.

In addition to progress on the implementation of mitigation actions, including efforts to obtain outside funding; and obstacles or impediments to implementation of actions, the information that Planning Committee representatives shall be expected to document, as needed and appropriate include:

- Any grant applications filed on behalf of any of the participating jurisdictions
- Hazard events and losses occurring in their jurisdiction,
- Additional mitigation actions believed to be appropriate and feasible,
- Public and stakeholder input.

7.1.2 Integration Process of the HMP into Jurisdictional Planning Mechanisms

Hazard mitigation is sustained action taken to reduce or eliminate the long-term risk to human life and property from natural hazards. Integrating hazard mitigation into a community's existing plans, policies, codes, and programs leads to development patterns that do no increased risk from known hazards or leads to redevelopment that reduces risk from known hazards. The Douglas County Planning Partnership was tasked with identifying how hazard mitigation is integrated into existing planning mechanisms. Refer to Section 9 (Jurisdictional Annexes) for how this is done for each participating jurisdiction. During this process, many jurisdictions recognized the importance and benefits of incorporating hazard mitigation into future planning and regulatory processes.

The Planning Partnership representatives will incorporate mitigation planning as an integral component of daily government and special district operations. Planning Partnership representatives will work with local government and special district officials to integrate the newly adopted hazard mitigation goals and actions into the general operations of government and partner organizations. Further, the sample adoption resolution (Section 2 – Plan Adoption) includes a resolution item stating the intent of the local governing body to incorporate mitigation planning as an integral component of government and partner operations. By doing so, the Planning Partnership anticipates that:

1. Hazard mitigation planning will be formally recognized as an integral part of overall planning and emergency management efforts;
2. The Hazard Mitigation Plan, Comprehensive Plans, Emergency Management Plans and other relevant planning mechanisms will become mutually supportive documents that work in concert to meet the goals and needs of County residents.

During the HMP annual review process, each participating jurisdiction will be asked to document how they are utilizing and incorporating the Douglas County HMP into their day-to-day operations and planning and regulatory processes. Additionally, each jurisdiction will identify additional policies, programs, practices, and procedures that could be modified to accommodate hazard mitigation actions and include these findings and recommendations in the Annual HMP Progress Report. The following checklist was adapted from FEMA's Local Mitigation Handbook (2013), Appendix A, Worksheet 4.2. This checklist will help a community analyze how hazard mitigation is integrated into local plans, ordinances, regulations, ordinances, and policies. By completing the checklist, it will help participating jurisdictions identify areas that integrate hazard mitigation currently and where to make improvements and reduce vulnerability to future development. In this manner, the integration of mitigation into jurisdictional activities will evolve into an ongoing culture within the county and participating jurisdictions.

Table 7-2 Safe Growth Check List

Planning Mechanisms	Do you Do This? Yes	No	Notes: How is it being done or how will this be utilized in the future?
Operating, Municipal and Capital Improvement Program Budgets			
• When constructing upcoming budgets, hazard mitigation actions will be funded as budget allows. Construction projects will be evaluated to see if they meet the hazard mitigation goals.			
• Annually, during adoption process, the municipality will review mitigation actions when allocating funding.			
• Do budgets limit expenditures on projects that would encourage development in areas vulnerable to natural hazards?			
• Do infrastructure policies limit extension of existing facilities and services that would encourage development in areas vulnerable to natural hazards?			
• Do budgets provide funding for hazard mitigation projects identified in the County HMP?			
Human Resource Manual			
• Do any job descriptions specifically include identifying and/or implementing mitigation projects/actions or other efforts to reduce natural hazard risk?			
Building and Zoning Ordinances			
• Prior to, zoning changes, or development permitting, the jurisdiction will review the hazard mitigation plan and other hazard analyses to ensure consistent and compatible land use.			
• Does the zoning ordinance discourage development or redevelopment within natural areas including wetlands, floodways, and floodplains?			
• Does it contain natural overlay zones that set conditions			
• Does the ordinance require developers to take additional actions to mitigate natural hazard risk?			
• Do rezoning procedures recognize natural hazard areas as limits on zoning changes that allow greater intensity or density of use?			
• Do the ordinances prohibit development within, of filling of, wetlands, floodways, and floodplains?			
Subdivision Regulations			
• Do the subdivision regulations restrict the subdivision of land within or adjacent to natural hazard areas?			

Planning Mechanisms	Do you Do This? Yes	No	Notes: How is it being done or how will this be utilized in the future?
• Do the subdivision regulations restrict the subdivision of land within or adjacent to natural hazard areas?			
• Do the regulations provide for conservation subdivisions or cluster subdivisions in order to conserve environmental resources?			
• Do the regulations allow density transfers where hazard areas exist?			
Comprehensive Plan			
• Are the goals and policies of the plan related to those of the County HMP?			
• Does the future land use map clearly identify natural hazard areas?			
• Do the land use policies discourage development or redevelopment with natural hazard areas?			
• Does the plan provide adequate space for expected future growth in areas located outside natural hazard areas?			
Land Use			
• Does the future land use map clearly identify natural hazard areas?			
• Do the land use policies discourage development or redevelopment with natural hazard areas?			
• Does the plan provide adequate space for expected future growth in areas located outside natural hazard areas?			
Transportation Plan			
• Does the transportation plan limit access to hazard areas?			
• Is transportation policy used to guide growth to safe locations?			
• Are transportation systems designed to function under disaster conditions (e.g. evacuation)?			
Environmental Management			
• Are environmental systems that protect development from hazards identified and mapped?			
• Do environmental policies maintain and restore protective ecosystems?			
• Do environmental policies provide incentives to development that is located outside protective ecosystems?			
Grant Applications			
• Data and maps will be used as supporting documentation in grant applications.			
Municipal Ordinances			
• When updating municipal ordinances, hazard mitigation will be a priority			
Economic Development			
• Local economic development group will take into account information regarding identified hazard areas when assisting new businesses in finding a location.			
Public Education and Outreach			
• Does the jurisdiction have any public outreach mechanisms / programs in place to inform citizens on natural hazards, risk, and ways to protect themselves during such events?			

7.1.3 Evaluating

The evaluation of the mitigation plan is an assessment of whether the planning process and actions have been effective, if the HMP goals are being achieved, and whether changes are needed. The HMP will be evaluated on an annual basis to determine the effectiveness of the programs, and to reflect changes that could affect mitigation priorities or available funding.

The status of the HMP will be discussed and documented at an annual plan review meeting of the Planning Committee, to be held either in person or via teleconference approximately one year from the date of local adoption of this update, and successively thereafter. At least two weeks before the annual plan review meeting, the Douglas County HMP Coordinator will advise Planning Committee members of the meeting date, agenda and expectations of the members.

The Douglas County HMP Coordinator will be responsible for calling and coordinating the annual plan review meeting and Soliciting input regarding progress toward meeting plan goals and objectives. These evaluations will assess whether:

- Goals and objectives address current and expected conditions.
- The nature or magnitude of the risks has changed.
- Current resources are appropriate for implementing the HMP and if different or additional resources are now available.
- Actions were cost effective.
- Schedules and budgets are feasible.
- Implementation problems, such as technical, political, legal or coordination issues with other agencies are presents.
- Outcomes have occurred as expected.
- Changes in county, city, town or special district resources impacted plan implementation (e.g., funding, personnel, and equipment)
- New agencies/departments/staff should be included, including other local governments as defined under 44 CFR 201.6.

Specifically, the Planning Committee will review the mitigation goals, objectives, and activities using performance-based indicators, including:

- New agencies/departments
- Project completion
- Under/over spending
- Achievement of the goals and objectives
- Resource allocation
- Timeframes
- Budgets
- Lead/support agency commitment
- Resources
- Feasibility

Finally, the Planning Committee will evaluate how other programs and policies have conflicted or augmented planned or implemented measures, and shall identify policies, programs, practices, and procedures that could be modified to accommodate hazard mitigation actions ("Implementation of Mitigation Plan through Existing Programs" subsection later in this section discusses this process). Other programs and policies can include those that address:

- Economic development
- Environmental preservation
- Historic preservation
- Redevelopment
- Health and/or safety
- Recreation
- Land use/zoning
- Public education and outreach
- Transportation

The Planning Committee should refer to the evaluation forms, Worksheets #2 and #4 in the FEMA 386-4 guidance document, to assist in the evaluation process (see Appendix G – Plan Review Tools). Further, the Planning Committee should refer to any process and plan review deliverables developed by the county or participating jurisdictions as a part of the plan review processes established for prior or existing local HMPs within the county.

The Douglas County HMP Coordinator shall be responsible for preparing an Annual HMP Progress Report for each year of the performance period, based on the information provided by the local Planning Committee members, information presented at the annual Planning Committee meeting, and other information as appropriate and relevant. These annual reports will provide data for the five-year update of this HMP and will assist in pinpointing any implementation challenges. By monitoring the implementation of the HMP on an annual basis, the Planning Committee will be able to assess which projects are completed, which are no longer feasible, and what projects should require additional funding.

The Annual HMP Progress Report shall be posted on the Douglas County Local Natural Hazard Mitigation webpage to keep the public apprised of the plan's implementation (https://www.douglas.co.us/natural-hazard-mitigation-plan/). Additionally, the website provides details on the HMP update planning process. For communities who might choose to join the NFIP CRS program, this report will also be provided to each CRS participating community in order to meet annual CRS recertification requirements. To meet this recertification timeline, the Planning Committee will strive to complete the review process and prepare an Annual HMP Progress Report by April of each year.

The HMP will also be evaluated and revised following any major disasters, to determine if the recommended actions remain relevant and appropriate. The risk assessment will also be revisited to see if any changes are necessary based on the pattern of disaster damages or if data listed in the Section 5.4 (Hazard Profiles) of this plan has been collected to facilitate the risk assessment. This is an opportunity to increase the community's disaster resistance and build a better and stronger community.

7.1.4 Updating

44 CFR 201.6.d.3 requires that local hazard mitigation plans be reviewed, revised as appropriate, and resubmitted for approval in order to remain eligible for benefits awarded under DMA 2000. It is the intent

of the Douglas County HMP Planning Committee to update this plan on a five-year cycle from the date of initial plan adoption.

To facilitate the update process, the Douglas County HMP Coordinator, with support of the Planning Committee, shall use the second annual Planning Committee meeting to develop and commence the implementation of a detailed plan update program. The Douglas County HMP Coordinator shall invite representatives from the Colorado DHSEM to this meeting to provide guidance on plan update procedures. This program shall, at a minimum, establish who shall be responsible for managing and completing the plan update effort, what needs to be included in the updated plan, and a detailed timeline with milestones to assure that the update is completed according to regulatory requirements.

At this meeting, the Planning Committee shall determine what resources will be needed to complete the update. The Douglas County HMP Coordinator shall be responsible for assuring that needed resources are secured.

Following each five-year update of the mitigation plan, the updated plan will be distributed for public comment. After all comments are addressed, the HMP will be revised and distributed to all planning group members and the Colorado State Hazard Mitigation Officer.

7.1.5 Grant Monitoring and Coordination

Douglas County recognizes the importance of having an annual coordination period that helps each planning partner become aware of upcoming mitigation grant opportunities identifies multi-jurisdiction projects to pursue. Grant monitoring will be the responsibility of each municipal and special district partner as part of their annual progress reporting. The Douglas County HMP Coordinator will keep the planning partners apprised of Hazard Mitigation Assistance grant openings and assist in developing letters of intent for grant opportunities when practicable.

Douglas County intends to be a resource to the planning partnership in the support of project grant writing and development. The degree of this support will depend on the level of assistance requested by the partnership during open windows for grant applications. As part of grant monitoring and coordination, Douglas County intends to provide the following:

- Notification to planning partners about impending grant opportunities.
- A current list of eligible, jurisdiction-specific projects for funding pursuit consideration.
- Notification about mitigation priorities for the fiscal year to assist the planning partners in the selection of appropriate projects.

Grant monitoring and coordination will be integrated into the annual progress report or as needed based on the availability of non-HMA or post-disaster funding opportunities.

7.2 Implementation of Mitigation Plan through Existing Programs

Effective mitigation is achieved when hazard awareness and risk management approaches and strategies become an integral part of public activities and decision-making. Within the county there are many existing plans and programs that support hazard risk management, and thus it is critical that this hazard mitigation plan integrate and coordinate with, and complement, those existing plans and programs.

The "Capability Assessment" section of Section 6 (Mitigation Strategy) provides a summary and description of the existing plans, programs and regulatory mechanisms at all levels of government (federal, state, county and local) that support hazard mitigation within the county. Within each jurisdictional annex in Section 9 (Jurisdictional Annexes), the county and each participating jurisdiction identified how they have integrated hazard risk management into their existing planning, regulatory and operational/administrative framework ("existing integration"), and how they intend to promote this integration ("opportunities for future integration").

It is the intention of Planning Committee representatives to incorporate mitigation planning as an integral component of daily government operations. Planning Committee representatives will work with local government officials to integrate the newly adopted hazard mitigation goals and actions into the general operations of government and partner organizations. Further, the sample adoption resolution (Section 2 – Plan Adoption) includes a resolution item stating the intent of the local governing body to incorporate mitigation planning as an integral component of government and partner operations. By doing so, the Planning Committee anticipates that:

1) Hazard mitigation planning will be formally recognized as an integral part of overall emergency management efforts;
2) The Hazard Mitigation Plan, Comprehensive Plans, Emergency Management Plans and other relevant planning mechanisms will become mutually supportive documents that work in concert to meet the goals and needs of county residents.

Other planning processes and programs to be coordinated with the recommendations of the hazard mitigation plan include the following:

- Emergency response plans
- Training and exercise of emergency response plans
- Debris management plans
- Recovery plans
- Capital improvement programs
- Municipal codes
- Community design guidelines
- Water-efficient landscape design guidelines
- Stormwater management programs
- Water system vulnerability assessments
- Community Wildfire Protection Plans
- Comprehensive Flood Hazard Management Plans
- Resiliency plans
- Community Development Block Grant-Disaster Recovery action plans
- Public information/education plans

Some action items do not need to be implemented through regulation. Instead, these items can be implemented through the creation of new educational programs, continued interagency coordination, or improved public participation.

During the annual plan evaluation process, the Planning Committee representatives will identify additional policies, programs, practices, and procedures that could be modified to accommodate hazard mitigation actions and include these findings and recommendations in the Annual HMP Progress Report.

7.3 Continued Public Involvement

Douglas County and participating jurisdictions are committed to the continued involvement of the public in the hazard mitigation process. This HMP update will continue to be posted on-line (https://www.douglas.co.us/natural-hazard-mitigation-plan/). In addition, public outreach and dissemination of the HMP will include:

- Links to the plan on websites of each jurisdiction with capability.
- Continued utilization of existing social media outlets (Facebook, Twitter, and Nextdoor) to inform the public of natural hazard events, such as floods and severe storms. Educate the public via the jurisdictional websites on how these applications can be used in an emergency situation.
- Development of annual articles or workshops on high risk hazards to educate the public and keep them aware of the dangers in the planning partnership area.

Planning Committee representatives and the Douglas County HMP Coordinator will be responsible for receiving, tracking, and filing public comments regarding this HMP. The public will have an opportunity to comment on the plan via the hazard mitigation website at any time. The HMP Coordinator will maintain this website, posting new information and maintaining an active link to collect public comments.

The public can also provide input at the annual review meeting for the HMP and during the next five-year plan update. The Douglas County HMP Coordinator is responsible for coordinating the plan evaluation portion of the meeting, soliciting feedback, collecting and reviewing the comments, and ensuring their incorporation in the five-year plan update as appropriate. Additional meetings might also be held as deemed necessary by the planning group. The purpose of these meeting would be to provide the public an opportunity to express concerns, opinions, and ideas about the mitigation plan.

The Planning Committee representatives shall be responsible to assure that:

- Public comment and input on the plan, and hazard mitigation in general, are recorded and addressed, as appropriate.
- Copies of the latest approved plan (or draft in the case that the five-year update effort is underway) are available for review, along with instructions to facilitate public input and comment on the Plan.
- Appropriate links to the Douglas County Hazard Mitigation Plan website are included on jurisdictional websites.
- Public notices are made as appropriate to inform the public of the availability of the plan, particularly during Plan update cycles.

The Douglas County HMP Coordinator shall be responsible to assure that:

- Public and stakeholder comment and input on the plan, and hazard mitigation in general, are recorded and addressed, as appropriate.
- The Douglas County HMP website is maintained and updated as appropriate.

- Copies of the latest approved plan are available for review at appropriate county facilities along with instructions to facilitate public input and comment on the plan.
- Public notices, including media releases, are made as appropriate to inform the public of the availability of the plan, particularly during plan update cycles.