2015 - 2020

Arapahoe County, CO, Multi-Hazard Mitigation Plan

ARAPAHOE COUNTY SHERIFF'S OFFICE

13101 E. Broncos Pkwy
Centennial, CO 80112

This Plan was developed in cooperation with:

The Arapahoe County Sheriff's Office and the following participating jurisdictions:

Arapahoe County

Town of Bennett

Town of Bow Mar

City of Centennial

City of Cherry Hills Village

Town of Columbine Valley

Town of Deer Trail

City of Englewood

Town of Foxfield

City of Glendale

City of Greenwood Village

City of Littleton

City of Sheridan

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[insert signed adoption resolutions for all participating jurisdictions]

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CERTIFICATION OF ANNUAL MEETINGS

The Arapahoe County Local Emergency Planning Committee (LEPC) has reviewed this Multi-Hazard Mitigation Plan. See Chapter 4 of this Plan for further details regarding the following table. The following table hereby certifies this review.

YEAR	DATE	PUBLIC OUTREACH ADDRESSED	SIGNATURE
2015			
2016			
2017			
2018			
2019			
2020			

EXECUTIVE SUMMARY

Arapahoe County has been and will continue to be committed to a long-term strategy for reducing the risks of hazards.

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

Some portions of Arapahoe County were developed long before the impacts of natural hazards were fully understood. Therefore, sections of our community are vulnerable to flooding, severe storms, wildfire, earthquakes, and other hazards. Working through the cycle of hazard mitigation can help ensure that those vulnerabilities will not increase over time. Encouraging acquisition, relocation, or retrofitting of existing vulnerable structures, along with the protection of valuable natural resources, are steps that can be taken to further decrease those vulnerabilities.

Communities face significant challenges during post-disaster redevelopment in balancing the immediate needs associated with rapid recovery with the implementation of long-term hazard mitigation strategies. The necessity to meet basic needs and resettle displaced populations immediately following a disaster often overshadows the more abstract, longer-term sustainability considerations. Once full-scale reconstruction is initiated, it is difficult to modify projects in progress to meet sustainability objectives. This trend highlights the need for pre-disaster mitigation planning that incorporates principles of sustainable development into the reconstruction context, so that communities can more easily rebuild in a manner that will make them less vulnerable to future hazard events while improving quality of life.

It is imperative that local decision makers become and stay involved in this planning process to provide new ideas and insight for future updates to the Arapahoe County Multi-Hazard Mitigation Plan. Now that a mitigation strategy has been developed, it will remain a challenge and a goal for Arapahoe County to provide necessary updates as mitigation techniques are implemented. It is critical that all local agencies, units of government, non-profit organizations, businesses and industries, and private citizens continue their involvement and dedication to hazard mitigation.

It is our long-term goal that the Multi-Hazard Mitigation Plan and the mitigation strategies identified within will be fully integrated into daily decisions and routines of government and business. This will continue to require dedication and hard work, and to this end, this Plan update continues efforts to further strengthen the sustainability of Arapahoe County.

CHAPTER 1: THE PLANNING PROCESS

This section of the Plan describes the mitigation planning process undertaken by Arapahoe County and participating municipalities in the preparation of this Multi-Hazard Mitigation Plan. This chapter consists of the following subsections:

- BACKGROUND
- OVERVIEW OF HAZARD MITIGATION PLANNING
- LOCAL METHODOLOGY AND UPDATE PROCESS
- THE PLANNING TEAM
- PLANNING MEETINGS AND DOCUMENTATION
- PUBLIC AND STAKEHOLDER PARTICIPATION
- MULTI-JURISIDICTIONAL PLANNING AND PARTICIPATION
- EXISTING PLANNING MECHANISMS
- COMMUNITY PROFILE

Figure 1. The Emergency Management Cycle

BACKGROUND

Emergency Management is the discipline of identifying, managing, and avoiding risks. It is a discipline that involves preparing for a disaster before it occurs, supporting those affected by the disaster, as well as rebuilding after the natural or human-caused disaster event. Emergency Management is an ever changing process by which all individuals, groups, and communities attempt to manage hazards in an effort to avoid or reduce the impact of disasters. One method to attempt to prevent hazards from developing into disasters all together is Hazard Mitigation Planning. Hazard Mitigation Planning is a process to identify policies, capabilities, activities, and tools necessary to implement successful and sustainable mitigation actions.

Why undertake mitigation planning? Mitigation planning offers many benefits, including:

- Saving lives and property
- Saving money
- Ensuring quick and effective recovery following disasters
- Reducing future vulnerability through wise development and post-disaster recovery and reconstruction
- Enhancing coordination within and across participating jurisdictions,
- Expediting the receipt of pre-disaster and post-disaster grant funding, and
- Demonstrating a firm commitment to improving community health and safety

Typically, mitigation planning is described as having the potential to produce long-term and recurring benefits by breaking the repetitive cycle of disaster loss. A core assumption of hazard mitigation is that pre-disaster investments will significantly reduce the demand for post-disaster assistance by lessening the need for emergency response, repair, recovery, and reconstruction. Furthermore, mitigation practices will enable local residents, businesses, and industries to re-establish themselves in the wake of a disaster, getting the community economy back on track sooner and with less interruption.

The benefits of mitigation planning go beyond reducing hazard vulnerability. Measures such as the acquisition or regulation of land in known hazard areas can help achieve multiple community goals, such as preserving open space, improving water quality, maintaining environmental health, and enhancing recreational opportunities. Thus, it is vitally important that any local mitigation planning process be integrated with other concurrent local planning efforts, and any proposed mitigation strategies must take into account other existing community goals or initiatives that will help complement or hinder their future implementation. Arapahoe County and its municipalities have embraced this approach, identifying multiple opportunities to link the Plan with pre-existing programs, policies, plans, and initiatives.

During the last two decades, the approach to the emergency management cycle has evolved considerably. A renewed emphasis has been placed on planning for disasters before they occur as a complement to effective response and recovery. As a result, hazard mitigation has gained increasing prominence as a critical part of emergency management. By mitigating hazards through sustained action taken to reduce or eliminate the long-term risk to human life and property from hazards, risks can be proactively combated in a systematic manner, rather than being reacted to once they occur.

This 2015 Plan is the result of continuing work by the citizens of the county to update a regional pre-disaster multi-hazard mitigation plan that will not only continue to guide the county towards greater disaster resistance, but will also respect the character and needs of the community.

PURPOSE

Arapahoe County adopted the 2010 Denver Regional Natural Hazard Mitigation Plan in November, 2010. The 2010 Plan provided momentum for making homes, businesses, and communities as safe as possible against the impacts of floods, tornadoes, winter weather, and other natural hazards. It also assessed the effectiveness of prior and current programs and activities in the region and identified shortfalls; mitigation measures were further developed to help reduce the region's exposure to emerging natural hazards.

Arapahoe County has remained dedicated in continuing the work started in the 2010 Denver Regional Natural Hazard Mitigation Plan and has elected to develop a county-scale hazard mitigation plan. The purposes of the 2015 Arapahoe County Multi-Hazard Mitigation Plan are:

- To protect life and property by reducing the potential for future damages and economic losses that result from natural hazards;
- To qualify for additional grant funding, in both the pre-disaster and post-disaster environment;
- To provide quick recovery and redevelopment following future disasters;
- To integrate other existing and associated local planning documents;
- To demonstrate a firm local commitment to hazard mitigation principles; and
- To comply with state and federal legislative requirements tied to local hazard mitigation planning.

SCOPE

This 2015 Plan has been prepared to meet requirements set forth by the Federal Emergency Management Agency (FEMA) and the Colorado Division of Homeland Security and Emergency Management (DHSEM) in order for Arapahoe County to be eligible for funding and technical assistance from state and federal hazard mitigation programs. It will continue to be updated and maintained to continually address those natural hazards determined to be of high and moderate risk as defined by the updated results of the local hazard, risk, and vulnerability summary. Other natural hazards will continue to be evaluated during future updates of the Plan in order to determine if they warrant additional attention, including the development of specific mitigation measures intended to reduce their impact. This Plan will be updated and FEMA-approved within its five-year expiration date.

AUTHORITY

This Hazard Mitigation Plan has been adopted by Arapahoe County and the following jurisdictions: Town of Bennett, Town of Bow Mar, City of Centennial, City of Cherry Hills Village, Town of Columbine Valley, Town of Deer Trail, City of Englewood, Town of Foxfield, City of Glendale, City of Greenwood Village, City of Littleton, and City of Sheridan in accordance with the authority granted to counties by the State of Colorado.

This Plan was developed in accordance with current state and federal rules and regulations governing local hazard mitigation plans. The Plan shall be monitored and updated on a routine basis to maintain compliance with the following legislation and guidance:

- Robert T. Stafford Disaster Relief and Emergency Assistance Act, 42 U.S.C., Section 322, Mitigation Planning, as enacted by Section 104 of the Disaster Mitigation Act of 2000 (P.L. 106-390) and by FEMA's Interim Final Rule published in the Federal Register on February 26, 2002, at 44 CFR Part 201

The following Federal Emergency Management Agency (FEMA) guides and reference documents were used to prepare this document:

- FEMA. 386-1: Getting Started. September 2002.
- FEMA. 386-2: Understanding Your Risks: Identifying Hazards and Estimating Losses. August 2001.
- FEMA. 386-3: Developing the Mitigation Plan. April 2003.
- FEMA. 386-4: Bringing the Plan to Life. August 2003.
- FEMA. 386-5: Using Benefit-Cost Review in Mitigation Planning. May 2007.
- FEMA. 386-6: Integrating Historic Property and Cultural Resource Considerations into Hazard Mitigation Planning. May 2005.
- FEMA. 386-7: Integrating Manmade Hazards into Mitigation Planning. September 2003.
- FEMA. 386-8: Multi-Municipality Mitigation Planning. August 2006.
- FEMA. Coordinators Manual, National Flood Insurance Program Community Rating System. 2007.
- FEMA. 386-9: Using the Hazard Mitigation Plan to Prepare Successful Mitigation Projects. August 2008.

- FEMA. Local Mitigation Plan Review Guide. October 1, 2011
- FEMA. Local Multi-Hazard Mitigation Planning Handbook. March, 2013.

OVERVIEW OF HAZARD MITIGATION PLANNING

Local hazard mitigation planning is the process of organizing community resources, identifying and assessing hazard risks, and determining how to best minimize or manage those risks. This process results in a hazard mitigation plan that identifies specific mitigation actions, each designed to achieve both short term planning objectives and a long-term community vision. To ensure the functionality of each mitigation action, responsibility is assigned to a specific individual, department, or agency along with a schedule for its implementation. Plan maintenance procedures are established to help implement, evaluate, and enhance the Plan as necessary. Developing clear plan maintenance procedures ensures that Arapahoe County's Multi-Hazard Mitigation Plan remains a current, dynamic, and effective planning document over time.

LOCAL METHODOLOGY AND UPDATE PROCESS

This updated Plan contains a narrative description of the process followed to prepare it. All municipalities were notified of the requirement relating to the update process and the formation of the Mitigation Planning Work Group (MPWG). Subsequent meetings were held to ensure that all information is correct, and that input provided by participating agencies, organizations, and the public was included as presented. Throughout the planning update process, the Arapahoe County MPWG reviewed and analyzed each section of the plan. In preparing the updated Plan, documentation indicates that the MPWG utilized a multi-jurisdictional planning process consistent with the one recommended by FEMA (Publication Series 386).

The first Denver Regional Natural Hazard Mitigation Plan was prepared in 2003 and adopted in 2004. An updated plan was approved by FEMA in 2010. Development of the 2010 plan was a concerted effort on the part of the Denver Regional Council of Governments (DRCOG) and 19 local jurisdictions, including Arapahoe County. DRCOG planning staff spearheaded the hazard mitigation planning process and prepared the updated mitigation plan document. DRCOG convened a Regional Natural Hazard Plan Steering Committee to help guide the preparation of the plan. The Steering Committee was comprised of representatives from participating city and county governments, the State Office of Emergency Management, and FEMA Region VIII. Additionally, several special district stakeholders participated in flood mitigation planning. These included both the Urban Drainage Flood Control District and the Southeast Metro Stormwater Authority.

During the development of the 2010 Plan, DRCOG initiated an open public planning process to provide opportunities for the public and stakeholders to comment on the plan at all stages of its development. Because of the large size and diversity of the Denver metropolitan region, DRCOG also relied greatly on its local member governments to inform and gather input from the public.

Arapahoe County decided that prior to the expiration of the 2010 DRCOG Plan, Arapahoe County would produce its own Hazard Mitigation Plan focused specifically on the County and its jurisdictions. The 2010 Denver Regional Natural Hazard Mitigation Plan and the current 2013 State of Colorado Natural

Hazards Mitigation Plan were reviewed for incorporation into the 2015 Arapahoe County Multi-Hazard Mitigation Plan.

The following documents were reviewed and incorporated into the 2015 plan update when necessary:

- 2010 Denver Regional Natural Hazard Mitigation Plan
- 2013 Colorado Natural Hazards Mitigation Plan
- 2012 Eastern Arapahoe County Community Wildfire Protection Plan (CWPP)
- 2013 Arapahoe County Housing Needs Assessment
- 2014 Englewood Dam Emergency Action Plan
- 2014 Holly Dam Emergency Action Plan
- 2012 South Metro Fire Rescue Authority Comprehensive Emergency Management Plan (CEMP): Risk Assessment and Mitigation Plan (RAMP)

In 2012 the South Metro Fire Rescue Authority (SMFRA) prepared the Risk Assessment and Mitigation Plan (hereafter referred to as the RAMP) to eliminate or reduce long-term risks to people, property, and the environment due to natural and human-caused hazards. Using FEMA guidelines, the RAMP identifies risks, assesses vulnerabilities, and prioritizes goals and actions for mitigating the effects of hazards on SMFRA's communities. Through the leadership of the Community Safety Services Division (CSS), the Risk Assessment Work Group was formed to drive the development of the RAMP. The Risk Assessment Work Group collected data and stakeholder input, conducted a community asset/vulnerability analysis, and identified preferred mitigation alternatives. Ultimately, the mitigation strategy and goals identified in the 2012 RAMP were integrated into the Community Preparedness Bureau's Annual Management Plan.

The RAMP represents the collective work of the citizens, elected officials, and other stakeholders in SMFRA's jurisdiction and was a valuable asset to the development of the 2015 Arapahoe County Multi-Hazard Mitigation Plan. Members of the SMFRA who were directly involved in the development of the 2012 RAMP actively participated in the development of the 2015 Arapahoe County Mitigation Plan and mitigation strategies from the RAMP were incorporated in to the 2015 Plan when appropriate.

The map below shows the geographic extent of the SMFRA's district boundary. Located in the western area of Arapahoe County, the SMFRA serves a large portion of the County's urban population.

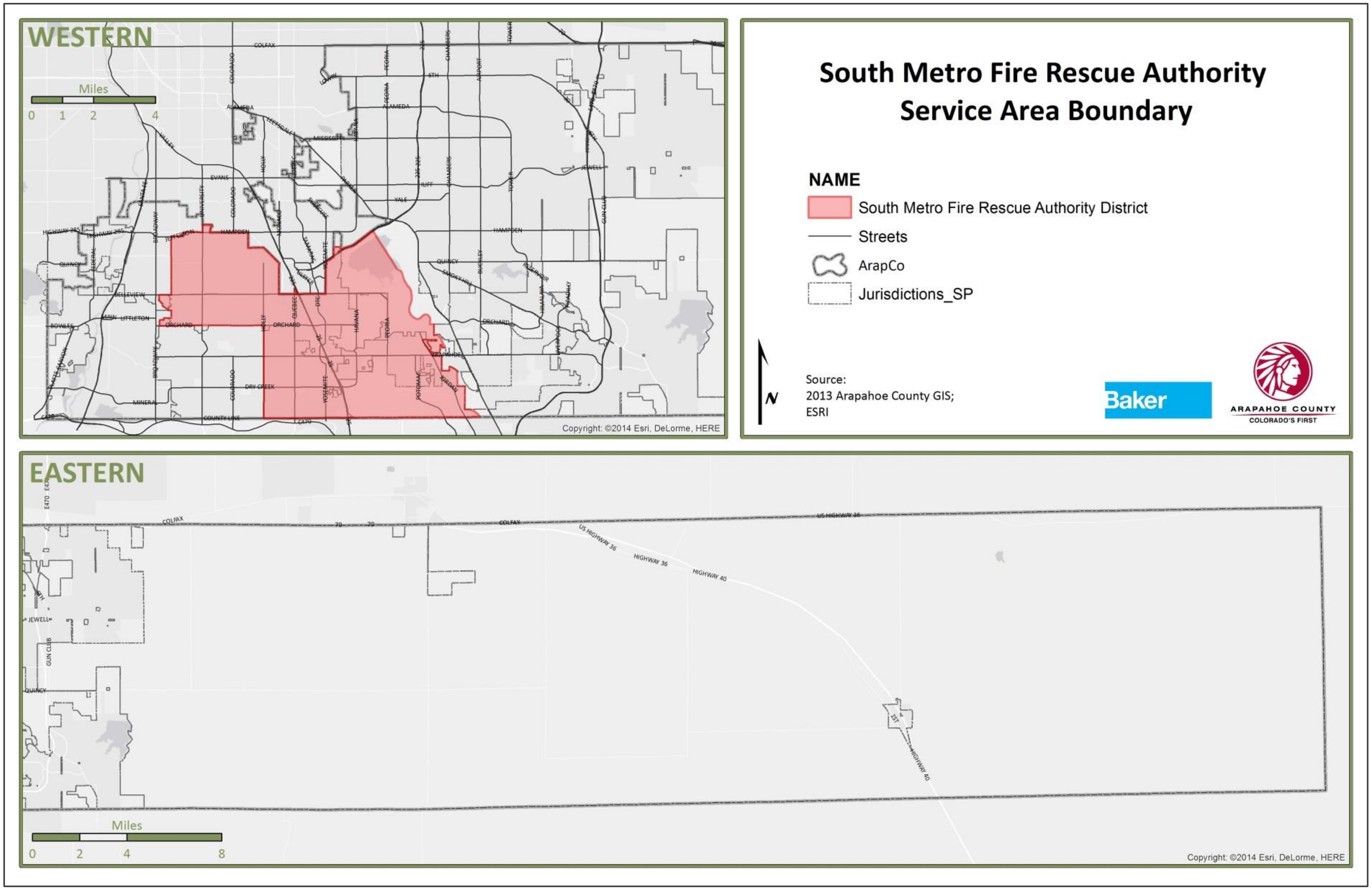


Figure 2. South Metro Fire Rescue Authority Service Area Boundary

The 2010 Regional Natural Hazard Mitigation Plan addressed fourteen (14) natural hazards. Each hazard was assessed by previous occurrences, vulnerability, and exposure to County and municipal assets, and potential loss estimates (if applicable). In addition, the 2010 Plan defined those hazards that were considered to have the highest probability of occurrence. The update to the 2010 Plan was initiated in January 2014 with funding support from a Colorado State Hazard Mitigation Program (SHMP) Grant. Michael Baker International, Inc. (located in Lakewood, Colorado) provided planning support and guidance to Arapahoe County throughout the Plan update process.

The planning process used for the 2015 Plan update was based on Section 322 of the Disaster Mitigation Act of 2000 and supporting guidance developed by FEMA. The planning process followed these steps:

- Conduct kickoff meeting with the Arapahoe County Local Emergency Planning Committee (LEPC)
- Conduct a 5-year Plan review
- Conduct a Hazard Risk Factor exercise
- Establish a Mitigation Planning Work Group (MPWG) made up of local stakeholders and subject matter experts
- Review and update the local hazard, risk, and vulnerability summary
- Determine capability for the county and each municipality
- Update the mitigation strategy
- Update the Plan maintenance procedures
- Complete a draft plan for review by the Mitigation Planning Work Group (MPWG)
- Advertise opportunity/hold public meeting for comment on final draft
- Provide final draft to DHSEM for review
- Provide final draft to FEMA for review
- Present Plan to municipalities for adoption
- Present Plan to Arapahoe County for adoption

Each of the planning steps described above resulted in key products and outcomes that collectively make up the Multi-Hazard Mitigation Plan. These work elements are further discussed below for introductory purposes.

The *Community Profile*, located later in this chapter, describes the general makeup of Arapahoe County and its municipalities, including prevalent geographic, demographic, and economic characteristics. This baseline information provides a snapshot of the countywide planning area and thereby assists participating officials in recognizing those social, environmental, and economic factors that ultimately play a role in determining community vulnerability to natural hazards.

The *Hazard Identification and Risk Assessment* (*HIRA*), found in Chapter 2, focuses on three elements for each identified hazard: *Hazard Identification/Profile*, *Hazard Analysis* and a *Vulnerability/Loss Assessment*. Together, these elements serve to identify, analyze, and assess Arapahoe County's overall risk to natural and human-caused hazards. The HIRA builds on available historical data from previous occurrences, establishes hazard-by-hazard profiles, and culminates in a hazard risk priority or ranking based on conclusions about the frequency of occurrence, potential impact, spatial extent, warning time, and duration of each hazard. FEMA's Hazus loss estimation software was also used in evaluating known flood and earthquake risks according to their relative long-term cost, measured in expected damages. The HIRA is designed to assist communities in seeking the most appropriate mitigation actions to pursue and implement by focusing their efforts on those hazards of greatest concern and those structures or planning areas facing the greatest risk(s).

The *Community Profile and HIRA* collectively serve as a basis for establishing goals for this Plan, each contributing to the development, adoption, and implementation of a meaningful *Mitigation Strategy* update that is based on accurate background information.

The *Mitigation Strategy*, located in Chapter 3, consists of broad goal statements as well as specific mitigation actions for each jurisdiction participating in the planning process. This updated strategy provides the foundation for detailed *Mitigation Action Plans* that link jurisdictionally-specific mitigation actions to locally assigned implementation mechanisms. Together, these sections are designed to make the 2015 Plan more strategic and functional through the identification of both long-term goals and near-term actions that will guide day-to-day decision-making and project implementation.

In addition to the identification and prioritization of possible mitigation projects, emphasis has been placed on the use of program and policy alternatives to help make Arapahoe County and participating municipalities less vulnerable to the damaging forces of nature while improving the economic, social, and environmental health of the community. The concept of multi-objective planning is emphasized throughout this Plan, identifying ways to link hazard mitigation policies and programs with complimentary community goals that may be related to housing, economic development, community revitalization, recreational opportunities, transportation improvements, environmental quality, land development, and public health and safety. This Multi-Hazard Mitigation Plan should be seen as a proactive document that represents a concerted effort to make Arapahoe County and participating jurisdictions more livable communities.

The *Plan Implementation, Capabilities, and Maintenance* procedures, found in Chapter 4, includes the measures Arapahoe County and participating jurisdictions will take to ensure the Plan's continuous long-term implementation. The procedures also include the manner in which the Plan will be regularly monitored, reported upon, evaluated, and updated to remain a current and meaningful planning document. Local capabilities are outlined in this section to highlight strengths and areas of improvement related to personnel, planning capacity, and ongoing risk-reduction efforts.

THE PLANNING TEAM

A well-rounded community-based planning team contributed heavily to the development of this Plan. Arapahoe County engaged members of the pre-existing Local Emergency Planning Committee (LEPC), as well as local government officials, public stakeholders, and Arapahoe County residents in local meetings and planning workshops to discuss and complete tasks associated with preparing the Plan. The Mitigation Planning Work Group (MPWG) was created after the initial kick-off meeting and consisted of members of the LEPC, as well as public stakeholders and Arapahoe County staff. Members of the MPWG participated in the risk assessment, mitigation strategy development, plan review, public outreach, and plan maintenance strategy.

The participants listed in the following Table represent the members of the LEPC and MPWG who were responsible for participating in the updating of this Plan.

Table 1. 2015 Arapahoe County LEPC and MPWG Members

2015 Arapahoe County Local Emergency Planning Committee Members
NAME, AGENCY/JURISDICTION
Lt. Nathan Fogg, Arapahoe County Sheriff's Office, OEM
Chris Garner, Arapahoe County Sheriff's Office, OEM
Ashley Cappel, Arapahoe County Sheriff's Office, OEM
Karl Ditus, Arapahoe County Sheriff's Office, OEM
Bill Oliver, Littleton Fire
Eric Eddy, City of Centennial
Marianne Schilling, City of Centennial
Rick Boyer, Centura Health
Dylan Larrson, Tri-County Health Department
Clinton Anderson, Tri-County Health Department
Laura Herblan, Englewood Fire Department
Rose Lynch, Englewood OEM
Ken Killip, South Metro Fire Rescue Authority
Jerry Rhodes, Cunningham Fire Protection District
Greg Thornton, Arapahoe County Sheriff's Office, OEM
Arapahoe County Mitigation Planning Work Group Members
NAME, AGENCY/JURISDICTION
Veronica Moody, Tri-County Health Department
Randy Councell, Cherry Creek School District
Troy Schlichting, Arapahoe Douglas Mental Health Network
Mike Disher, Byers Fire
Matt Hilinski, Sable Altura Fire
Ashley Cox, Aurora OEM
Kevin Kay, Arapahoe County Sheriff's Office, OEM

Earl Cumley, Bennett Fire
Caleb Connor, Bennett Fire
Tim McCawley, Bennett Fire
Ken Brink, CO DHSEM
Kerry Webster, CO DHSEM
Brian Lewis, Arapahoe County Public Airport Authority (ACPAA)
Lorie Hinton, Arapahoe County Public Airport Authority (ACPAA)
Jim Olsen, Littleton Fire Department, OEM
Chuck Haskins, Arapahoe County Engineering Services Division
Christine Rabe, American Red Cross
Marianne Schilling, City of Centennial
Stacey Thompson, SEMSWA Floodplain Manager
Steve Standridge, South Metro Fire Rescue Authority
Michael Garner, Project Manager, Michael Baker Jr., Inc.
Enessa Janes, Lead Planner , Michael Baker Jr., Inc.
Invited, but not in attendance:
Allen Peterson, Arapahoe County Road and Bridge
Andrew Marsh, Englewood Fire
Bill Lane, Heritage Eagle Bend Homeowner's Association
Chuck Graham, South Metro Fire Rescue Authority
Dan Qualman, South Metro Fire Rescue Authority
Dan Vilkofsky, Cherry Creek School District
David Mallory, Urban Drainage and Flood Control District
Debra Kirsten, Arapahoe County Council on Aging
Mel Harris, Arapahoe County Council on Aging
Monica Gardner, Arapahoe County Council on Aging
Denise McNeill, Home Builders Association
Gary Atkin, Arapahoe County Water and Wastewater Authority
Guy Grace, Littleton Public School District
James Katzer, Arapahoe County Public Works
John Brackney, South Metro Denver Chamber
John Tarbert, Regional Transportation District

Julie Baxter, FEMA Region VIII – Mitigation Division

Ken Killip, South Metro Fire Rescue Authority

Mark Boddy, Arapahoe County Amateur Radio Emergency Services

Mark Campbell, Sheridan Police Department

Rebecca Mayer, Metro Denver Homeless Initiative

Robert Glancy, NOAA

Sherry Manson, The Salvation Army

Sherry Wailes, Eastern Soil Conservation District

Tim Cox, Cunningham Fire

Tim Aston, CSU Extension

All members of the LEPC were also included as members of the MPWG. After the initial LEPC kick-off meeting the MPWG was assembled for meetings and plan development throughout all phases of the planning process. The MPWG reviewed drafts of the 2010 Plan, identified new information that needed to be included in the 2015 Plan update and incorporated it as required by state and federal guidelines. The MPWG was also tasked with collecting all accurate data from plan participants and provided outreach to the public and business stakeholders to ensure that everyone's information was included in this Plan.

PLANNING MEETINGS AND DOCUMENTATION

The preparation of the Plan update required a series of meetings and workshops intended to facilitate discussion and initiate data collection efforts with local community officials. More importantly, the meetings and workshops prompted continuous input and feedback from local officials throughout the update process.

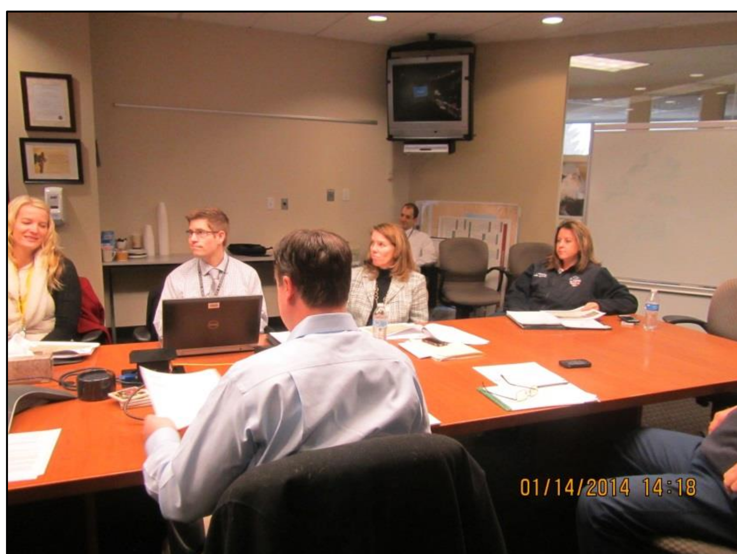


Figure 3. LEPC Meeting

Below is a summary of the key meetings and workshops conducted throughout the development of the 2015 Arapahoe County Multi-Hazard Mitigation Plan. Sign-in sheets and minutes (when available) are provided in Appendix A.

FIRST MEETING / LEPC MEETING AND PLANNING KICK-OFF

The first mitigation planning meeting was held during an Arapahoe County Local Emergency Planning Committee (LEPC) meeting at the South Metro Fire Rescue Authority headquarters in Centennial, CO on January 14th, 2014.

The intent of the meeting was to introduce the mitigation planning update project to the LEPC, to explain the DMA 2000 planning requirements, and to present a project timeline to the planning committee. The meeting also initiated preliminary data collection efforts for the HIRA summary associated with the Plan update as the planning committee took time to decide on a list of hazards to profile in the plan.

The kickoff meeting began with introductions and a presentation on the mitigation planning process led by the county's contractor for this Plan development project, Michael Baker Jr., Inc. (the Baker Team). Specific data collection needs were thoroughly explained, including the need for accurate GIS data as well as any unique local hazard risk data available for specific areas of concern.

During their presentation, the Baker Team led a brief discussion on a 5-Year Plan Review exercise. Ten questions were posed to the LEPC pertaining to the current plan, the 2010 Denver Regional Natural Hazard Mitigation Plan (hereafter referred to as the 2010 Plan). The ten questions are as follows:

- Do the goals and actions contained in the 2010 Plan address current and expected conditions in Arapahoe County?
- Has the nature or magnitude of hazard risk changed in Arapahoe County since the adoption of the 2010 Plan?
- Are current resources (regional and/or local) adequate to implement the mitigation actions in the 2010 Plan?
- Should additional local resources be committed to address identified hazard threats?
- Are there any issues that have limited the implementation schedule of the 2010 Plan?
- Has the implementation of identified mitigation actions in Arapahoe County resulted in expected outcomes?
- How effective have completed hazard mitigation projects in Arapahoe County been in terms of specific dollar losses avoided?
- Within Arapahoe County, did the jurisdictions, agencies, and other partners participate in the implementation of the 2010 Plan as proposed?
- Which steps or processes pertaining to hazard mitigation planning present the biggest challenge for communities in Arapahoe County?
- What are some examples of strengths and weaknesses in the 2010 Plan?

Figure 4. LEPC Meeting

Minimal responses were provided to the ten questions during the meeting, primarily due to the group's unfamiliarity with the 2010 Plan and a lack of defined mitigation actions and plan maintenance procedures. An online survey containing the same 10 questions was later sent out to the LEPC and to members of the MPWG in an attempt to solicit more comments.

LEPC members did offer general comments on the planning process and what they would like to see implemented moving forward. The most salient comments and suggestions include:

- It is important to the LEPC that the 2015 Arapahoe County Hazard Mitigation Plan is integrated with existing local hazardous materials plans.
- The LEPC expressed a strong desire to customize the 2015 Plan at the local jurisdiction scale.
- Members of the committee commented that GIS resources are available at the county level to assist with risk analysis.
- Although the 2015 Plan is specific to Arapahoe County, the Plan should follow the structure of the recently approved 2013 Colorado State Hazard Mitigation Plan as closely as possible in order to facilitate resource integration and strategy implementation.

In addition to the 5-Year Plan Review discussion, the Baker Team introduced the hazard prioritization and risk factor activity to the LEPC. The LEPC reviewed the hazards that were profiled and assessed as part of the 2013 State Hazard Mitigation Plan. After discussing options for the upcoming 2015 plan, the LEPC decided to profile the following nine hazards:

- **Atmospheric Hazards**
    - Drought
    - Extreme Temperatures (Hot and Cold)
    - Flooding
    - Severe Storms (Hail/Lightning/Snow & Ice)
    - Severe Wind/Tornado
- **Geologic Hazards**
    - Earthquake
    - Erosion/Land Subsidence
- **Other**
    - Wildfire
    - Public Health Hazards

After the Kickoff Meeting, the Baker Team created a public project website and two online surveys: a 5-Year Plan Review Survey and a Hazard Risk Survey.

The Hazard Risk Survey was provided as a follow-up to the LEPC meeting on January 14th. The online survey was designed to solicit direct input from LEPC members related to various hazard risks in Arapahoe County. A total of 14 LEPC respondents participated in the Risk Survey.

Using the "Risk Factor" (RF) approach, LEPC members evaluated the nine identified hazards and ranked them by their relative risk to people and property in Arapahoe County. The RF approach combines historical data, local knowledge, and consensus opinions to produce numerical values that allow several hazards to be ranked against one another (the higher the RF value, the greater the hazard risk). RF values are obtained by assigning varying degrees of hazard risk across five factors:

- Probability
- Impact
- Spatial Extent
- Warning Time
- Duration

Using the Risk Factor rating methodology (detailed in Chapter 2), the Hazard Risk Survey guided the committee through ranking the hazards for the 2015 Plan as shown in table below.

Table 2. Mitigation Planning Risk Factor Exercise Results (February 2014)

Hazard	Probability	Impact	Spatial Extent	Warning Time	Duration	Risk Factor Value
Severe Storm	1.1	0.5	0.6	0.2	0.2	2.7
Extreme Temperature	1.0	0.5	0.7	0.1	0.3	2.7
Drought	0.9	0.5	0.6	0.1	0.4	2.4
Severe Wind/Tornado	0.8	0.6	0.4	0.4	0.1	2.3
Wildfire	0.8	0.5	0.4	0.4	0.2	2.3
Public Health Hazard	0.6	0.5	0.5	0.2	0.3	2.2
Flood	0.7	0.5	0.5	0.3	0.2	2.2
Earthquake	0.4	0.5	0.5	0.4	0.1	1.9
Erosion/Land Subsidence	0.5	0.3	0.3	0.2	0.3	1.5

Based on the results of the Risk Factor exercise, the LEPC determined that Severe Storms, Extreme Temperatures, Drought, Severe Wind/Tornadoes, Wildfire, Floods, and Public Health Hazards are the hazards with the highest local risk.

Figure 5. Mitigation Planning Work Group (MPWG) Meeting (April 24, 2014)

SECOND MEEETING / MPWG MEETING AND RISK ASSESSMENT REVIEW

A second planning meeting was conducted on the morning of April 24th, 2014 in Arapahoe County. During this meeting, 19 members of the Mitigation Planning Work Group (MPWG) met at the Arapahoe County Sheriff's Office to review the results of the county-wide multi-hazard risk assessment. The intent of the meeting was to share the risk assessment methodology, data, and results with the MPWG. Additionally, new risk communication tools were shared with the MPWG for continued mitigation planning outreach efforts.

The Baker Team presented a detailed overview of the quantitative risk assessment results and invited stakeholders and subject matter experts to ask questions and provide feedback.

In addition to discussing the results of the hazard rick assessment, the Baker Team presented the results of the online surveys and familiarized the group with an online GIS tool for mapping multi-hazard risks in Arapahoe County. The online mapping tool allowed community stakeholders to navigate the county and zoom in on various neighborhoods and regions to assess their local risk. An open question and answer session followed the presentation.

Before the meeting concluded, the Baker Team explained the process of developing a mitigation strategy, including goal development, objectives, and potential mitigation actions as an introduction to the next MPWG meeting.

THIRD MEETING / MPWG MITIGATION STRATEGY DEVELOPMENT

In early June, 2014, the MPWG met again to develop the Arapahoe County Multi-Hazard Mitigation Strategy. At this meeting the MPWG reviewed the current mitigation goals, objectives, and strategies outlined in the 2010 Denver Regional Natural Hazard Mitigation Plan in order to develop a revised framework to meet Arapahoe County's goals. The meeting was facilitated by the planning team from Michael Baker Jr., Inc.

To begin, the MPWG went through an in-depth evaluation of the current mitigation goals, objectives, and actions included in the 2010 Plan. The MPWG worked together to determine which goals and objectives were applicable to the County and its jurisdictions and what new goals and actions should be included in the 2015 Plan. Additionally, several new mitigation actions were added to the plan (see Chapter 3 for a list of new and ongoing mitigation actions). A summary of this evaluation can be found in Chapter 3 of this Plan.

Figure 6. Mitigation Strategy Meeting (June 11, 2014)

As a final exercise, the Baker Team led the group through a STAPLEE evaluation of the 2010 on-going mitigation actions and new proposed 2015 mitigation actions (results of the STAPLEE review are included in Chapter 3). STAPLEE is a systematic evaluation and prioritization method used to assess whether existing and potential alternative mitigation actions fulfill the plan's objectives and whether they are appropriate for the planning area. STAPLEE stands for Social, Technical, Administrative, Political, Legal, Economic, and Environmental and the framework provides a systematic approach to weighing the pros and cons of potential mitigation actions. FEMA recommends using the STAPLEE framework because it comprehensively addresses the major factors important to weighing the costs and benefits of implementing one action over another.

The table below summarizes each of the seven STAPLEE characteristics by highlighting the considerations taken when weighing one mitigation action against another.

Table 3. STAPLEE Evaluation Summary

Evaluation Category	Consideration
Social	• Effects on a specific segment of the population • Disruption of communities • Impact on community values • Impact on cultural resources
Technical	• Technically Feasible • Long-term solution • Secondary impacts
Administrative	• Capability (staffing levels and training) • Funding availability • Maintenance/Operations oversight
Political	• Political support • Public support • Local champion or proponent
Legal	• Existing local authority • State Authority • Action potentially subject to legal challenge
Economic	• Cost effectiveness • Contribution to economic goals
Environmental	• Affects land/water resources • Effect on endangered species • Effect on HAZMAT/waste sites • Consistent with applicable environmental laws • Consistent with community's environmental goals

The STAPLEE method was adapted for the 2015 Arapahoe County Plan to include a higher weighting for one element of the economic feasibility factors – Cost Effectiveness. The purpose of this weighting was to meet County goals by prioritizing those mitigation actions with a more attractive economic cost/benefit profile.

FOURTH MEETING / PUBLIC ENGAGEMENT MEETING

A fourth planning meeting was conducted on the evening of August 21st, 2014, in the Arapahoe County Sheriff's Office in Centennial, CO. During this meeting, members of the MPWG met with the public in the Community Room to discuss the 2015 Plan update process. The planning team introduced the mitigation planning project to the general public and reviewed both the multi-hazard risk assessment and the draft mitigation strategies for the County. The goals of the public engagement were three-fold:

- To inform community members about multi-hazard risks,
- To educate community members about the purpose of mitigation planning and options for local risk reduction, and
- To gather feedback from the public on the draft mitigation strategies and alternatives for improvement.

Figure 7. Public Meeting 1 (August 21, 2014)

The county's contractor, Michael Baker, Jr., presented a detailed overview of the results of the local hazard, risk, and vulnerability analysis results and summarized the mitigation strategy for the public, including goals, objectives, and proposed actions. Attendees were given opportunities throughout the meeting to ask questions, add comments, and provide feedback related to the planning process and results.

FIFTH MEETING / PUBLIC ENGAGEMENT MEETING

A fifth planning meeting (and second public engagement meeting) was conducted on the evening of August 28th, 2014, at the Deer Trail Fire building. During this meeting, members of the MPWG met with the public in to discuss the 2015 Plan update project. The planning team introduced the mitigation planning project to the general public and reviewed both the multi-hazard risk assessment and the draft mitigation strategies for the County. Again, the goals of the public engagement meeting were three-fold:

- To inform community members about multi-hazard risks,
- To educate community members about the purpose of mitigation and options for local risk reduction, and

Figure 8. Public Meeting 2 (August 28, 2014)

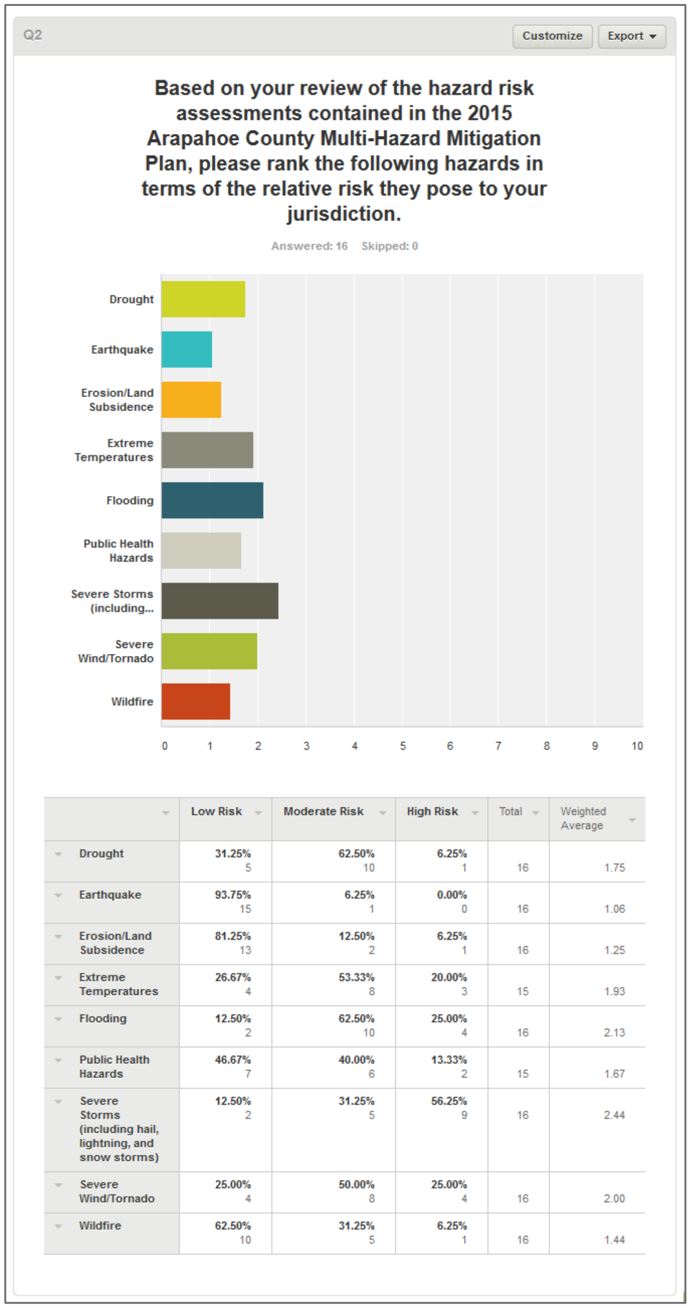
- To gather feedback from the public on the draft mitigation strategies and alternatives for improvement.

The county's contractor, Michael Baker Jr., again presented a detailed overview of the results of the local hazard, risk, and vulnerability analysis results and summarized the mitigation strategy for the public, including goals, objectives, and proposed actions. Attendees were given opportunities throughout the meeting to ask questions, add comments, and provide feedback related to the planning process and results.

FINAL PARTICIPATING JURISDICTION COORDINATION AND OUTREACH

In order to ensure the full engagement and participation of local jurisdictions in the hazard mitigation planning process, the Sheriff's Office coordinated with the State and with the County's contractor to reach out individually to participating jurisdictions and gather meaningful data including local risk and vulnerability information, mitigation priorities, specific mitigation actions/projects, and strategies for integrating hazard mitigation into local planning mechanisms and policies.

The planning team distributed a web-based survey to all local jurisdictions with questions about local risks and vulnerabilities, priorities, capacities, and existing planning mechanisms. All participating jurisdictions used this opportunity to assess their unique hazard risks. They reviewed the County's risk assessment results and hazard maps, drilled down, and took the data into account when identifying their mitigation actions. All participating jurisdictions completed the survey and mitigation action planning in consultation with the Sheriff's Office.



	Low Risk	Moderate Risk	High Risk	Total	Weighted Average
Drought	31.25% 5	62.50% 10	6.25% 1	16	1.75
Earthquake	93.75% 15	6.25% 1	0.00% 0	16	1.06
Erosion/Land Subsidence	81.25% 13	12.50% 2	6.25% 1	16	1.25
Extreme Temperatures	26.67% 4	53.33% 8	20.00% 3	15	1.93
Flooding	12.50% 2	62.50% 10	25.00% 4	16	2.13
Public Health Hazards	46.67% 7	40.00% 6	13.33% 2	15	1.67
Severe Storms (including hail, lightning, and snow storms)	12.50% 2	31.25% 5	56.25% 9	16	2.44
Severe Wind/Tornado	25.00% 4	50.00% 8	25.00% 4	16	2.00
Wildfire	62.50% 10	31.25% 5	6.25% 1	16	1.44

Figure 9. Example of Jurisdiction Survey Results

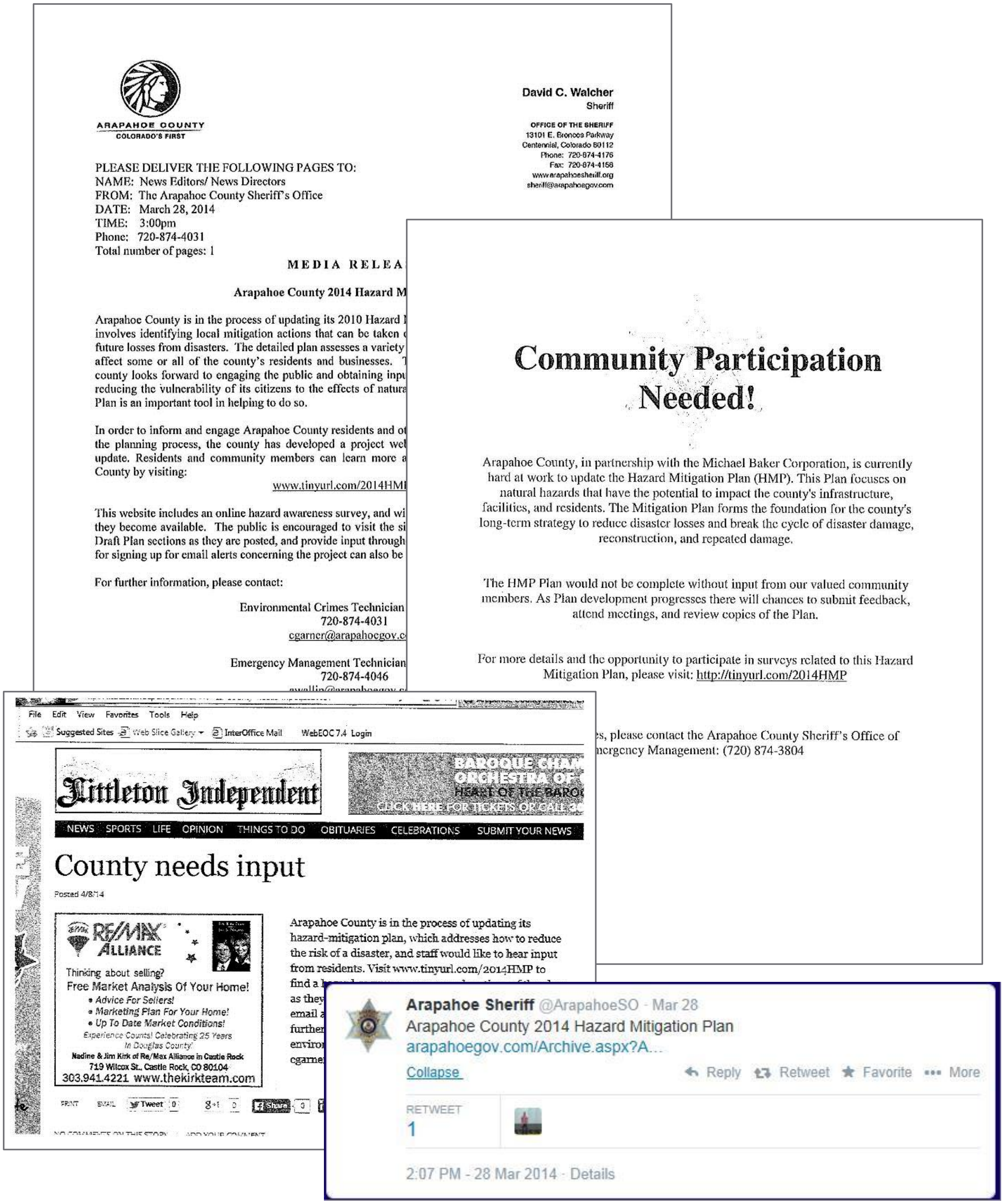
PUBLIC AND STAKEHOLDER PARTICIPATION

An important component of the success of Arapahoe County's community-based mitigation planning process involved ongoing public, stakeholder, and jurisdiction participation. Individual citizen involvement provides the LEPC and MPWG with a greater understanding of local concerns and ensures a higher degree of mitigation success by developing community "buy-in" from those directly affected by the planning decisions of public officials.

Public input was sought throughout the planning process by advertising open public meetings through the following outlets:

- Local newspapers and bulletins across the county
- Social media networks (including agency and municipal Twitter and Facebook accounts)
- Online agency websites (including the Arapahoe County website)

The following page includes examples of a number of the planning announcements and public meeting invitations created and distributed by members of the MPWG. Multiple media platforms were used in order to reach and engage the maximum number of local and regional stakeholders. Communication pathways included printed newspapers and neighborhood newsletters, social media outlets including Twitter and Facebook, and County and local jurisdiction websites and email lists.



ARAPAHOE COUNTY
COLORADO'S FIRST

David C. Walcher
Sheriff

OFFICE OF THE SHERIFF
13101 E. Broncos Parkway
Centennial, Colorado 80112
Phone: 720-874-4176
Fax: 720-874-4158
www.arapahoesheriff.org
sheriff@arapahoegov.com

PLEASE DELIVER THE FOLLOWING PAGES TO:
NAME: News Editors/ News Directors
FROM: The Arapahoe County Sheriff's Office
DATE: March 28, 2014
TIME: 3:00pm
Phone: 720-874-4031
Total number of pages: 1

MEDIA RELEA

Arapahoe County 2014 Hazard M

Arapahoe County is in the process of updating its 2010 Hazard involves identifying local mitigation actions that can be taken future losses from disasters. The detailed plan assesses a variety affect some or all of the county's residents and businesses. county looks forward to engaging the public and obtaining inpu reducing the vulnerability of its citizens to the effects of natura Plan is an important tool in helping to do so.

In order to inform and engage Arapahoe County residents and o the planning process, the county has developed a project we update. Residents and community members can learn more County by visiting:

www.tinyurl.com/2014HM

This website includes an online hazard awareness survey, and wi they become available. The public is encouraged to visit the si Draft Plan sections as they are posted, and provide input through for signing up for email alerts concerning the project can also be

For further information, please contact:

Environmental Crimes Technician
720-874-4031
cgarner@arapahoegov.c

Emergency Management Technician
720-874-4046

Community Participation Needed!

Arapahoe County, in partnership with the Michael Baker Corporation, is currently hard at work to update the Hazard Mitigation Plan (HMP). This Plan focuses on natural hazards that have the potential to impact the county's infrastructure, facilities, and residents. The Mitigation Plan forms the foundation for the county's long-term strategy to reduce disaster losses and break the cycle of disaster damage, reconstruction, and repeated damage.

The HMP Plan would not be complete without input from our valued community members. As Plan development progresses there will chances to submit feedback, attend meetings, and review copies of the Plan.

For more details and the opportunity to participate in surveys related to this Hazard Mitigation Plan, please visit: http://tinyurl.com/2014HMP

s, please contact the Arapahoe County Sheriff's Office of nergency Management: (720) 874-3804

File Edit View Favorites Tools Help
Suggested Sites Web Slice Gallery InterOffice Mail WebEOC 7.4 Login

Littleton Independent

NEWS SPORTS LIFE OPINION THINGS TO DO OBITUARIES CELEBRATIONS SUBMIT YOUR NEWS

County needs input

Posted 4/8/14

Arapahoe County is in the process of updating its hazard-mitigation plan, which addresses how to reduce the risk of a disaster, and staff would like to hear input from residents. Visit www.tinyurl.com/2014HMP to find a

PRINT EMAIL Tweet 0 8+1 0 Share 0

Arapahoe Sheriff @ArapahoeSO · Mar 28
Arapahoe County 2014 Hazard Mitigation Plan
arapahoegov.com/Archive.aspx?A...
Collapse Reply Retweet Favorite More
RETWEET
1
2:07 PM - 28 Mar 2014 · Details

Figure 10. Examples of Planning Announcements for Public Stakeholder Input

Additionally, a website was created to provide information to public stakeholders and to obtain feedback on the 2015 Arapahoe County Hazard Mitigation Plan Update.[1] In addition to providing hazard mitigation information, announcements and calendar information, the draft Plan was posted on the website. Community members were encouraged to share their input, photos and experiences for use during the hazard mitigation planning process. The screen shot below provides a visual of the project website.

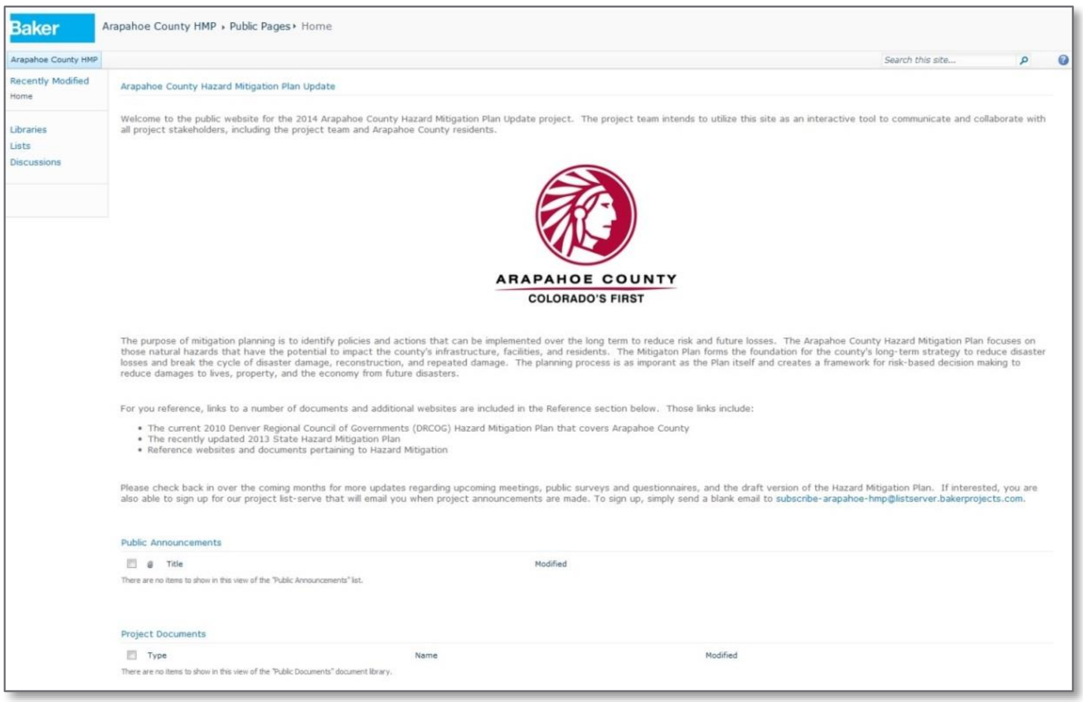


Figure 11. Project Website and Public Engagement Platform

In addition to a project website, the Baker Team combined the data from the results of the risk assessment to create a series of online maps. Available to the public on the internet, the maps served as a tool for analyzing hazards and patterns of risk at various scales within Arapahoe County. The online maps were also designed as an outreach tool and were used to communicate risk and to ground-truth quantitative risk assessment results at local public meetings throughout the planning process. The Figure below provides a screen shot of the online mapping tool. Available layers are visible on the left hand side of the screen.

[1] The project website was discontinued upon completion of the Plan update.

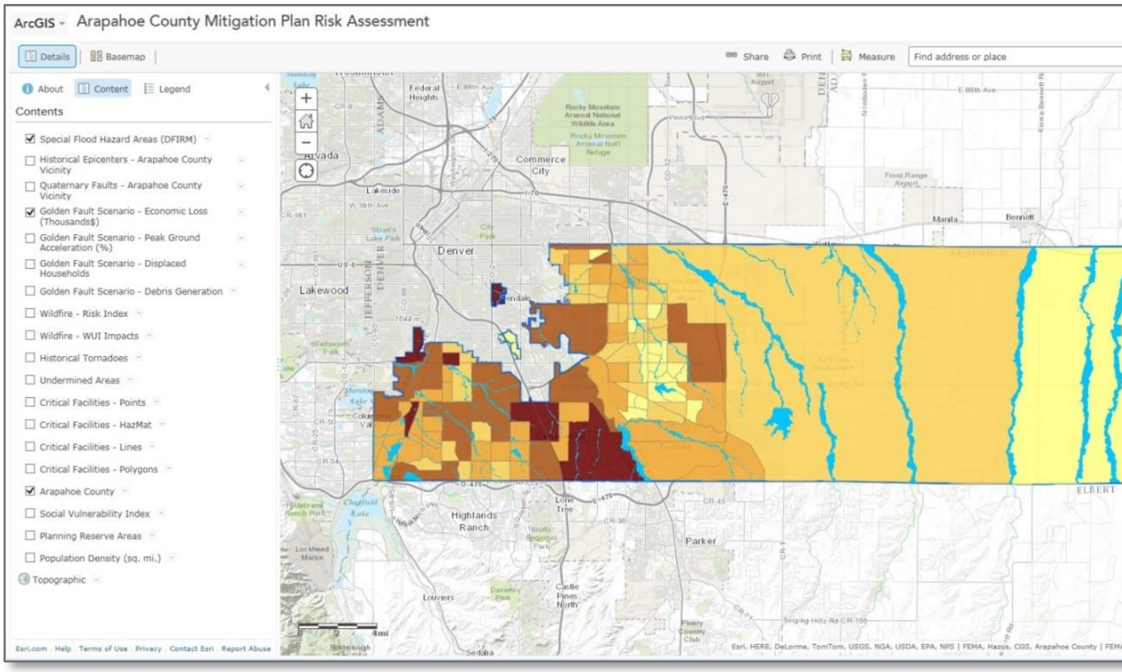


Figure 12. Public Portal for Online Risk Assessment Mapping

As an additional public outreach effort, the Arapahoe County Sheriff's office staffed a Community Resources booth during the Arapahoe County Fair (July 24th – 27th, 2014). Preparedness materials were provided to County Fair visitors, including *Ready, Set, Go* preparedness booklets. Booth visitors were also informed of the local hazard mitigation planning process, the community website, and upcoming opportunities to provide input and participate.

Figure 13. The Sheriff's Office Community Resources Booth at the Arapahoe County Fair (July 2014)

Figure 14. Preparedness materials available at the Sheriff's Office booth (2014 Arapahoe County Fair)

MULTI-JURISDICTIONAL PLANNING AND PARTICIPATION

The 2015 Arapahoe County Multi-Hazard Mitigation Plan is a multi-jurisdictional plan and includes the participation of County officials and the following incorporated communities of Arapahoe County:

- Town of Bennett
- Town of Bow Mar
- City of Centennial
- City of Cherry Hills Village
- Town of Columbine Valley
- Town of Deer Trail
- City of Englewood
- Town of Foxfield
- City of Glendale
- City of Greenwood Village
- City of Littleton
- City of Sheridan

At the time of this writing, the City of Aurora was moving forward with developing a Hazard Mitigation Plan independent of Arapahoe County. Aurora did, however, still participate in the planning efforts for the 2015 Arapahoe County Multi-Hazard Mitigation Plan. To satisfy multi-jurisdictional participation requirements, each of the local jurisdictions listed above was required to perform the following tasks:

(1) Designate a representative to serve on the Arapahoe County LEPC/MWPG;
(2) Participate in mitigation planning meetings and workshops;
(3) Provide best available data as required for the update to the local hazard, risk, and vulnerability summary section of the Plan;
(4) Determine capability and provide copies of any mitigation or hazard-related documents for review and incorporation into the Plan;
(5) Support the update of the current countywide mitigation strategy, including the evaluation, design and adoption of general goal statements for all jurisdictions to pursue;
(6) Review and provide timely comments on all draft components of the Plan update;
(7) Adopt the 2015 Arapahoe County Multi-Hazard Mitigation Plan, including the local mitigation action plan(s) specific to their jurisdiction.

Through the completion of these tasks, twelve jurisdictions along with Arapahoe County participated in developing this Plan. Additionally, all participants reviewed and provided timely comments on all draft components of the Plan. See the following Table below.

Table 4. 2010 and 2015 Multi-Jurisdictional Hazard Mitigation Plan Participation

JURISDICTION	PARTICIPATION IN 2010 DRGOG HMP	PARTICIPATION IN 2015 ARAPAHOE COUNTY HMP	2015 ADOPTION DATE
Arapahoe County	•	•	[INSERT DATE]
City of Aurora	•	Aurora is developing their own LHMP.	n/a
Town of Bennett	•	•	[INSERT DATE]
Town of Bow Mar		•	[INSERT DATE]
City of Centennial	•	•	[INSERT DATE]
City of Cherry Hills Village	•	•	[INSERT DATE]
Town of Columbine Valley		•	[INSERT DATE]
Town of Deer Trail		•	[INSERT DATE]
City of Englewood	•	•	[INSERT DATE]
Town of Foxfield		•	[INSERT DATE]
City of Glendale		•	[INSERT DATE]
City of Greenwood Village	•	•	[INSERT DATE]
City of Littleton	•	•	[INSERT DATE]
City of Sheridan	•	•	[INSERT DATE]

STAKEHOLDER PARTICIPATION

It should be noted that per Colorado revised Statues;

Each county shall maintain a disaster agency or participate in a local or inter-jurisdictional disaster agency which, except as otherwise provided under this part 7, has jurisdiction over and serves the entire county.

The disaster agency of a county shall cooperate with the disaster agencies of municipalities situated within its borders but shall not have jurisdiction within a municipality having its own disaster agency.

Due to this, Arapahoe County Office of Emergency Management has responsibility for the following jurisdictions in addition to the unincorporated part of the county;

- Town of Bennett
- Town of Bow Mar
- City of Centennial
- City of Cherry Hills Village
- Town of Columbine Valley
- Town of Deer Trail[2]
- Town of Foxfield
- City of Sheridan

Arapahoe County Office of Emergency Management works closely with the following OEM's in the following jurisdictions:

- City of Aurora
- City of Englewood
- City of Glendale
- City of Greenwood Village
- City of Littleton

A range of public and private stakeholders, including agencies, local businesses, nonprofits, and other interested parties were invited to participate in the development of the 2015 Plan. Stakeholder involvement was encouraged through Arapahoe County's invitations to agencies and individuals to actively participate in Mitigation Planning Work Group (MPWG) meetings and to interact with the planning materials and surveys posted on the project website. The invitation and attendance of these stakeholders at the MPWG meetings are documented in the following Table.

Additionally, the County consulted with the State to ensure the full engagement and participation of all participating jurisdictions in the plan development process. These efforts included individual phone calls

[2] See Appendix C for follow-up participation documentation

and meetings, web-surveys and risk assessment review, and discussions about local capabilities, planning mechanisms, and mitigation action implementation strategies specific to the needs and vulnerabilities of local jurisdictions.

Table 5. Stakeholder Involvement in the Planning Process

ORGANIZATION	CONTACT	ATTENDED MEETING(S)
Arapahoe County Public Airport Authority	Brian Lewis	•
Arapahoe County Public Airport Authority	Lorie Hinton	•
ACWWA	Gary Atkin	
American Red Cross	Christine Rabe	•
Arapahoe County Council on Aging (ACCOA)	Debra Kirsten	
Arapahoe County Infrastructure Manager	--	
Arapahoe County Road and Bridge	Allen Peterson	
Arapahoe County Public Works and Development	Chuck Haskins	•
Arapahoe County Sheriff's Office: OEM	Ashley Cappel	•
Arapahoe County Sheriff's Office: OEM	Chris Garner	•
Arapahoe County Sheriff's Office: OEM	Kevin Kay	•
Arapahoe County Sheriff's Office: OEM	Lt. Nathan Fogg	•
Arapahoe/Douglas Mental Health Network	Troy Schlichting	•
Arapahoe County Amateur Radio Emergency Service (ARES)	Mark Boddy	
Bennett Fire Department	Earl Cumley	•
Bennett Fire Department	Tim McCawley	•
Bennett Fire Department	Caleb Connor	•
Byers Fire Rescue	Mike Disher	•
Centennial Airport Authority	Robert Olislagers	•
Centura Health: OEM	Rick Boyer	•
Chamber of Commerce	John Brackney	
Cherry Creek School District	Randy Councell	•
City of Centennial	Marianne Schilling	•
Colorado Coalition for the Homeless	--	
Colorado Water Conservation Board	--	
CSU Extension	Tim Aston	
Cunningham Fire Department	Jerry Rhodes	•
Deer Trail Conservation District (Soil Conservation)	Sherry Wailes	
Deer Trail Fire	Rich Loveless	
Englewood Fire Department	Rose Lynch	•
EPA	--	
Heritage Eagle Bend HOA	Bill Lane	
Home Builders Association	Denise McNeill	
Intermountain Rural Electric Association	Alex Mendez	
Littleton Fire Department/OEM	Jim Olsen	•
Littleton Public Schools	Guy Grace	
Metro Denver Homeless Initiative	Rebecca Mayer	
NOAA/NWS	Bob Glancy	
Plains Conservation Center	Melanie Zeitler	
Rocky Mountain Human Services	--	
Sable Altura Fire Department	Matt Hilisnki	•

ORGANIZATION	CONTACT	ATTENDED MEETING(S)
Salvation Army	Sherry Manson	
SEMSWA: Floodplain Planner	Stacey Thompson	•
Sheridan Police Department	Mark Campbell	
South Metro Fire Rescue Authority	Steve Standridge	•
State of Colorado	Kerry Webster	•
State of Colorado Mitigation Team Supervisor	Ken Brink	•
Strasburg Fire Department	Stan Shuck	
Tri County Health Department	Veronica Moody	•
Urban Drainage and Flood Control District	David Mallory	
Xcel Energy	Matt Ziska	•

EXISTING PLANNING MECHANISMS

There are numerous existing regulatory and planning mechanisms in place at the state and county levels of government which support hazard mitigation planning efforts. These tools include the State of Colorado Hazard Mitigation Plan, county subdivision regulations and road and bridge standards, the Arapahoe County Comprehensive Land Use Plan, and local zoning regulations. These mechanisms were discussed at mitigation planning meetings and the Arapahoe County MPWG reviewed all available technical information and had incorporated them into this Plan update. Moving forward, the local jurisdictions included in the 2015 Arapahoe County Multi-Hazard Mitigation Plan will continue to integrate the goals and actions of the Plan into their evolving local planning mechanisms, including comprehensive plans, capital improvement plans and resource and land use regulation.

The State of Colorado mitigates natural hazards by way of diverse statutes and programs. Funded by the state and federal government, several agencies and programs within the state implement mitigation actions through assistance to local governments. State statues that are applicable to hazard mitigation are listed below:

- County Fire Planning Authority, Colorado Statute, Title 30, Article 11, Part 1:30-11-124
- Colorado Land Use Commission Authority, Colorado Revised Statute, 24-65-101 & 102
- Colorado Land Use Commission Directives & Duties, Colorado Revised Statutes, 25-65-105 & 24-65-104
- County Building Codes – Master Plan, Colorado Statute, Title 30, Article 28, Part 1:30-28-106
- Local Government Land Use Control Enabling Act, Colorado Revised Statute, 29-20-101, *et seq*
- Local Land Use Control and Regulation, Colorado Revised Statute, 29-20-104
- Colorado Wildfire Preparedness Plan and Fund, Colorado Revised Statute 24-30-310(2)(3)
- Fire Suppression Program Rules, Colorado Revised Statute, 24-33.5-1205(1) (a)
- State Fire Ban Authority, Colorado Revised Statute, 24-30-308
- Colorado Geological Survey (CGS), Colorado Statute, 34-1-1-1 & 103
- CGS Land Use Review Program (Subdivision Law), Colorado Revised Statute, 30-28-101, *et seq*
- Soils & Hazard Analyses of Residential Construction Act, Colorado Revised Statute, 6-6.5-101
- Drought Mitigation Planning, Colorado Revised Statute, 37-60-126.5

- Building Codes – Zoning – Planning, Colorado Revised Statute, 22-32-124(1)
- Colorado Floodplain Management Authority, Colorado Revised Statute, 24-65.1-403(1)
- Emergency Dam Repair Cash Fund, Colorado Revised Statute, 37-60-122.5
- Flood Response Fund, Colorado Revised Statute, 37-60-123.2
- Office of Smart Growth, Colorado Revised Statute, 24-32-3201 *et seq*
- State Engineer – High Hazard Dams Reports, Colorado Revised Statute, 37-87-123
- State Planning and Interest, Colorado Revised Statute, 24-65.1-203

Colorado Statute includes a number of measures that dictate the state's ability to influence land use decisions and subsequently impact local vulnerability to hazards. In most cases, these statutes allow county level and local governments to establish their own rules and regulations.

Arapahoe County's risk and vulnerability reduction efforts are supported by additional planning efforts, including the following:

- The Arapahoe County Comprehensive Plan (2001 and 2015)
- Colorado Emergency Resource Mobilization Plan (2012)
- State of Colorado Emergency Operations Plan (2013)
- State of Colorado EOP Emergency Support Function Annexes (2013):
    - ESF# 1 Transportation
    - ESF # 2 Communications
    - ESF # 3 Public Works and Engineering
    - ESF # 4 Firefighting
    - ESF # 5 Emergency Management
    - ESF # 6 Mass Care, Housing, and Human Services
    - ESF # 7 Resource Support
    - ESF # 8 Public Health and Medical Services
    - ESF # 8 A Behavioral Health
    - ESF # 9 Search and Rescue
    - ESF # 10 Oil and Hazardous Materials Response
    - ESF # 11 Agriculture and Natural Resources
    - ESF # 12 Energy
    - ESF # 13 Public Safety and Security
    - ESF # 14 Long-Term Community Recovery and Mitigation
    - ESF # 15 External Affairs
- State of Colorado EOP Supporting Annexes (2013):
    - Evacuation
    - Geographic Information Systems (GIS)
    - International Coordination
    - Public Affairs
    - Tribal Relations
    - Volunteer and Donations Management

- State of Colorado EOP Incident Annexes (2013):
  - Drought Incident
  - Tornado Incident
  - Mass Casualty Incident
  - Earthquake Incident
  - Landslide and Debris Flow Incident
  - Flood Incident
  - Winter Incident
  - Terrorism, Law Enforcement, and Investigation Incident
  - Cyber Incident
  - Biological Incident
  - Chemical Stockpile Emergency Preparedness Program Incident
- The Eastern Arapahoe County Community Wildfire Protection Plan (2012)
- The 2010 Arapahoe County Land Development Code

Arapahoe County entered the Regular Program of the National Flood Insurance Program (NFIP) in 1977. Since then, the County has adopted the minimum NFIP requirements and imposed additional requirements into its Zoning Regulations and Land Development Code. These additional requirements were adopted for consistency with the rules and procedures of the Arapahoe County Stormwater Management Manual and the Urban Drainage and Flood Control District (UDFCD) Urban Storm Drainage Criteria Manual to provide a higher level of floodplain management than required by FEMA. The Arapahoe County Planning Commission, with support from the Planning Division of Public Works and Development, follows local subdivision regulations and refers to the current Land Use Plan when reviewing development plans and amendments to the Land Development Code.

In the future, this plan will serve as a source document and will be incorporated into existing planning mechanisms as they are updated or developed. These planning mechanisms enhance the county's mitigation strategy and are therefore incorporated into several of the mitigation actions identified in this Plan. For example, floodplain ordinances in Arapahoe County serve to guide development away from hazardous areas while local stormwater management plans reduce the effects of erosion due to increased runoff.

During the planning process, the planning team worked with local jurisdictions to identify ways in which identified mitigation actions/projects will be incorporated into their existing planning and regulatory mechanisms over time. The results of these conversations and planning activities are described in Chapter 4.

COMMUNITY PROFILE

Not only is Arapahoe County Colorado's first county, it is also one of the largest counties in the state. The City of Denver was the original county seat until 1902 when the city split off and became a separate county. The City of Littleton became the new Arapahoe County seat and remains the county seat today.

The Arapahoe County base map shown in the following map provides an overview of the geographic area of the county. It includes prominent features including interstate highway paths, US highways, municipalities and water bodies.

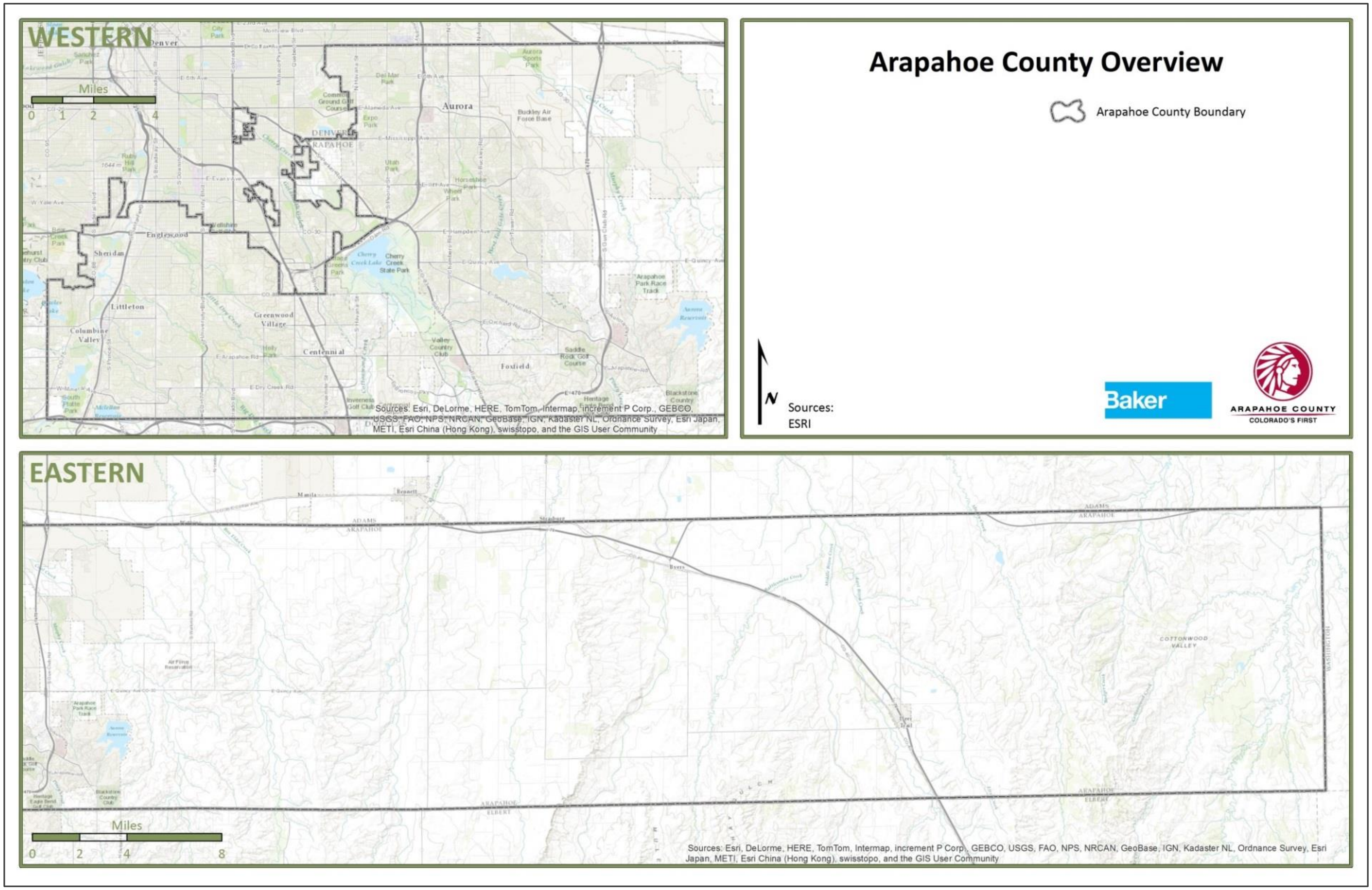


Figure 15. Map of Arapahoe County, Colorado

Arapahoe County, located in the South Denver Metro area, spans 809 square miles. A land of diverse ecosystems and communities, the western reaches of the county are primarily urban, with residential, retail, office, and industrial development. The eastern area of Arapahoe County consists of primarily agricultural and rural development.

Arapahoe County is the third most populated county in Colorado (behind Denver and El Paso Counties). In 2013, the Colorado Division of Local Government, Demography Section, estimated that the total population of Arapahoe County was 602,868. This represents a 23% increase in population since 2000. The population of Arapahoe County is expected to grow by another 7.4% (or 44,697 people) by 2018. The City of Aurora contains just under half of the county's total population.

Table 6. Population in Arapahoe County, 2000 - 2018

Area	2000	2010	2013	2014	2015	2016	2017	2018
Unincorporated Arapahoe County	49,265	84,066	88,250	89,609	90,900	92,154	93,446	94,793
Aurora	237,328	286,754	301,270	305,910	310,318	314,597	319,010	323,606
Bennett	8	354	373	379	384	390	395	410
Bow Mar	597	591	617	626	635	644	653	662
Centennial	101,377	100,694	10,5175	106,795	108,334	109,827	111,368	112,972
Cherry Hills Village	5,975	6,014	6,278	6,375	6,467	6,556	6,648	6,744
Columbine Valley	1,142	1,260	1,318	1338	1,357	1,376	1,395	1,415
Deer Trail	594	548	572	581	589	598	606	615
Englewood	31,877	30,354	31,674	32,162	32,626	33,075	33,539	34,023
Foxfield	719	687	723	734	744	755	765	776
Glendale	4,516	4,197	4,382	4,450	4,514	4,576	4,640	4,707
Greenwood Village	11,623	13,978	14,659	14,884	15,099	15,307	15,522	15,745
Littleton	40,170	39,640	41,375	42,012	42,617	43,205	43,811	44,442
Sheridan	5,531	5,682	6,202	6,297	6,388	6,476	6,567	6,662
Total:	**490,722**	**574,819**	**602,864**	**612,152**	**620,974**	**629,535**	**638,367**	**647,563**

Source: Colorado Demography Office; 2013 Arapahoe County Housing Needs Assessment

The map shown in the following Figure shows population densities across Arapahoe County in 2012.

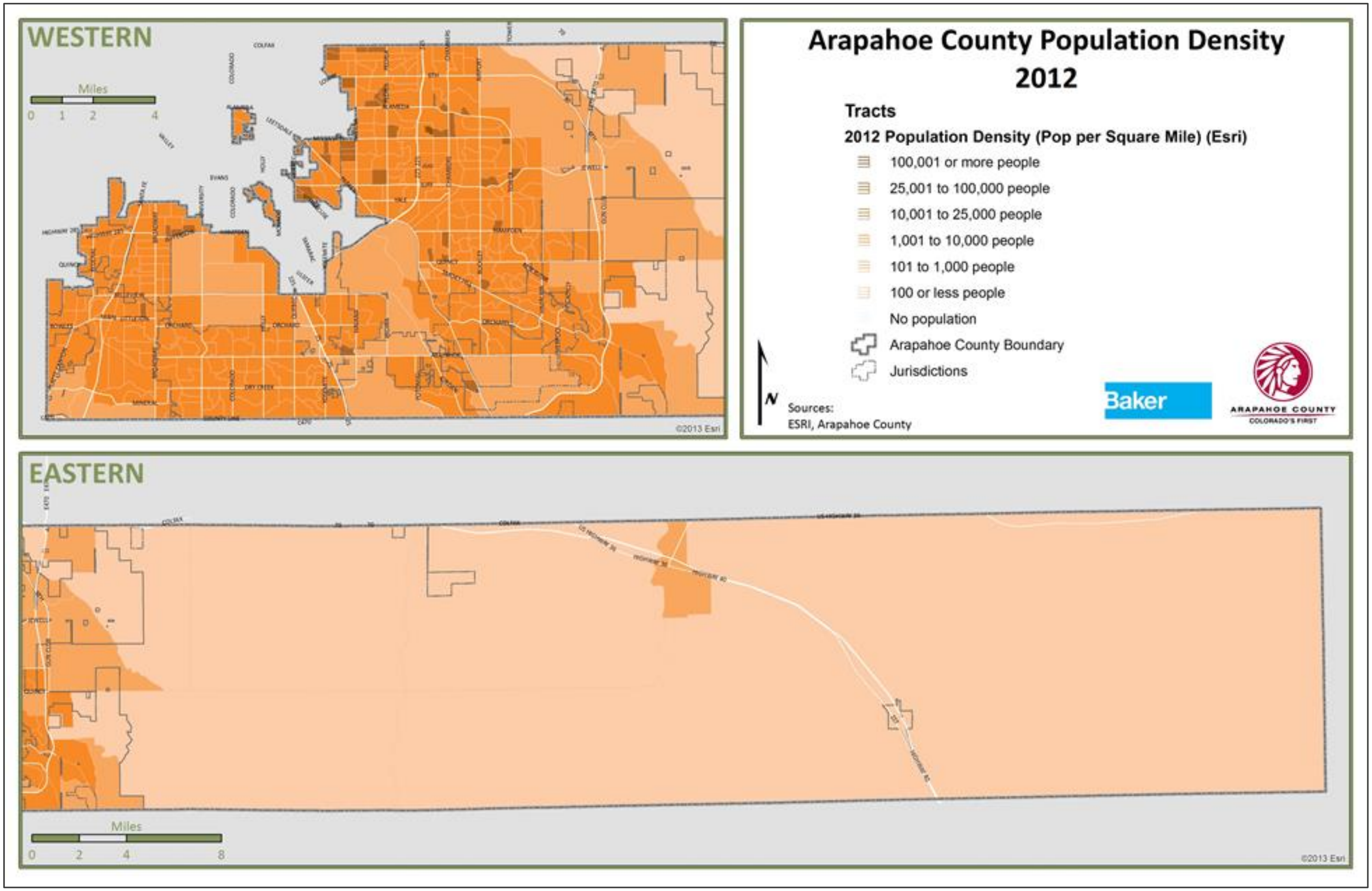


Figure 16. Map of Population Density in Arapahoe County

Population densities are the highest in the western region of Arapahoe County. In contrast, the eastern region of the County is largely rural, with population densities of 100 people or less per square mile.

The majority of employment and income in Arapahoe County are generated from the following key economic sectors:

- Construction
- Finance
- Administration and Waste Management
- Health Services
- Retail Trade
- Government

Major state highways cross the county from east to west (I-70, US Highway 36, and US Highway 40). The Union Pacific Railroad also passes through the county at the west edge and runs parallel to I-70 before it exits at the eastern border of the county. Several petroleum lines intersect the county. This includes an interstate high pressure gas line that runs diagonally through the county. Eastern Arapahoe County is home to multiple high pressure gas and gas by-product underground lines. The companies of ownership include:

- Colorado Interstate Gas
- ConocoPhillips Pipeline, Colorado
- NuStar Logistics
- DCP Midstream
- Rocky Mountain Pipeline System, LLC

In August 2013, the unemployment rate in Arapahoe County was 6.6%, slightly lower than the State unemployment rate of 6.8% (U.S. Bureau of Labor Statistics). Arapahoe County is adjacent to the City and County of Denver, Adams County, Washington County, Lincoln County, Elbert County, Douglas County, and Jefferson County. Many residents commute across county boundaries for work. The top five commuting destinations by workers living in Arapahoe County are as follows (DRCOG Arapahoe County Community Profile):

1. Arapahoe County
2. Denver County
3. Adams County
4. Douglas County
5. Jefferson County

The table below provides an economic and demographic snapshot of Arapahoe County in contrast to the broader Metro Denver Region.

Table 7. Economic and Demographic Snapshot

	Arapahoe County	Metro Denver Region
Population	602,868	2,923,386
Median Age	36	38
Percent of Housing Build Before 1980	46%	48%
Median Household Income	$59,937	$56,360
Poverty Rate	9%	19%
Percent of Population > Age 25 with Bachelor's Degree or Higher	38%	41%
Percent of Population with High School Diploma Only	21%	21%

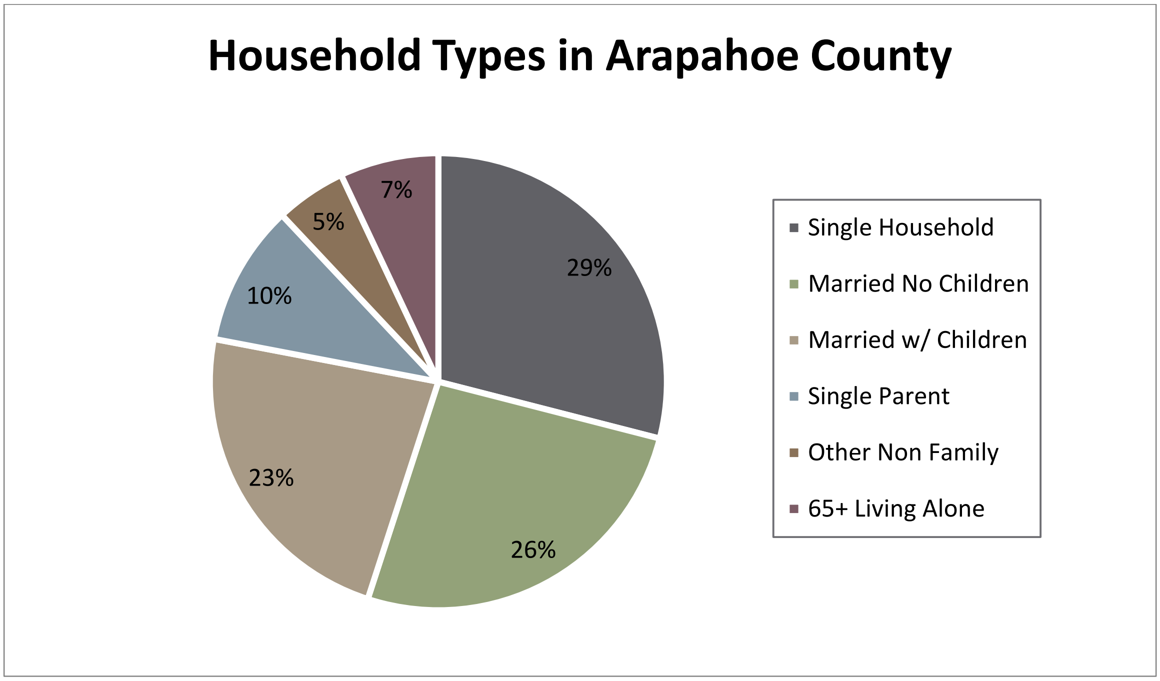
Source: DRCOG Arapahoe County Community Profile (September 2013); Metro Denver Economic Development Corporation 2013 Economic Profile

Below, the County and Regional Housing Snapshot highlights the similarities between Arapahoe County and the Metro Denver Region. Although Arapahoe County has a slightly higher percentage of multifamily housing than the Region, homeownership percentage in the County is comparable to the Region at 65% and 69%, respectively.

Table 8. County and Regional Housing Snapshot, 2013

	Arapahoe County	Metro Denver Region
Households	224,011	1,108,422
Average Household Size	2.53	2.46
Percent of Multifamily Housing	43%	31%
Home Ownership	65%	69%
Owned Vacancy Rate	2%	2%
Rented Vacancy Rate	7%	6%
Number of Single-Family Permits	955	5,961
Number of Multifamily Permits	762	8,978

Source: DRCOG Arapahoe County Community Profile (September 2013); U.S. HUD 2012



Source: DRCOG Arapahoe County Community Profile (September 2013)

Figure 17. Summary of Household Types in Arapahoe County

The majority of households in Arapahoe County consist of single adults (29%). Households with married adults with no children and married adults with children make up 26% and 23% of Arapahoe County households, respectively. 10% of households within Arapahoe County consist of single parents and 7% consist of adults over 65 years old who are living alone.

HOMELESS POPULATION

When it comes to hazards and disasters the homeless are one of the most vulnerable populations. For homeless people, who constitute the poorest of the poor in an urban environment, not only are their lives at constant risk during a hazard event, but they are even less likely to find a place to settle post-disaster. This creates additional emergency response challenges to adequately locate and protect homeless individuals during a hazard event. Identifying and understanding the challenges and resources currently available to the homeless in Arapahoe County is an important step in mitigating losses from disasters and boosting local resilience.

In January of 2013, a Point-In-Time (PIT) count identified a total of 802 homeless persons in Arapahoe County. Seventy percent (70%) of homeless counted in Arapahoe County in 2013 were people with children. In contrast, of the 6,358 homeless people in the Denver metro area in 2013, 58% are people in households with children.[3] At the time of the PIT count, none of the homeless in Arapahoe County were in rural areas. If households living in rural Arapahoe County were homeless, they were seeking services

[3] Source: Metro Denver Homeless Initiative; 2013 Metro Denver Homeless Initiative Point-In-Time Count

in the urban areas of the County. The Table below summarizes 2013 homelessness statistics for Arapahoe County.

Table 9. Arapahoe County Homelessness Statistics

Population	Estimated # of people experiencing homelessness on a given night		Estimated # of people experiencing homelessness each year
	Sheltered	**Unsheltered**	--
Persons in households with Adult(s) and Child(ren)	516	45	842
Persons in households with Only Adults	223	19	363
Chronically Homeless Individuals	17	2	29
Veterans	24	2	39
Unaccompanied Child	0	0	0

Source: Metro Denver Homeless Initiative; 2013 Metro Denver Homeless Initiative Point-In-Time Count

The 2013 Point-In-Time (PIT) count found relatively few chronically homeless individuals in Arapahoe County. 45% of the homeless in Arapahoe County has been homeless only one time, according to the count. Another 26% had been homeless two or three times. Households with unstable housing costs or conditions were found to be the most likely to be homeless multiple times, as well as those with untreated medical issues, substance abuse problems, and/or few job skills. Twenty-nine percent (29%) of the homeless people who were counted in Arapahoe County were employed.

The PIT count identified 201 newly homeless individuals. 40% of the homeless individuals counted by the PIT had been homeless for more than one month and less than one year. Another 28% had been homeless for one to three years, and 6% had been homeless for more than three years. 10% of the homeless individuals counted in the PIT had been homeless for less than a month.

According to the respondents from the Point-In-Time count, the leading causes of homelessness in Arapahoe County are lost jobs, housing costs, mental illness, family problems, and evictions or foreclosures. There were 110 individuals counted who were homeless because of domestic violence issues.

FEMA's "Whole Community" approach to emergency management highlights the importance of leveraging existing networks and relationships to facilitate more effective prevention, protection, mitigation, response, and recovery activities. Many NGOs and faith-based organizations within Arapahoe County are already on the front lines working to provide services for at-risk families and individuals. Below is a list of organizations in Arapahoe County that currently provide shelter and services for the homeless and/or victims of domestic violence.

Table 10. Arapahoe County Support Organizations for the Homeless

Name	Service Description	Capacity	Contact*
Gateway Battered Women's Services	Provides shelter and services for victims of domestic violence.	• 24 bed facility (Aurora) • 15 bed facility (west Arapahoe County, near Englewood)	Phone: 303-343-1856 Crisis Hotline: 303-343-1851
House of Hope	A service of *Family Tree*, is an emergency homeless shelter	• 30 beds	3301 S. Grant St Englewood, CO 80113 303-762-9525
Family Promise	Serves homeless families in Arapahoe County and the Denver metro area; households move between churches in the Denver area	• 5 families or up to 14 individuals at one time • Households can stay for 60 days	303-675-0713
Family Tree	Provides shelter and services for female victims of domestic violence.	• "Women in Crisis" domestic violence emergency shelter, capacity unknown	Confidential location, 24 hour crisis hotline: 303-420-6752
Interfaith Community Services	Provides transitional housing; Rent/mortgage or utility assistance	• Various	3370 S. Irving St. Englewood, CO 80110-1816 303-789-0501
Colorado Coalition for the Homeless	Provides walk-in services for homeless families and individuals including housing referrals, shelter information, Medicaid enrollment, donations and bus tokens when available	• N/A	Help for families: 303-312-9700 Help for individuals and couples without children: 303-293-2217

*Contact information current as of February 2014

Engaging community partners like the ones listed in the table above during the planning and implementation of mitigation strategies will lead to a greater integration of resources from across the

County, a shared understanding of community needs and capabilities, and greater disaster resilience at both the community and State levels.

NON-HOMELESS SPECIAL NEEDS

There are a number of agencies within Arapahoe County that serve people with special needs. These people include the elderly, people with mental, physical, and developmental disabilities, and people with health challenges. While many people with disabilities do not need special assistance, many do during times of disaster.

The Table below provides a profile of the special needs community in Arapahoe County.

Table 11. Disability Status, Arapahoe County

	Percent	Number
Disability	8.8%	49,906
Hearing difficulty	2.6%	15,055
Vision difficulty	1.7%	9,479
Cognitive difficulty	3.2%	18,222
Ambulatory difficulty	4.1%	23,575
Self-care difficulty	1.6%	9,309
Independent living difficulty	3.0%	17,165

Source: US Census Bureau, American Community Survey 2012; Arapahoe County Housing Needs Assessment

In Arapahoe County, 8.8% of the population, or just under 50,000 people, had a disability between 2009 and 2011. People may have more than one self-reported disability in the table above. The most common disabilities were ambulatory difficulty, cognitive difficulty, and difficulty with independent living. People who identify as having ambulatory, hearing, and/or vision difficulty require special assistance when preparing and responding to a disaster. The organizations listed below have potential to be valuable partners in educating special needs populations about hazard mitigation and supporting people with special needs during disaster response and recovery.

Table 12. Arapahoe County Support Organizations for Special Needs, Non-Homeless

Organization	About	Contact*
Developmental Pathways	• Operates 10 group homes in Arapahoe and Douglas Counties for people with developmental disabilities	303-214-3200 11111 E. Mississippi Ave.

Organization	About	Contact*
		Aurora, CO. 80012
Arapahoe/Douglas Mental Health Network	• Provides broad mental health services, including affordable housing	303-730-8858 155 Inverness Dr. West, Suite 200 Englewood, CO 80112
Aurora Mental Health	• Provides broad mental health services, including affordable housing	303-617-2300 11059 E. Bethany Dr., Suite 200 Aurora, CO 80014
Colorado Center for the Blind	• Training for blind adults and children • Short-term housing and independent living training for adults	303-778-1130 2233 W Shepperd Ave., Littleton, CO 80120
HERO Alliance	• Assists people with disabilities to become homeowners • Homebuyer counseling and credit repair	720-941-8901 11177W 8th Ave, Lakewood, CO 80215

*Contact information current as of February 2014

Most of these organizations provide counseling, job training, and housing support for special needs individuals and families. Because they have continued access to special needs populations, these organizations can also be tasked with providing information and resources about hazards and mitigation to their members.

SOCIAL VULNERABILITY

Local vulnerability to disasters depends on more than simply the relationship between a place and its exposure to a hazard. Social and economic factors – like race, age, income, renter status, or institutionalized living – directly affect a community's ability to prepare for, respond to, and recover from hazards and disasters. The concept of social vulnerability helps explain why communities often experience a hazard differently, even when they experience the same amount of physical impacts. Social vulnerability to disasters refers to "the characteristics and situation of a person or group that influence their capacity to anticipate, cope with, resist, or recover from the impact of a hazard" (Wisner et al. 2004)[4] and it is determined by a number of pre-existing social and economic characteristics.

Very often, the impacts of hazards fall disproportionately on the most disadvantaged or marginalized people in a community, including the poor, children, the elderly, the disabled, and racial/ethnic minorities. During emergencies, for example, self-evacuation can be nearly impossible for disabled or

[4] Wisner, B., Blaikie, P., Cannon, T., Davis, I. (2004). At Risk: Natural Hazards, People's Vulnerability and Disasters. London: Routledge.

institutionalized individuals. Additionally, the willingness of an individual/family to invest limited resources in residential mitigation actions is often limited if their home is a rental property. Not only do conditions like these limit the ability of vulnerable groups to get out of harm's way, they also decrease the ability of communities to recover from and thrive in the aftermath of a disaster event.

The Arapahoe County social vulnerability assessment is designed to improve local decision making, hazard prioritization, and emergency management activities. By incorporating social vulnerability into the risk assessments of individual hazards, local communities are able to identify highly vulnerable areas and tailor their mitigation actions to accommodate all members of their community, including the most sensitive groups.

The pre-existing social conditions that contribute to disaster losses can be identified by using social vulnerability indicators. Using methods and indicators identified in the Social Vulnerability Index (SoVI) developed by Cutter et al (2003),[5] an Arapahoe County social vulnerability analysis was carried out at the Block Group scale. Local socioeconomic and demographic data were used to identify spatial patterns in social vulnerability across the county and have been applied to the hazards in the 2015 Arapahoe County Hazard Mitigation Plan.

The Table below outlines the nine social vulnerability indicators that were used in the Arapahoe County social vulnerability analysis. Indicators with plus signs are positively related to social vulnerability levels. For example, communities with higher percentages of people 65 years or older have higher levels of social vulnerability to hazards. Indicators with minus signs are negatively related to social vulnerability levels. Communities with higher per-capita income and higher home values have lower levels of social vulnerability to hazards.

Table 13. Social Vulnerability Indicators

Social Vulnerability Factors	Indicators	Data Set → Table
Age	• Children (Age 18 and under) (+) • Elderly (Age 65 and over) (+)	• ACS 2007-2011 Summary File 1 → P12
Special Needs	• Institutionalized population (nursing, correctional, juvenile detention facilities (+) • Renters (+)	• ACS 2007-2011 Summary File 1 → QT-P13 • ACS 2007-2011 Summary File → P19
Poverty	• Single female head of household (female householder, no husband present with own children) (+)	• ACS 2007-2011 Summary File 1 → P19
Race/Ethnic Minorities	• African American Population (+) • Hispanic Population (+)	• ACS 2007-2011 Summary File 1 → P4

[5] Cutter, S.L., Boruff, B.J., and Shirley, W.L. (2003). Social Vulnerability to Environmental Hazards. Social Science Quarterly, 84:242-261.

Social Vulnerability Factors	Indicators	Data Set → Table
Wealth	• Per-Capita Income (-) • Median Home Value (-)	• ACS 2007-2011 Summary File → P082

American Community Survey 2007-2011 Block Group data was used for the 2015 Arapahoe County Social Vulnerability analysis.

The tables below outline the social vulnerability indicator values for each of the jurisdictions located within Arapahoe County. The higher the indicator value, the more that factor contributes to multi-hazard vulnerability in the community.

Table 14. Social Vulnerability Indicator Values for Arapahoe County:
Age, Special Needs, and Poverty

	Age			Female Householder, no husband, with own children >18 (%)	Persons Below Poverty Level (%)	Renter-occupied housing units (%)	Institutionalized Population (%)
Jurisdiction	5 yrs and under (%)	18 yrs and under (%)	65 yrs and over (%)				
Colorado	**6.8**	**24.4**	**10.9**	**6.0**	**12.9**	**34.5**	**1.2**
Aurora	8.4	27.3	8.9	8.7	16.2	40.1	0.6
Bennett	7.1	30.5	7.2	7.6	5.8	25.5	0.0
Bow Mar	4.3	31.9	16.3	2.8	0.2	2.8	0.0
Centennial	5.3	25.1	11.9	5.1	4.6	16.5	1.6
Cherry Hills Village	4.7	29.4	14.7	2.6	1.9	4.6	0.0
Columbine Valley	4.1	21.1	22.3	1.4	5.1	3.1	0.0
Deer Trail	5.7	26.2	14.8	5.7	5.8	33.9	0.0
Englewood	6.4	18.3	12.5	5.8	14.4	50.9	0.8
Foxfield	4.1	22.6	16.5	2.5	10.5	5.4	1.2
Glendale	5.5	15.5	2.8	4.4	17.2	90.5	0.0

Jurisdiction	Age			Female Householder, no husband, with own children >18 (%)	Persons Below Poverty Level (%)	Renter-occupied housing units (%)	Institutionalized Population (%)
	5 yrs and under (%)	18 yrs and under (%)	65 yrs and over (%)				
Greenwood Village	3.7	24.6	11.7	4.2	3.3	34.8	0.4
Littleton	5.7	21.6	15.8	5.1	11.1	38.1	1.1
Sheridan	7.5	25.7	11.7	9.8	24.6	51.3	0.0

Source: DOLA; Census 2010

Table 15. Social Vulnerability Indicator Values for Arapahoe County: Race/Ethnic Minorities

Jurisdiction	Black or African American (%)	Hispanic or Latino (of any race) (%)
Colorado	**10.2**	**18.4**
Aurora	15.7	28.7
Bennett	0.3	10.7
Bow Mar	0.2	2.9
Centennial	3.3	7.4
Cherry Hills Village	0.9	3.2
Columbine Valley	0.7	2.1
Deer Trail	0.9	1.8
Englewood	2.2	18.1
Foxfield	1.5	3.8
Glendale	7.1	32.3
Greenwood Village	1.6	4.5
Littleton	1.4	12.4
Sheridan	2.8	40.5

Source: DOLA; Census 2010

For the purpose of the Arapahoe County hazard mitigation plan, each social vulnerability variable was weighted equally in the Social Vulnerability Index. The results of the Arapahoe County social vulnerability assessment are displayed on the map in the Figure below. On the map, social vulnerability is represented at the Census Block Group level by 5 classes of vulnerability: Low (bottom 20% of the county), Medium-Low, Medium, Medium-High, and High (top 20% of the county).

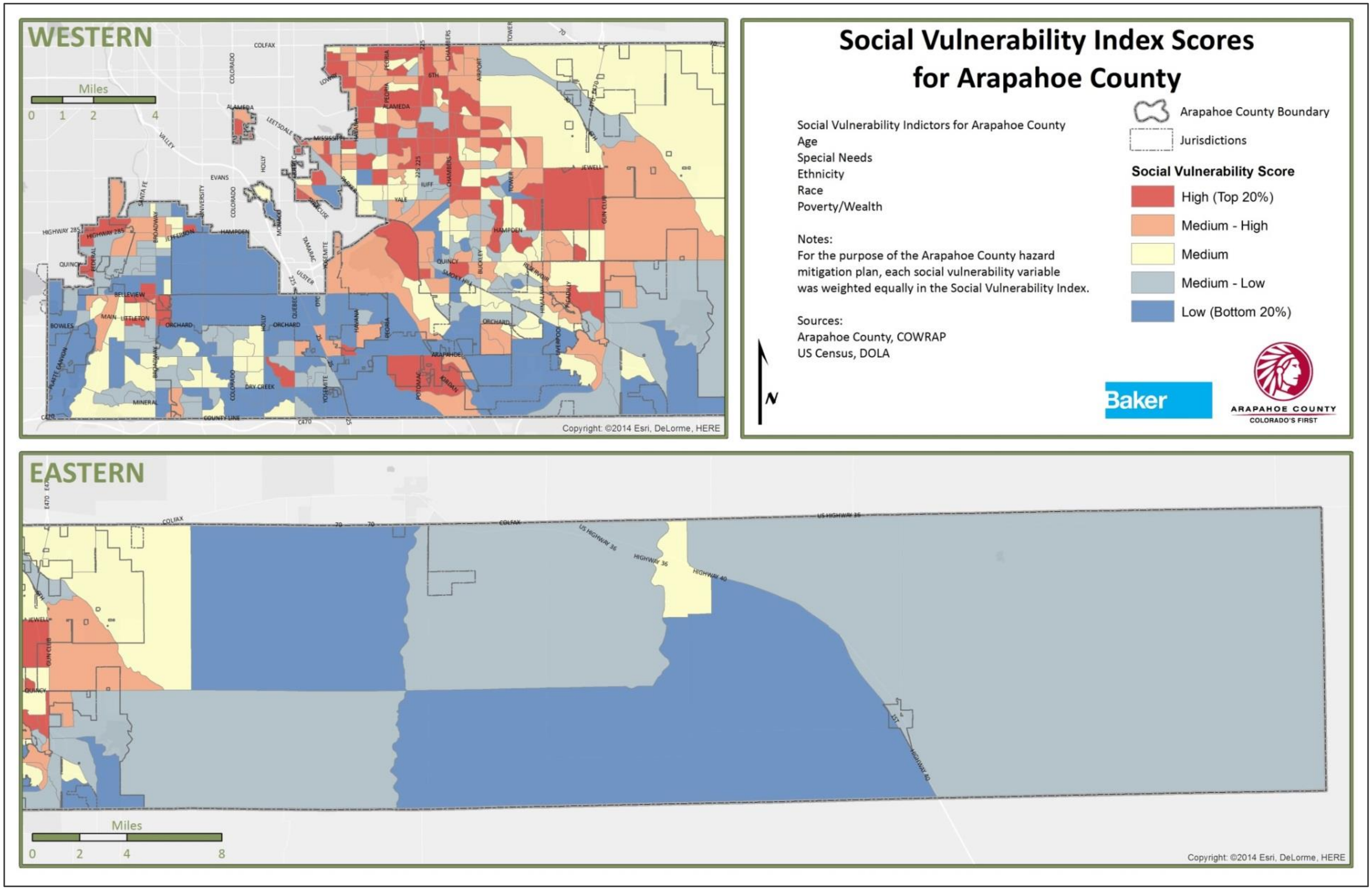


Figure 18. Map of the Arapahoe County Social Vulnerability Assessment

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

FUTURE DEVELOPMENT

A key strategy for reducing future losses in a community is to avoid development in known hazard areas and to enforce the development of safe structures in other areas. The purpose of this strategy is to keep people, businesses, and buildings out of harm's way before a hazard event occurs. The 2015 Arapahoe County Multi-Hazard Mitigation Plan highlights areas where future development can be expected and areas where mitigation options can be considered in future land use decisions to ensure safe, smart growth in the county.

The State Demography Office, a division of the Colorado Department of Local Affairs (DOLA), monitors population growth trends across the state and between counties. The two tables below provide a picture of future population growth rates and numbers within the state, within the Denver primary metro statistical area (PMSA), and within Arapahoe County.

Table 16. Population Forecasts by Region and County, 2000 - 2040

	Average Annual Percent Change							
	00-05	05-10	10-15	15-20	20-25	25-30	30-35	35-40
Colorado	1.4%	1.6%	1.7%	1.9%	1.7%	1.4%	1.3%	1.1%
Denver PMSA	1.6%	1.7%	1.6%	1.6%	1.3%	1.1%	1.0%	0.8%
Arapahoe County	1.5%	1.7%	1.6%	1.6%	1.4%	1.2%	1.1%	0.9%

Source: CO Department of Local Affairs

Table 17. State Demographers Office Population Projections by Region and County (2010 – 2040)

	Population Projections						
	July, 2010	July, 2015	July, 2020	July, 2025	July, 2030	July, 2034	July, 2040
Colorado	5,056,990	5,499,618	6,043,504	6,567,980	7,058,020	7,520,178	7,858,167
Denver PMSA	2,496,876	2,698,398	2,916,364	3,116,560	3,293,253	3,454,144	3,596,523
Arapahoe County	573,857	621,033	671,384	720,240	765,849	807,765	843,613

Source: CO Department of Local Affairs

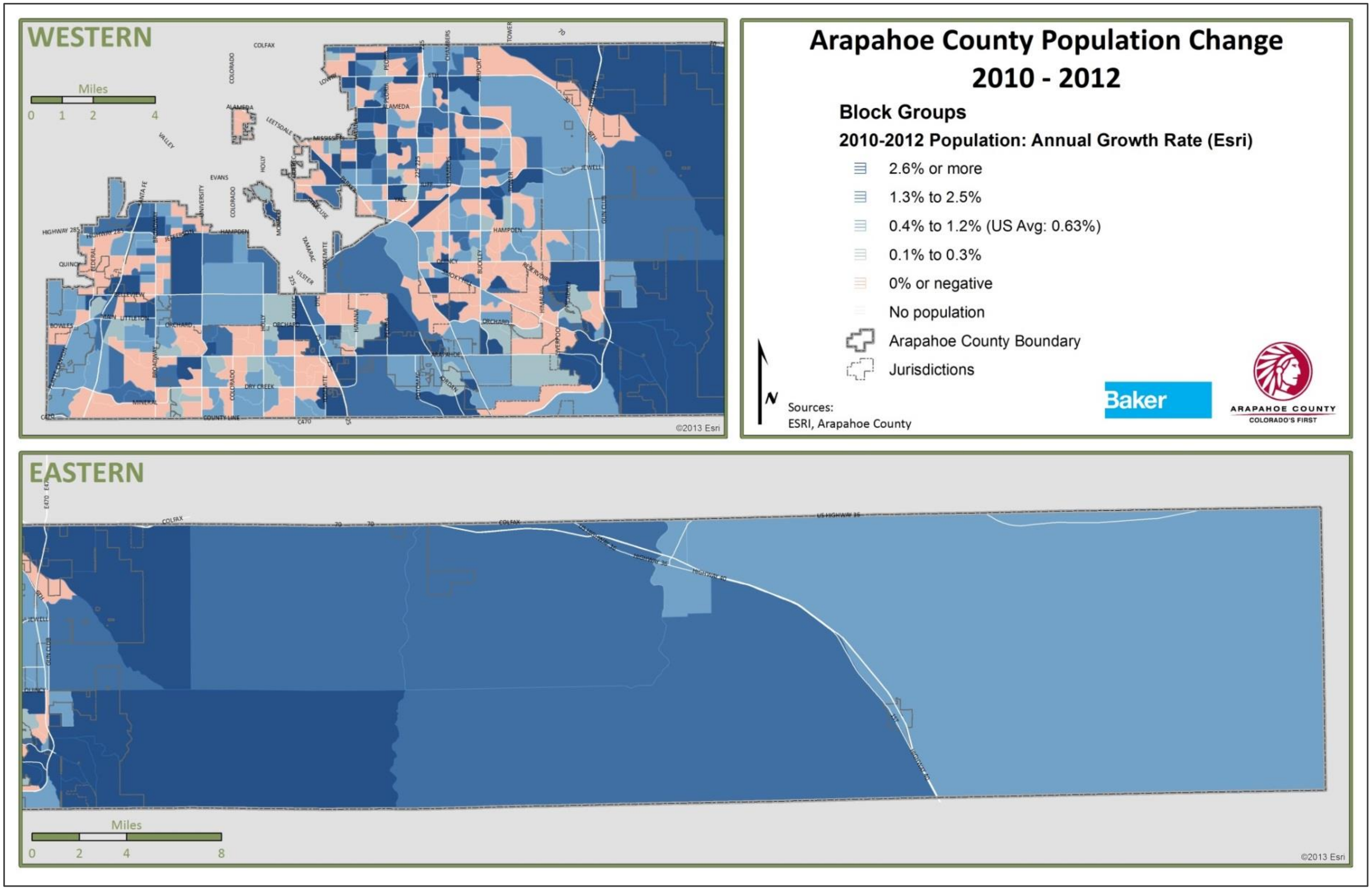


Figure 19. Map of Annual Population Growth Rate (2010 – 2012)

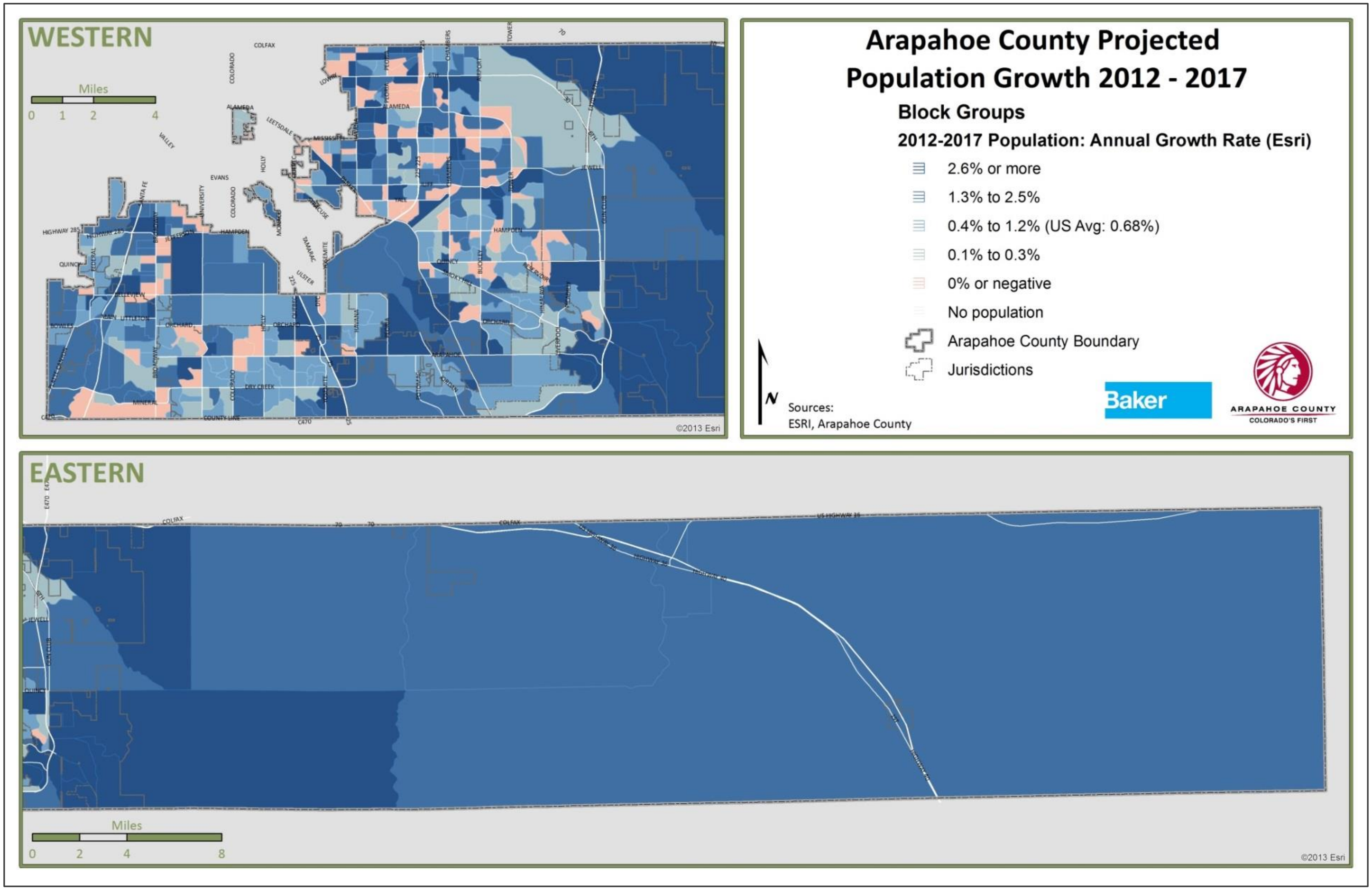


Figure 20. Map of Projected Population Growth (2012-2017)

The population of Arapahoe County is expected to reach over 700,000 by 2025 and almost 850,000 by 2040. This growth is on-par with the relative growth of the state of Colorado and the Denver PMSA. The previous two Figures geographically illustrate annual population growth rates and projected population growth rates at the Block Group scale (respectively).

Arapahoe County has grown significantly in the past decade and is one of the fastest growing counties in the Denver Metro Area. The amount of growth that Arapahoe County has seen over the past decade has been dictated by the availability of undeveloped land. Based on observed population growth trends, housing demand within Arapahoe County is expected to remain steady over the next five years. Since the adoption of the 2010 Denver Regional Natural Hazard Mitigation Plan, new residential and commercial development has continued to occur across the county. The following Table depicts the number of new residential building permits issued annually in Arapahoe County between 1990 and 2012.

Table 18. Annual New, Privately-Owned Residential Building Permits Issued in Arapahoe County

Year	Permits/Buildings	Units
2012	967	1,715
2011	615	805
2010	830	1,279
2009	574	1,172
2008	801	1,764
2007	1,776	3,881
2006	2,791	3,526
2005	3,212	3,986
2004	3,156	3,847
2003	2,431	3,311
2002	3,409	4,805
2001	3,701	7,655
2000	4,442	8,140
1999	4,298	5,728
1998	3,147	4,456
1997	2,708	4,131
1996	2,473	3,213

Year	Permits/Buildings	Units
1995	2,139	3,351
1994	2,478	4,361
1993	2,269	2,951
1992	1,831	2,274
1991	1,084	1,085
1990	654	654

Source: U.S. Census Bureau 2010

Since, 2008, there have been 3,787 permits let for new privately-owned residential buildings in Arapahoe County. The data shows that permit numbers have not increased substantially from year to year over the last five years. As the home sales market recovers from the recent economic recession, it is likely that developers will begin constructing new housing units at volumes on par with development between 2000 and 2007.

According to DRCOG and DOLA population growth forecasts, the demand for developable land for urban density development by 2030 is equal to approximately 8,000 acres.[6] The majority of needed land is for residential development purposes, with commercial and industrial growth accounting for approximately 15 percent of the demand.

Based on information provided by Arapahoe County planning staff for the 2013 Arapahoe County Housing Needs Assessment, and the REAP I-70 Corridor Economic Assessment, there is little empty developable land zoned for housing in the unincorporated areas of the county. In the future, development activity is expected to be focused on the eastern portions of the metro area as land availability and prices become barriers to growth elsewhere (including large-scale established land uses and land reservations). The area most feasible for future development is located in northeastern Arapahoe County, along the I-70 corridor.

The 2013 – 2014 Arapahoe County Comprehensive Land Use Plan illustrates the desired concentration of future urban development in distinct zones within the County. These zones are called Planning Reserve Areas. Planning Reserve Areas are areas designated for a greater mix of uses and higher densities than what is currently being developed across the county. Moreover, the vision of the Planning Reserve Areas is that ample employment opportunities will be available near the places where people live.

The Comprehensive Plan distinguishes Planning Reserve Areas from the parts of the County that will not undergo urban development, at least within the Plan's 20-year time horizon. In places outside of the

[6] REAP I-70 Corridor Economic Assessment (2011). Economic Planning Systems, Inc.

designated Planning Reserve Areas, land is intended for agricultural purposes, open lands, low density rural development, and sensitive development/conservation areas.

The map in the Figure below shows the location of the Planning Reserve Areas identified in the 2013-2014 Arapahoe County Comprehensive Land Use Plan. The I-70 corridor, located in the eastern portion of the county, is an important area of emerging residential (and commercial) growth. It has been designated as a priority area for future development of mixed-use, high-density residential properties.

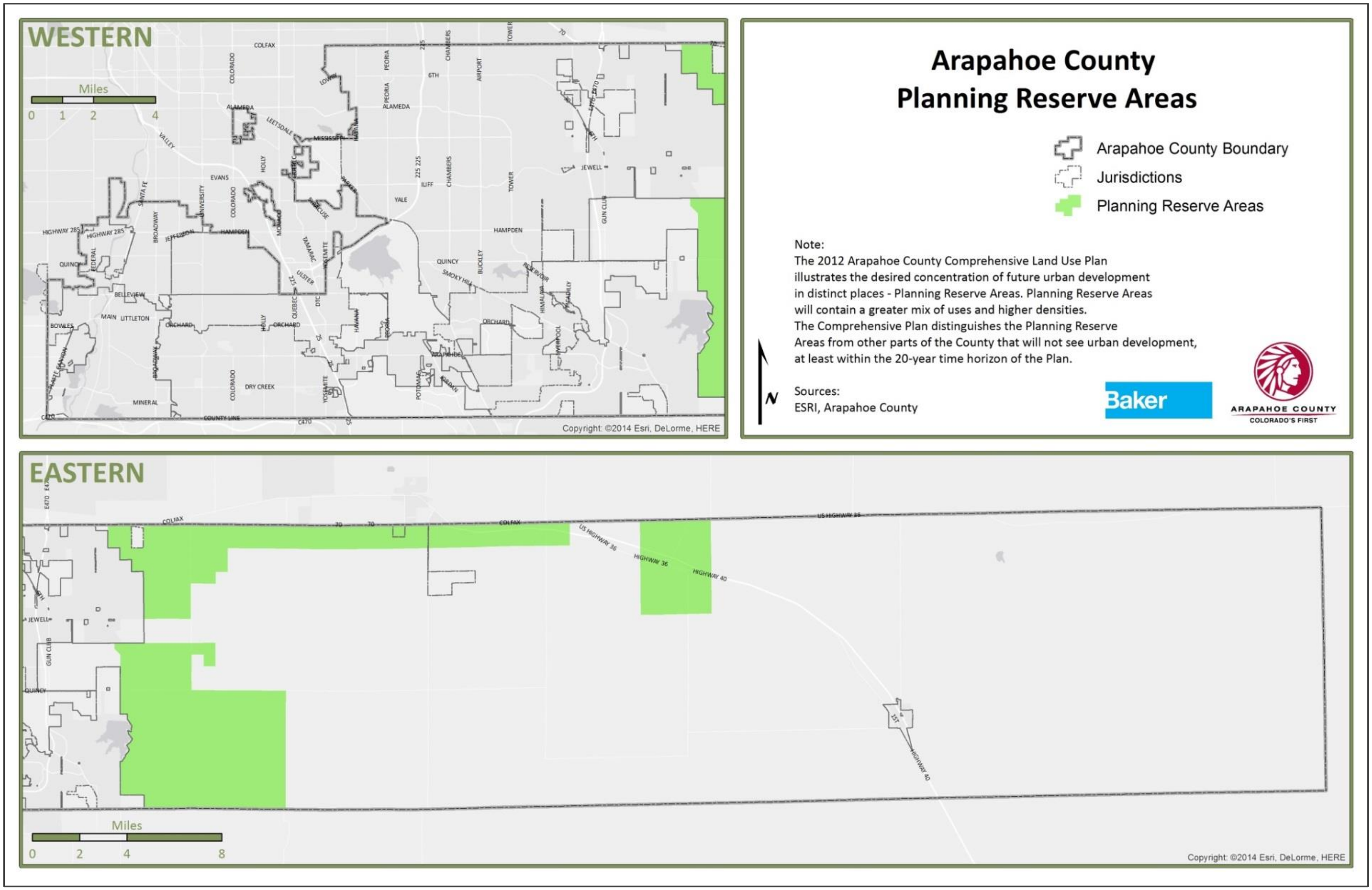


Figure 21. Map of Planning Reserve Areas

CRITICAL FACILITIES

For the purpose of the Arapahoe County Multi-Hazard Mitigation Plan, 'critical facilities' are defined as local assets vital to the health, safety, and well-being of residents and visitors during time of natural disaster. Critical facilities are essential to a community's long-term disaster resilience as they are important delivery pathways for diverse crisis management services and resources.

Members of the Arapahoe County LEPC worked to define a critical facility inventory for the 2015 Multi-Hazard Mitigation Plan. Critical facilities profiled in this plan include facilities of the following types:

- Airports
- Bridges
- Churches
- City facilities
- County facilities
- Clean water supply systems/facilities
- Fire stations
- Fuel depots
- Gas/oil lines
- Hazmat locations
- Historic sites
- Libraries
- Light-rail lines
- Light-rail stations
- Medical facilities and hospitals
- Military infrastructure
- Nursing homes
- Police/Sheriff stations
- Railroads
- Schools

The map shown in the Figure below presents these community-identified critical facilities included in the risk and vulnerability assessment of this plan.

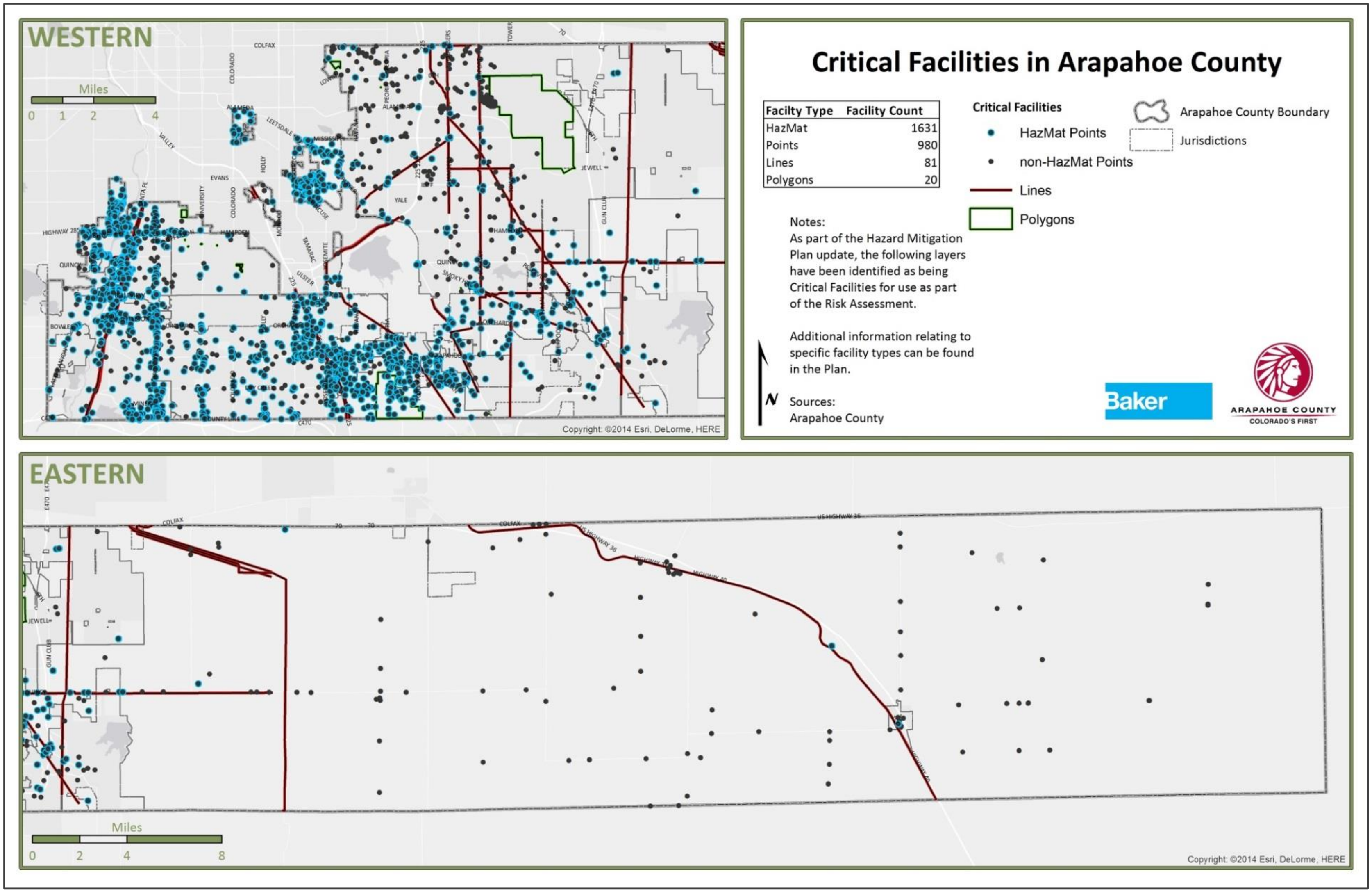


Figure 22. Map of Critical Facilities in Arapahoe County

The following Tables provide a count of how many critical facilities of each type are located in Arapahoe County and outline estimated replacement costs based on aggregate appraised values, when available.

Table 19. City and County Facilities

City and County Facilities			
County Facilities		**City Facilities**	
Count	*Appraisal Value*	*Count*	*Appraisal Value*
25	$206,520,075	16	$74,040,321

Table 20. Critical Emergency Service Facilities

Critical Facilities: Emergency Services							
Fire Stations		**Police/Sheriff Stations**		**Military Infrastructure**		**Medical Hospitals**	
Count	*Appraisal Value*	*Count*	*Appraisal Value*	*Count*	*Appraisal Value*	*Count*	*Appraisal Value*
40	$66,384,642	16	$50,479,712	149	-	10	$148,618,454

Table 21. Critical Community Service Facilities

Critical Facilities: Community Services						
Schools		**Libraries**		**Churches**		**Historic Sites**
Count	*Appraisal Value*	*Count*	*Appraisal Value*	*Count*	*Appraisal Value*	*Count*
251	$2,552,311,396	15	$78,243,520	236	$651,491,498	18

Table 22. Critical Infrastructure and Transportation Facilities

Critical Facilities: Infrastructure and Transportation						
Bridge		**Water Facility**		**Light Rail Station**		**Airports**
Count	*Appraisal Value*	*Count*	*Appraisal Value*	*Count*	*Appraisal Value*	*Count*
140	-	16	$24,045,574	9	-	2

Table 23. Critical Fuel and Rail Lines

Critical Facilities: Fuel and Rail Lines					
Fuel Lines		**Light Rail Stations**		**Rail Lines (Railroad and Light Rail)**	
Count	*Miles*	*Count*	*Miles*	*Count*	*Miles*
31	113.19	9	-	50	116.2

Table 24. Hazardous Materials Sites

Critical Facilities: Hazardous Materials Sites		
Hazmat Locations	**Fuel Depots**	
Count	*Count*	*Appraisal Value*
1631	36	$18,735,584

Critical facilities deserve additional mitigation attention because of the higher potential for the loss of life, property, and/or environmental quality in the event that they suffer significant damage. The protection of critical facilities is essential because these specific facilities can have a significant impact on the scope of damage caused by a natural disaster. Additionally, the disruption of critical facilities during a natural disaster is likely to affect response and recovery activity.

CHAPTER 2: HAZARD IDENTIFICATION AND RISK ASSESSMENT (HIRA) 2015 - 2020

This section of the Arapahoe County Hazard Mitigation Plan (hereinafter referred to as *the Plan*) describes the local Hazard Identification and Risk Assessment summary undertaken by Arapahoe County and participating municipalities. This section consists of the following subsections:

- INTRODUCTION AND UPDATE SUMMARY
- CLIMATE CHANGE AND HAZARDS
- DROUGHT
- EARTHQUAKE
- EROSION/LAND SUBSIDENCE
- EXTREME TEMPERATURES
- FLOODING
- PUBLIC HEALTH HAZARDS
- SEVERE STORMS (including hail, lightning, and snow storms)
- SEVERE WIND/TORNADO
- WILDFIRE
- 2015 - 2020 HIRA SUMMARY

INTRODUCTION AND UPDATE SUMMARY

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

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

Source: Federal Emergency Management Agency, 2001

The Local Hazard Identification and Risk Assessment (HIRA) summary is a method for evaluating risk as defined by probability and frequency of occurrence of a hazard event, exposure of people and property to the hazard, and consequences of that exposure. Different methodologies exist for assessing the risk of hazard events, ranging from qualitative to quantitative approaches.

Arapahoe County and its communities are vulnerable to a wide range of natural and human-caused hazards that threaten life and property. The hazards identified by the Mitigation Planning Work Group (MPWG) for inclusion in the Plan are those determined to be of actual potential threat to Arapahoe County and its municipalities and are consistent with the hazards identified by the State of Colorado and the Federal Emergency Management Agency for this part of the State and this region of the country. The hazards profiled for the 2015 Plan include:

- DROUGHT
- EARTHQUAKE
- EROSION/LAND SUBSIDENCE
- EXTREME TEMPERATURES
- FLOODING
- PUBLIC HEALTH HAZARDS
- SEVERE STORMS (including hail, lightning, and snow storms)
- SEVERE WIND/TORNADO
- WILDFIRE

Some of these hazards can be interrelated (for example, severe storms can cause flooding, drought can lead to wildfire), and thus discussion of these hazards may overlap where necessary throughout the HIRA. Of the sixteen (16) hazards profiled in the State of Colorado's 2013 Hazard Mitigation Plan, twelve (12) are addressed in the 2015 Arapahoe County Plan. The following Table summarizes this information.

Table 25. State/Local Plan Hazards Matrix

2013 STATE OF COLORADO NATURAL HAZARD MITIGATION PLAN	INCLUDED IN 2015 ARAPAHOE COUNTY MITIGATION PLAN	RATIONALE FOR EXCLUSION
AVALANCHE		No significant vulnerability identified
DROUGHT	•	
EARTHQUAKE	•	
EROSION AND DEPOSITION	•	
EXPANSIVE SOIL		No significant vulnerability identified

EXTREME TEMPERATURES	•	
FLOOD	•	
HAIL	•	
LANDSLIDE, MUD/DEBRIS FLOW, ROCKFALL		No significant vulnerability identified
LIGHTNING	•	
PEST INFESTATION		No significant vulnerability identified
SEVERE WIND	•	
SUBSIDENCE	•	
TORNADO	•	
WILDFIRE	•	
WINTER STORM	•	

The following Table documents the review by the MPWG as it relates to those hazards that were to be re-evaluated and/or identified, analyzed, and addressed through the updating of the 2010 Denver Regional Natural Hazard Mitigation Plan. Hazards were either *deferred*, *deleted*, *changed*, or *new* hazards were identified.

Table 26. Evaluation of Hazards for Inclusion in the 2015 HIRA Summary

2010 HAZARD	STATUS	NOTES	2015 HAZARD
AVALANCHE	Deleted	--	--
DROUGHT	Deferred	--	DROUGHT
EARTHQUAKE	Deferred	--	EARTHQUAKE
FLOOD	Deferred	--	FLOODING
HAIL	Changed	Merged into another chapter	SEVERE STORM

HEAT WAVE	Changed	Merged into another chapter	EXTREME TEMPERATURES
LANDSLIDE	Deleted	--	--
LAND SUBSIDENCE	Changed	Merged into another chapter	EROSION/LAND SUBSIDENCE
THUNDERSTORM AND LIGHTNING	Changed	Merged into another chapter	SEVERE STORM
TORNADO	Changed	Merged into another chapter	SEVERE WIND/TORNADO
SEVERE STORM AND WIND	Changed	Merged into another chapter	SEVERE WIND/TORNADO
WINTER STORM AND FREEZING	Changed	Broken down into two hazards	SEVERE STORM; EXTREME TEMPERATURES
WILDFIRE	Deferred	--	WILDFIRE
PUBLIC HEALTH HAZARDS	Deferred	--	PUBLIC HEALTH HAZARDS

To further focus on the list of identified hazards for the Plan, the next Table presents a list of all federal disaster and emergency declarations that have occurred in Arapahoe County since 1963, according to the Federal Emergency Management Agency. This list presents the foundation for identifying what hazards pose the greatest risk within Arapahoe County.

Table 27. Presidential Disaster and Emergency Declarations in Arapahoe County

DECLARATION #	DATE	EVENT DETAILS
FEMA-4145-DR	09/14/2013	Severe Storms, Flooding, Landslides, and Mudslides
FEMA-EM-3270	01/07/2007	Snowstorm
FEMA-EM-3224	09/05/2005	Colorado Hurricane Katrina Evacuation
FEMA-EM-3185	04/09/2003	Snowstorm
FEMA-1421-DR	06/19/2002	Wildfires

DECLARATION #	DATE	EVENT DETAILS
FEMA-385-DR	05/23/1973	Heavy Rain, Snowmelt, Flooding
FEMA-261-DR	05/19/1969	Severe Storms, Flooding
FEMA-200-DR	06/19/1965	Tornadoes, Severe Storms, Flooding

Hazards were ranked in order to provide structure and prioritize the mitigation goals and actions discussed in the Plan. Ranking was both quantitative and qualitative. First, the quantitative analysis considered all the historical and geospatial hazard-specific data available. Then, a qualitative method, the Risk Factor (RF) approach, was used to provide additional insights on the specific risks associated with each hazard. This process also served as a valuable cross-check and validation of the quantitative analysis performed.

The RF approach combines historical experiences, local knowledge, and consensus opinions to produce numerical values that allow identified hazards to be ranked against one another. During the planning process, the Arapahoe County MPWG compared the results of the hazard profile against their local knowledge to generate a set of ranking criteria. These criteria were used to evaluate hazards and identify those posing the highest risk.

RF values are obtained by assigning varying degrees of risk to five categories for each hazard: *probability, impact, spatial extent, warning time*, and *duration*. Each degree of risk is assigned a value ranging from 1 to 4 and a weighing factor for each category was agreed upon by the MPWG (documented in the following Table). Based upon any unique concerns for the planning area, the MPWG may also adjust the RF weighting scheme. To calculate the RF value for a given hazard, the assigned risk value for each category is multiplied by the weighting factor. The sum of all five categories equals the final RF value, as demonstrated in the following example equation:

RF Value = [(Probability x .30) + (Impact x .30) +

(Spatial Extent x .20) + (Warning Time x .10) + (Duration x .10)]

Table 28. Risk Factor Criteria

RISK ASSESSMENT CATEGORY	LEVEL	DEGREE OF RISK LEVEL	INDEX	WEIGHT
PROBABILITY What is the likelihood of a hazard event occurring in a given year?	**UNLIKELY**	LESS THAN 1% ANNUAL PROBABILITY	**1**	**30%**
	POSSIBLE	BETWEEN 1 & 10% ANNUAL PROBABILITY	**2**	
	LIKELY	BETWEEN 10 &100% ANNUAL PROBABILITY	**3**	
	HIGHLY LIKELY	100% ANNUAL PROBABILTY	**4**	
IMPACT *In terms of injuries, damage, or death, would you anticipate impacts to be minor, limited, critical, or catastrophic when a significant hazard event occurs?*	**MINOR**	VERY FEW INJURIES, IF ANY. ONLY MINOR PROPERTY DAMAGE & MINIMAL DISRUPTION OF QUALITY OF LIFE. TEMPORARY SHUTDOWN OF CRITICAL FACILITIES.	**1**	**30%**
	LIMITED	MINOR INJURIES ONLY. MORE THAN 10% OF PROPERTY IN AFFECTED AREA DAMAGED OR DESTROYED. COMPLETE SHUTDOWN OF CRITICAL FACILITIES FOR MORE THAN ONE DAY.	**2**	
	CRITICAL	MULTIPLE DEATHS/INJURIES POSSIBLE. MORE THAN 25% OF PROPERTY IN AFFECTED AREA DAMAGED OR DESTROYED. COMPLETE SHUTDOWN OF	**3**	

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ARAPAHOE COUNTY COLORADO'S FIRST

RISK ASSESSMENT CATEGORY	LEVEL	DEGREE OF RISK LEVEL	INDEX	WEIGHT
		CRITICAL FACILITIES FOR MORE THAN ONE WEEK.		
	CATASTROPHIC	HIGH NUMBER OF DEATHS/INJURIES POSSIBLE. MORE THAN 50% OF PROPERTY IN AFFECTED AREA DAMAGED OR DESTROYED. COMPLETE SHUTDOWN OF CRITICAL FACILITIES FOR 30 DAYS OR MORE.	**4**	
SPATIAL EXTENT *How large of an area could be impacted by a hazard event? Are impacts localized or regional?*	**NEGLIGIBLE**	LESS THAN 1% OF AREA AFFECTED	**1**	**20%**
	SMALL	BETWEEN 1 & 10% OF AREA AFFECTED	**2**	
	MODERATE	BETWEEN 10 & 50% OF AREA AFFECTED	**3**	
	LARGE	BETWEEN 50 & 100% OF AREA AFFECTED	**4**	
WARNING TIME *Is there usually some lead time associated with the hazard event? Have warning measures been implemented?*	**MORE THAN 24 HRS**	SELF DEFINED	**1**	**10%**
	12 TO 24 HRS	SELF DEFINED	**2**	
	6 TO 12 HRS	SELF DEFINED	**3**	
	LESS THAN 6 HRS	SELF DEFINED	**4**	
DURATION *How long does the hazard event usually last?*	**LESS THAN 6 HRS**	SELF DEFINED	**1**	**10%**
	LESS THAN 24 HRS	SELF DEFINED	**2**	
	LESS THAN 1 WEEK	SELF DEFINED	**3**	
	MORE THAN 1 WEEK	SELF DEFINED	**4**	

According to the default weighting scheme applied, the highest possible RF value is 4.0. The methodology illustrated above lists categories that are used to calculate the variables for the RF value.

RANKING RESULTS

The ensuing Table summarizes the results of the risk factor ranking exercise performed by members of the Arapahoe County MPWG. The results represent the relative rank of different hazards within the county from the perspective of local stakeholders and subject matter experts.

Table 29. Risk Factor Results for Arapahoe County and Participating Jurisdictions

#	NATURAL HAZARDS	PROBABILITY	IMPACT	SPATIAL EXTENT	WARNING TIME	DURATION	RF RATING
1	Severe Storms	4 (1.1)	2 (0.5)	3 (0.6)	2 (0.2)	2 (0.2)	**2.7**
2	Extreme Temperatures	3 (1.0)	2 (0.5)	4 (0.7)	1 (0.1)	3 (0.3)	**2.7**
3	Drought	3 (0.9)	1 (0.5)	3 (0.6)	1 (0.1)	4 (0.4)	**2.4**
4	Severe Wind/Tornado	3 (0.8)	2 (0.6)	2 (0.4)	4 (0.4)	1 (0.1)	**2.3**
5	Wildfire	3 (0.8)	2 (0.5)	2 (0.4)	4 (0.4)	2 (0.2)	**2.3**
6	Public Health Hazards	2 (0.6)	2 (0.5)	3 (0.5)	2 (0.2)	3 (0.3)	**2.2**
7	Flood	2 (0.7)	2 (0.5)	3 (0.5)	3 (0.3)	2 (0.2)	**2.2**
8	Earthquake	1 (0.4)	2 (0.5)	2 (0.5)	4 (0.4)	1 (0.1)	**1.9**
9	Erosion/Land Subsidence	2 (0.6)	1 (0.3)	1 (0.5)	2 (0.2)	3 (0.3)	**1.5**

Based on the RF analysis, the natural hazards with the highest risk factor scores are “Severe Storms” and “Extreme Temperatures.” Both hazards have a RF value of 2.7. This is primarily due to the high probability of the hazards occurring and the wide spatial extent of their potential damages and impacts. “Drought” was qualitatively calculated as second in risk potential, with a RF value of 2.4. Its long duration, broad spatial extent, and high probability make Drought third in the risk ranking. The “Severe Wind/Tornado” and “Wildfire” hazards ranked third in terms of risk potential with a RF score of 2.3. This was mainly due to the short warning time for both hazards and the high probability of either event occurring in the County in any given year. “Flood” and “Public Health Hazards” round out the list of moderate to high ratings, both with scores of 2.2. The Risk Factor exercise determined that “Earthquake” and “Erosion/Land Subsidence” are relatively low-risk hazards in Arapahoe County. “Earthquake” had a risk factor score of 1.9, which was driven by the low probability and low duration of an event. “Erosion/Land Subsidence” was identified as having minimal impacts on people and property and a limited spatial extent.

The conclusions drawn from the qualitative assessment carried out by the Arapahoe County MPWG were fitted into three categories (shown in the subsequent table) for a summary of hazard risk for Arapahoe County based on High, Moderate or Low risk designations.

Table 30. Conclusions on Hazard Risk for Arapahoe County and Participating Jurisdictions

HIGH RISK (2.5 or higher)	**SEVERE STORMS, EXTREME TEMPERATURES**
MODERATE RISK (2.0 – 2.4)	**DROUGHT, SEVERE WIND/TORNADO, WILDFIRE, PUBLIC HEALTH HAZARDS, FLOOD**
LOW RISK (1.5 – 1.9)	**EARTHQUAKE, EROSION/LAND SUBSIDENCE**

The following table shows a summary of each participating jurisdictions’ vulnerability to the hazards identified in the Plan. The results are a product of each jurisdiction’s review of the multi-hazard risk assessment and their individual responses to the review and analysis of their unique risks and vulnerabilities.

Table 31. Hazard Vulnerability Summary by Jurisdiction

	Drought	Earthquake	Erosion/Land Subsidence	Extreme Temps.	Flooding	Public Health Hazards	Severe Storm	Severe Wind/Tornado	Wildfire
Arapahoe County	Moderate Risk	Low Risk	Low Risk	Moderate Risk	High Risk	Moderate Risk	Moderate Risk	Moderate Risk	Moderate Risk
Bennett	High Risk	Moderate Risk	Moderate Risk	Moderate Risk	High Risk	High Risk	High Risk	High Risk	High Risk
Bow Mar	Low Risk	Low Risk	Low Risk	Low Risk	Moderate Risk	Low Risk	Low Risk	Low Risk	Low Risk
Centennial	Moderate Risk	Low Risk	Low Risk	Moderate Risk	Low Risk	Low Risk	High Risk	High Risk	Moderate Risk
Cherry Hills Village	Moderate Risk	Low Risk	Low Risk	Low Risk	Moderate Risk	Low Risk	Moderate Risk	Low Risk	Low Risk
Columbine Valley	Low Risk	Low Risk	Low Risk	Moderate Risk	Moderate Risk	Low Risk	High Risk	Moderate Risk	Moderate Risk
Deer Trail	Low Risk	Low Risk	Low Risk	Low Risk	Moderate Risk	Low Risk	Low Risk	Low Risk	Moderate Risk
Englewood	Moderate Risk	Low Risk	Low Risk	High Risk	Moderate Risk	Moderate Risk	High Risk	Moderate Risk	Low Risk
Foxfield	Moderate Risk	Low Risk	Low Risk	Moderate Risk	Low Risk	Low Risk	High Risk	Moderate Risk	Moderate Risk
Glendale	Moderate Risk	Low Risk	Moderate Risk	Moderate Risk	High Risk	Moderate Risk	High Risk	High Risk	Low Risk
Greenwood Village	Moderate Risk	Low Risk	Low Risk	High Risk	Moderate Risk	Moderate Risk	High Risk	Moderate Risk	Low Risk
Littleton	Moderate Risk	Low Risk	Low Risk	Moderate Risk	Moderate Risk	Moderate Risk	Moderate Risk	Moderate Risk	Low Risk
Sheridan	Low Risk	Low Risk	Low Risk	Moderate Risk	Moderate Risk	Moderate Risk	Moderate Risk	Moderate Risk	Low Risk

CLIMATE CHANGE AND HAZARDS

In May of 2014, the U.S. Global Change Research Program released the Third U.S. National Climate Assessment, the authoritative and comprehensive report on climate change and its impacts in the United States. Not only did the report confirm that climate change is affecting Americans in every region of the U.S., the report identifies increased heat, drought, insect outbreaks, wildfire, and flooding as key climate-related concerns for the Southwest region of the U.S. (which includes Colorado).[7]

The myriad impacts of climate change are already being felt by communities and ecosystems in the southwestern United States. The Southwest is the hottest and driest region in the U.S. and climate change poses significant challenges for an already parched region that is expected to get hotter and significantly drier.

Recent warming in the region is among the most rapid in the nation and is significantly greater than the global average, and the period since 1950 has been hotter than any comparable long period in at least 600 years. Current climate models predict that average temperatures in Colorado will warm by 2.5°F to 5.5°F by 2041-2070 and by 5.5°F to 9.5°F by 2070-2099.[8] Summer temperatures across the state are expected to warm more than winter temperatures and projections suggest that typical summer months will be as warm as (or warmer than) the hottest 10% of summers that occurred between 1950 and 1999.[9]

[7] *Third U.S. National Climate Assessment*, 2014. U.S. Global Change Research Program.
[8] *Third U.S. National Climate Assessment*, 2014. U.S. Global Change Research Program.
[9] *Colorado Climate Change: A Synthesis to Support Water Resource Management and Adaptation*. Colorado Water Conservation Board (2008).

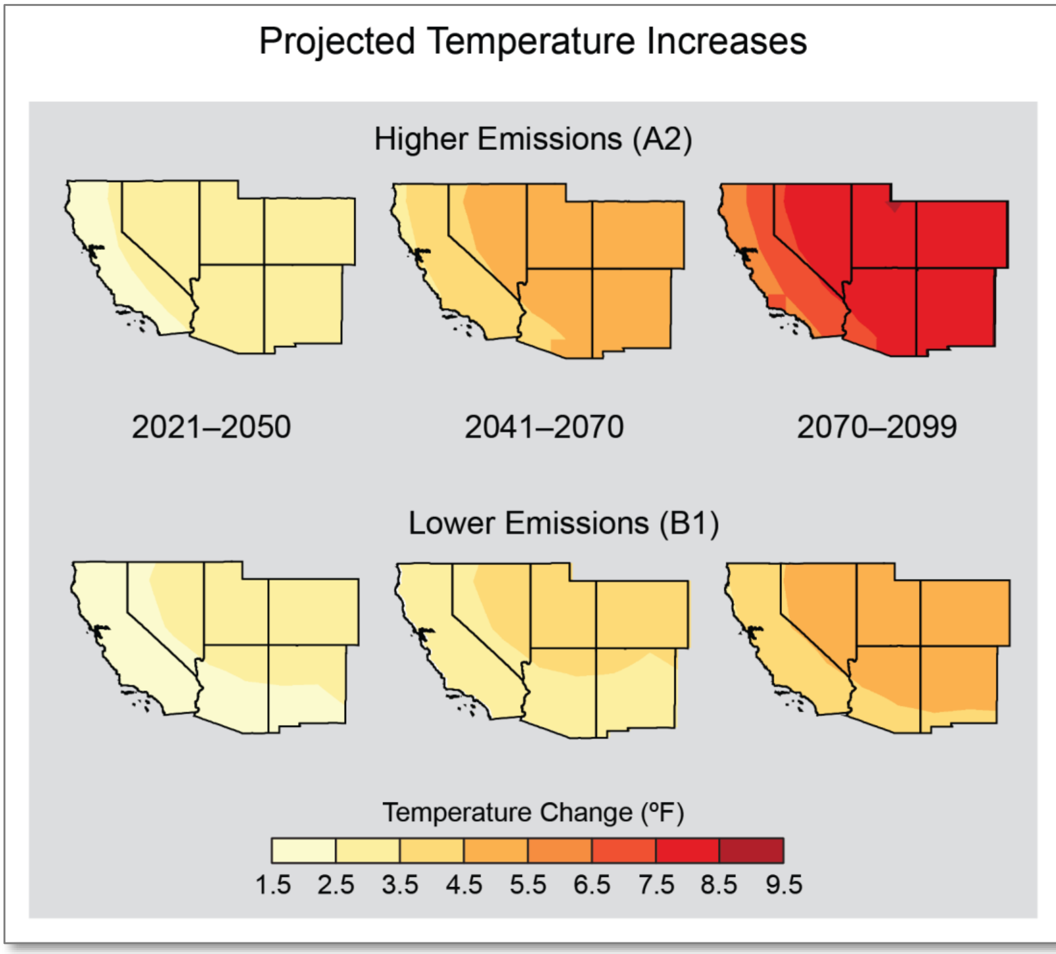

Figure 23. Climate Change: Projected Temperature Increased in the Southwestern U.S.[10]

The maps in the preceding Figure show projected changes in average temperatures in the Southwest region, as compared to 1971-1999. The top row (A2) shows projections assuming heat-trapping gas emissions continue to rise (business-as-usual). The bottom row shows projections assuming substantial reductions in emissions (B1). These temperature changes will directly affect urban public health through increased risk of heat stress, and urban infrastructure through increased risk of disruptions of electric power generation. Rising temperatures also have direct impacts on crop yields and productivity of key regional crops, such as fruit trees.

The impacts of climate change already pose a threat to people and property in the southwest region of the United States, including Arapahoe County. Together, these impacts represent a slow-onset disaster that is likely to manifest and change over time. Recently, climate change impacts have altered the intensity and rate of weather and climate extremes in the region. Current projections predict even more

[10] *Third U.S. National Climate Assessment*, 2014. U.S. Global Change Research Program.

rapid changes in the near future, which are likely to affect hazards such as heat waves, wildfire, and drought.[11]

In the future, many of the natural hazards that Arapahoe County has historically experienced are likely to change due to the effects of climate change. This is particularly true for drought, flooding, wildfire and extreme temperature hazards. The nature of erosion/land subsidence and public health hazards are also likely to evolve in intensity and character due to a changing regional climate. For these reasons, the hazard identification and risk assessment for the 2015 Arapahoe County Multi-Hazard Mitigation plan includes a discussion of how climate change may impact the frequency, intensity, and distribution of specific hazards within the county. Because many impacts of climate-related hazards cross county boundaries, some of the discussion looks at impacts on a regional scale. As climate science evolves, future mitigation plan updates may consider including climate change projections in the risk rankings and vulnerability assessments of the hazards included in the Plan.

The following sections provide hazard profiles and risk assessments for each of the nine hazards identified by the MPWG for the 2015 Plan update. The hazards are presented in alphabetical order rather by their levels of risk.

[11] *Summary for Policy Makers: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation.* IPCC (2012).

DROUGHT

NATURAL HAZARDS	PROBABILITY	IMPACT	SPATIAL EXTENT	WARNING TIME	DURATION	RF RATING
Drought	3 (0.9)	1 (0.5)	3 (0.6)	1 (0.1)	4 (0.4)	2.4
MODERATE RISK HAZARD (2.0 - 2.4)						

HAZARD IDENTIFICATION

Drought is a normal part of virtually all climates, including areas with high and low average rainfall. It is caused by a deficiency of precipitation and can be aggravated by other factors such as high temperatures, high winds, and low relative humidity.

Droughts can be grouped as meteorological, hydrologic, agricultural, and socioeconomic. Representative definitions commonly used to describe the various types of drought are summarized below.

- **Meteorological** drought is defined solely on the degrees of dryness. It is expressed as a departure of actual precipitation from an expected average or normal amount based on monthly, seasonal, or annual time scales.
- **Hydrologic** drought is related to the effects of precipitation shortfalls on stream flows and reservoir, lake, and groundwater levels.
- **Agricultural** drought is defined principally in terms of soil moisture deficiencies relative to water demands of plant life, usually crops.
- **Socioeconomic** drought associates the supply and demand of economic goods or services with elements of meteorological, hydrologic, and agricultural drought. Socioeconomic drought occurs when the demand for water exceeds the supply as a result of a weather related supply shortfall. The incidence of this type of drought can increase because of a change in the amount of rainfall, a change in societal demands for water (or vulnerability to water shortages), or both.

The Palmer Drought Severity Index (PDSI) was developed by Wayne Palmer in the 1960s and uses temperature and rainfall information in a formula to determine dryness. Over time it has become the semi-official drought index for risk assessment and hazard analysis. The Palmer Index is most effective in determining long term drought—a matter of several months—and is not used for short-term forecasts (a matter of weeks). It uses a 0 as normal conditions, and drought is shown in terms of negative numbers; for example, -2 is moderate drought, -3 is severe drought, and -4 is extreme drought. The following table provides an overview of the Palmer Index compared to other classifications.

Table 32. Drought Severity Classification

DROUGHT SEVERITY	RETURN PERIOD (YRS)	DESCRIPTION OF POSSIBLE IMPACTS	DROUGHT MONITORING INDICES		
			Standardized Precipitation Index (SPI)	NDMC* Drought Category	Palmer Drought Index
Minor Drought	3 to 4	Going into drought; short-term dryness slowing growth of crops or pastures; fire risk above average. Coming out of drought; some lingering water deficits; pastures or crops not fully recovered.	-0.5 to -0.7	D0	-1.0 to -1.9
Moderate Drought	5 to 9	Some damage to crops or pastures; fire risk high; streams, reservoirs, or wells low, some water shortages developing or imminent, voluntary water use restrictions requested.	-0.8 to -1.2	D1	-2.0 to -2.9
Severe Drought	10 to 17	Crop or pasture losses likely; fire risk very high; water shortages common; water restrictions imposed	-1.3 to -1.5	D2	-3.0 to -3.9
Extreme Drought	18 to 43	Major crop and pasture losses; extreme fire danger; widespread water shortages or restrictions	-1.6 to -1.9	D3	-4.0 to -4.9
Exceptional Drought	44 +	Exceptional and widespread crop and pasture losses; exceptional fire risk; shortages of water in reservoirs, streams, and wells creating water emergencies	Less than -2	D4	-5.0 or less

Source: National Drought Mitigation Center

HAZARD PROFILE

With its semi-arid climate, drought is a natural part of the Colorado environment. Because of natural variations in regional climate and precipitation, it is rare for the entire state to be deficient in moisture at the same time. Single season droughts that cover portions of the state, however, are fairly common.

Drought impacts can cover large areas and may come in many forms. The most significant drought impacts in Colorado are related to water-intensive activities including agriculture, municipal use, wildfire protections, recreation, wildlife preservation, commerce, and tourism. Drought conditions can lead to the compaction of soil, increasing erosion potential and decreasing water quality. The impacts associated with drought magnify as the duration of the event increases, as supplemental supplies in reservoirs are depleted and water levels in groundwater aquifers decline.

The State of Colorado has experienced severe, widespread drought several times since the late 1800s. The 2013 State of Colorado Drought Mitigation and Response Plan included a comprehensive description of the major droughts that have occurred in Colorado, including the Dust Bowl of 1930s, the 1950s drought of the Great Plains, and the Colorado drought of 2002. The table below summarizes the duration of historical dry and wet periods in Colorado.

Table 33. Historical Dry and Wet Periods in Colorado

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

Source: 2013 Colorado Drought Mitigation and Response Plan

The table above highlights seven multi-year droughts in Colorado since 1893. The most dramatic drought event occurred in the late 1930s and 1950s when a number of states in the region were affected by a several-year drought.

The Colorado drought of 2002 was the single most intensive year of drought in Colorado's history.[12] Statewide snowpack was at or near all-time lows, and the year is considered the driest single year recorded in Colorado history. What made the 2002 drought event so unusual was that all of the State was dry at the same time. Regional soil moisture was depleted and reservoirs dropped to extremely low levels. The dramatic drought conditions prompted widespread water restrictions that were heavily enforced and regulated. These restrictions included limits to watering lawns, washing cars, or the use of water for any other non-essential uses. Some municipalities offered incentives for property owners to remove their lawns and adopt xeriscaped landscape designs. Ultimately, it was the wet period of the late 1990s and the increased reservoir storage during that time that helped Colorado to survive the drought of 2002.

More recently, severe drought conditions have impacted the State of Colorado. Based on the U.S. Drought Monitor, approximately 50% of Colorado was already experiencing drought conditions by the start of 2012. Minimal accumulations of snow worsened conditions further, as below average snowfall and above average temperatures occurred in February and March. In April and May of 2012, warm temperatures caused early runoff as the thin snowpack melted rapidly. The entire State of Colorado was under drought conditions by the end of May 2012 and stream flows measured only slightly better compared to the extreme drought years of 1934, 1954, 1977 and 2002.

Local agricultural production was heavily impacted by the 2011-2013 drought. Because soil moisture was low and temperatures high on the plains during the spring planting season, many crops struggled to take root and failed to survive the summer. Agricultural drought impacts were exacerbated by limited water availability for summer irrigation diversions due to less snowpack and runoff. In the eastern plains of Colorado, June temperatures were consistently over 100°F. As hay production decreased to 10% - 50% of average supply, prices increased dramatically. For example, corn prices increased 43% over two years as neighboring corn-producing regions in other states also struggled with drought. By early June 2013, many areas of the Eastern Plains normally covered by crops or cattle were barren. Many ranchers sold their herds as grasses had gone dormant and hay was expensive and in short supply.

Additional economic impacts seen during the 2011-2013 drought period included disruptions to the tourism industry. Colorado experienced decreased rafting numbers due to low stream flows and wildfire conditions that made some river reaches inaccessible. Colorado's ski industry, another important economic driver for the state, experienced an 11.9% decrease in visits for the 2011-2012 season as compared to the five-year average. Many ski resorts closed early in 2012 because of high temperatures and minimal March snowfall.

In addition to having a devastating economic impact on Colorado agriculture and tourism, the 2011-2013 drought period contributed to elevated wildfire risk across the state. Two of the State's most destructive wildfires occurred during the 2012 drought period: the High Park Fire and the Waldo Canyon

[12] Pielke and Doesken, 2003. The Drought of 2002 in Colorado.

Fire. Dry conditions on the Eastern Plains contributed to an extended grass fire season that threatened homes and property.

During drought conditions Secretarial Disaster Declarations are used to make low interest loans and other emergency assistance available to those who have been affected (largely farmers and ranchers). Under the process laid out by the Farm Services Agency (FSA), a USDA Disaster Declaration can be made if any portion of a County has experienced eight consecutive weeks of severe drought according to the U.S. Drought Monitor.[13] The following Table lists the disaster declarations related to drought that have affected Arapahoe County since 2003.

Table 34. USDA Secretarial Disasters Affecting Arapahoe County 2003 - Present

[13] The 2013 Colorado Drought Mitigation Response Plan

Year	Type	Disaster # and Affected Counties
2006	Heat, High Winds, Insect Pests, Late Freeze, Drought	**S2329 -** Arapahoe, Archuleta, Bent, Boulder, Crowley, Delta, El Paso, Gunnison, Jefferson, Kiowa, La Plata, Montrose, Ouray, Park, Philips, Teller, Washington
2008	Drought	**S2750 -** Adams, Arapahoe, Baca, Bent, Cheyenne, Crowley, Douglas, El Paso, Elbert, Huerfano, Kiowa, Kit Carson, Las Animas, Lincoln, Logan, Otero, Park, Prowers, Pueblo, Teller, Washington, Weld
2011	Drought	**S3172 -** Arapahoe, Douglas, El Paso, Elbert, Jefferson, Lincoln, Park, Teller
2012	Drought	**S3229 -** Arapahoe, Cheyenne, Crowley, Elbert, El Paso, Kiowa, Kit Carson, Lincoln, Pueblo, Washington
2012	Drought, Wind/High Winds, Heat/Excessive Heat	**S3260 -** Adams, Alamosa, Arapahoe, Archuleta, Baca, Bent, Boulder, Broomfield, Chaffee, Cheyenne, Clear Creek, Conejos, Costilla, Crowley, Custer, Delta, Denver, Dolores, Douglas, Eagle, Elbert, El Paso, Fremont, Garfield, Gilpin, Grand, Gunnison, Hinsdale, Huerfano, Jackson, Jefferson, Kiowa, Kit Carson, Lake, La Plata, Larimer, Las Animas, Lincoln, Logan, Mesa, Mineral, Moffat, Montezuma, Montrose, Morgan, Otero, Ouray, Park, Phillips, Pitkin, Prowers, Pueblo, Rio Blanco, Rio Grande, Routt, Saguache, San Juan, San Miguel, Sedgwick, Summit, Teller, Washington, Weld, Yuma
2013*	Drought, Wind/High Winds, Fire/Wildfire, Heat/Excessive Heat, Insects	**S3456 -** Adams, Arapahoe, Baca, Bent, Boulder, Broomfield, Chaffee, Cheyenne, Clear Creek, Costilla, Crowley, Custer, Denver, Douglas, Eagle, Elbert, El Paso, Fremont, Gunnison, Huerfano, Jefferson, Kiowa, Kit Carson, Lake, Larimer, Las Animas, Lincoln, Logan, Morgan, Otero, Park, Phillips, Pitkin, Prowers, Pueblo, Saguache, Sedgwick, Teller, Washington, Weld, Yuma

Source: USDA – Colorado Farm Services Agency
*Through June 26, 2013

Numerous drought declarations occurred between 2011 and 2013. One of the most significant disaster periods occurred in early July 2012, in which 62 of the State's 64 counties were included in a Secretarial disaster designation due to the 2011-2013 drought. Farmers in designated counties were able to apply for Farm Service Agency emergency loans for the next eight months.

Because drought is usually considered a regional hazard, all jurisdictions are assumed to have the same risk level within Arapahoe County. Drought risk is based on a combination of the frequency, severity, and spatial extent (the physical nature of drought) and the degree to which a population or activity is vulnerable to the effects of drought. The degree of Arapahoe County's vulnerability to drought depends on the environmental and social characteristics of the region and is measured by its ability to anticipate, cope with, resist, and recover from drought. The 2013 State of Colorado Drought Mitigation and Response Plan includes information about total drought impacts for all Colorado counties from 1935 (the earliest reported drought impact) to May 8, 2013 for the following impact categories:

Agriculture: Drought impacts associated with agriculture, farming, aquaculture, horticulture, forestry or ranching. Examples of drought-induced agricultural impacts include: damage to crop quality; income loss for farmers due to reduced crop yields; reduced productivity of cropland; insect infestation; plant disease; increased irrigation costs; cost of new or supplemental water resource development (wells, dams, pipelines) for agriculture; reduced productivity of rangeland; forced reduction of foundation stock; closure/limitation of public lands to grazing; high cost or unavailability of water for livestock, Christmas tree farms, forestry, raising domesticated horses, bees, fish, shellfish, or horticulture.

Business and Industry: Drought impacts affecting non-agriculture and non-tourism businesses, such as lawn care businesses, sales of recreational vehicles or other recreational gear, and plant nurseries. Examples of drought-induced business impacts could include: reduction or loss of employees, change in sales or volume of business, variation in number of calls for service, early closure or late opening for the season, bankruptcy, permanent store closure, economic impacts.

Energy: Drought impacts associated with power production, electricity rates, energy revenue, and purchase of alternate sources of energy. Examples include hydropower and non-hydropower production when affected by drought, electricity rates, revenue shortfalls and/or windfall profits, purchase of electricity when hydropower generation is down.

Fire: Drought impacts contributing to forest, range, rural, or urban fires, fire danger, and burning restrictions. Examples of fire impacts include: Enactment/easing of burning restrictions, fireworks ban, increased fire risk, occurrence of fire (number of acres burned, number of wildfires compared to average, people displaced, etc.), increase in firefighting personnel, state of emergency during periods of high fire danger, closure of roads land due to fire occurrence or risk.

Plants and Wildlife: Drought impacts associated with unmanaged plants and wildlife, fisheries, forests, and other fauna. Examples of drought-induced impacts on plants and wildlife include: loss of biodiversity of plants or wildlife; loss of trees from rural or urban landscapes, shelterbelts, or wooded conservation areas; reduction and degradation of fish and wildlife habitat; lack of feed and drinking water; greater mortality due to increased contact with agricultural producers, as animals seek food from farms and producers are less tolerant of the intrusion; disease; increased vulnerability to predation (from species concentrated near water); migration and concentration (loss of wildlife in some areas and too many wildlife in other areas); increased stress to endangered species; salinity levels affecting wildlife, wildlife encroaching into urban areas, loss of wetlands.

Relief, Response, and Restrictions: Drought effects associated with disaster declarations, aid programs, requests for disaster declaration or aid, water restrictions, fire restrictions. Impacts include: Disaster declarations, aid programs, USDA Secretarial disaster declarations, Small Business Association disaster declarations, government relief and response programs, state-level declarations, county-level declarations, a declared "state of emergency," requests for declarations or aid, non-profit organization-based relief, water restrictions, fire restrictions, declaration of drought watches or warnings.

Society and Public Health: Drought effects associated with public and human health. Examples of drought-induced social impacts include: health-related problems related to reduced water quantity and/or quality, such as increased concentration of contaminants; loss of human life (e.g., from heat stress); increased respiratory ailments; increased disease caused by wildlife concentrations; population migration (rural to urban areas, migrants into the United States); loss of aesthetic values; change in daily activities (non-recreational, like putting a bucket in the shower to catch water), elevated stress levels, meetings to discuss drought, communities creating drought plans, lawmakers altering penalties for violation of water restrictions, demand for higher water rates, cultural/historical discoveries from low water levels, cancellation of fundraising events, cancellation/alteration of festivals or holiday traditions, stockpiling water, public service announcements and drought information websites, protests.

Tourism and Recreation: Drought effects associated with recreational activities and tourism. Examples of drought-induced tourism and recreation impacts include: water access or navigation problems for recreation; bans on recreational activities; reduced license, permit, or ticket sales (e.g. hunting, fishing, ski lifts, etc.); losses related to curtailed activities (e.g. bird watching, hunting and fishing, boating, etc.); reduced park visitation; delayed opening for ski resorts; increase in artificial snow generation; cancellation or postponement of sporting events.

Water Supply and Quality: Drought effects associated with water supply and water quality. Examples of drought-induced water supply and quality impacts include: Dry wells, water restrictions, changes in water rates, easing of water restrictions, increase in requests for new well permits, changes in water use due to water restrictions, greater water demand, decrease in water allocation or allotments, installation or alteration of water pumps or water intakes, changes to allowable water contaminants, water line damage or repairs due to drought stress, drinking water turbidity, change in water color or odor, declaration of drought watches or warnings, mitigation activities.

Based on data collected by the National Drought Mitigation Center (NDMC), the state-wide impact assessment, Arapahoe County has recorded major impacts from drought since 1935.[14] The table below summarizes the drought impacts reported in Arapahoe County alone since 2004.

[14] 2013 Colorado Drought Mitigation Response Plan (p. 24)

Table 35. Drought Impacts Reported in Arapahoe County (2004 – 2014)

Impact Category	Count	Percentage of Total Impacts
Agriculture	102	36.04%
Relief, Response, and Restrictions	50	17.67%
Water Supply and Quality	28	9.89%
Society and Public Health	27	9.54%
Plants and Wildlife	26	9.19%
Fire	25	8.83%
Business and Industry	14	4.95%
Tourism and Recreation	9	3.18%
Energy	2	0.71%
Total Impacts:	283	100%

Source: NDMC Drought Impact Reporter

Over the last decade, impacts related to Agriculture made up 36% of the total drought impacts reported in Arapahoe County. 17.67% of drought impacts reported in the county were related to Relief, Response, and Restrictions. Impacts related to Water Supply and Quality, Society and Public Health, and Plants and Wildlife, each fall at around 9% - 10% of the total reported drought impacts in the county. Fire related impacts make up 8.83% of drought impacts reported in Arapahoe County. Tourism and Recreation, and Business and Industry impacts account for a total of 8.13% of all reported drought impacts. Energy related impacts made up the lowest percentage of reported impacts in the last decade at 0.71%

Due to the nature of drought, it is an extremely difficult hazard to predict. However, identifying various indicators of drought, and tracking these indicators, provides us with a crucial means of monitoring drought. Additionally, understanding the historical frequency, duration, and spatial extent of drought assists in determining the likelihood and potential severity of future droughts. The characteristics of past droughts provide benchmarks for projecting similar conditions into the future. The probability of Arapahoe County and its municipalities experiencing a drought event can be difficult to quantify; However, based on historical record of 7 droughts since 1893, consisting of 42 “dry” years since, it can reasonably be assumed that this type of event has occurred once every 17.3 years from 1893 through 2014.

[(Current Year) 2014] subtracted by [(Historical Year) 1893] = 121 Years on Record

[(Years on Record) 121] divided by [(Number of Historical Events) 7] = 17.3

Furthermore, the historic frequency calculates that there is a 6% chance of this type of event occurring each year.

The National Oceanic and Atmospheric Administration Paleoclimatology Program studies drought by analyzing records from tree rings, lake and dune sediments, archaeological remains, historical documents, and other environmental indicators to obtain a broader picture of the frequency of droughts in the United States. According to their research, "paleoclimatic data suggest that droughts as severe as the 1950's drought have occurred in central North America several times a century over the past 300-400 years, and thus we should expect (and plan for) similar droughts in the future. The paleoclimatic record also indicates that droughts of a much greater duration than any in the 20th century have occurred in parts of North America as recently as 500 years ago." Based on this research, the 1950's drought situation could be expected approximately once every 50 years or a 20% chance every ten years. An extreme drought, worse than the 1930's "Dust Bowl," has an approximate probability of occurring once every 500 years or a 2% chance of occurring each decade.[15] A 500-year drought with a magnitude similar to that of the 1930's that destroys the agricultural economy and leads to wildfires is an example of a high magnitude event.

CLIMATE CHANGE IMPACTS

Based on the results of the 2014 Third U.S. National Climate Assessment, two of the key impacts of climate change in the southwest region of the U.S. are reduced snowpack and reduced stream flows. Snowpack and stream flow amounts are projected to decline in Colorado, decreasing surface water supply reliability for cities, agriculture, and ecosystems.

Warmer temperatures affect the evaporation rates of Colorado streams, rivers, and reservoirs, making less water available for use. Greater evaporation, particularly during summer and fall, also increase wildfire risk. Additionally, both high elevation (above 8200ft) and low elevation snowpack (elevations below 8200ft) are declining due to rising temperatures and seasonal shifts in precipitation.[16] The timing of runoff is projected to shift earlier in the spring and these changes, which are expected to occur regardless of changes in precipitation in Colorado, may significantly reduce late summer stream flows.

Climate change is expected to have a significant effect on Colorado's use and distribution of water. Currently, water managers and planners across the state are confronting specific challenges that have been exacerbated by current and projected climate change impacts. Changes in the local and regional water cycle are already affecting water supply.

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[15] National Oceanic and Atmospheric Administration, 2003

[16] *Global Climate Change Impacts in the United States.* Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson (eds.). Cambridge University Press, 2009.

INVENTORY ASSETS EXPOSED

Drought typically does not have a direct impact on critical facilities or structures. Drought conditions evolve slowly over time and communities typically have ample time to prepare for the effects. Should a drought affect the water available for public water systems or individual wells, the availability of clean drinking water could be compromised. This situation would require emergency actions and could possibly overwhelm the local government and financial resources.

Impacts from drought can include the following:

- Economic losses to agricultural producers (crops and livestock)
- Physical and mental health issues
- Water supply interruption for business and industry
- Water quality problems
- Reduced soil and vegetation moisture
- Vegetation mortality, insect infestations
- Impacts to fish and wildlife populations
- Increase in wildland fires and associated losses

POTENTIAL LOSSES

Possible losses/impacts to critical facilities include the loss of critical function due to low water supplies. Severe droughts can negatively affect drinking water supplies. Should a public water system be affected, the losses could total into the millions of dollars if outside water is shipped in. Private springs/wells could also dry up. Possible losses to infrastructure include the loss of potable water.

Although drought events rarely pose immediate risks to public health, they can impact local public health in numerous ways. Examples of drought-induced public health impacts include: increased respiratory ailments due to increased particulate matter in the air; sickness due to decreased availability of clean water; increased disease caused by wildlife concentrations; population migrations (rural to urban areas); loss of human life (e.g. from heat stress, suicides); and impacts on behavioral health (due to unemployment in the agricultural sector, stress on the tourism and other businesses related to the natural environment and/or water).

The impacts of drought on local vegetation and wildlife can include death from dehydration and spread of invasive species or disease because of stressed conditions. In general, environmental impacts from drought are more likely at the interface of the human and natural world. The loss of crops or livestock due to drought can have far-reaching economic effects on communities, wind and water erosion can alter the visual landscape, and dust can damage property. Water-based recreational resources are also heavily affected by drought conditions. Indirect impacts from drought arise from wildfire, which may have additional effects on the landscape and sensitive resources such as historic or archeological sites.

LAND USE & DEVELOPMENT TRENDS

Society's vulnerability to drought is affected largely by population growth, urbanization, demographic characteristics, technology, water use trends, government policy, social behavior, and environmental awareness. These factors are continually changing, and society's vulnerability to drought may rise or fall in response to these changes. For example, increasing and shifting populations puts increasing pressure on water and other natural resources—more people need more water.

Future development greatly impacts drought hazards by stressing both surface and ground water resources. Agricultural and industrial water users consume large amounts of water. Expansion of water-intensive enterprises is limited in a time when water resources are strained. In rapidly growing communities, new water and sewer systems or significant well and septic sites could use up more of the water available, particularly during periods of drought. Public water systems are monitored, but individual wells and septic systems are not as strictly regulated. Therefore, future development could have a profound impact on the vulnerability of Arapahoe County to drought.

Related to both current land use and future development trends, the use of turf grass affects the available water supplies. Maintaining lush, green lawns in the semi-arid climate of the Front Range requires large amounts of water. Urban lawn watering is the single largest water demand on most municipal supplies. Outdoor water use accounts for about 55 percent of the residential water use in the Front Range urban area, most of which is used on turf. [17] Residential and commercial landscaping can greatly impact future drought events and future water use regulations may be able to mitigate this trend.

MULTI-JURISDICTIONAL DIFFERENCES

Due to the nature of drought, all jurisdictions within Arapahoe County are expected to be impacted equally due to drought conditions. Agricultural communities are expected to bear the brunt of drought effects in the county.

HIRA SUMMARY

As stated previously, the onset of a drought is extremely difficult to predict. However, identifying various indicators of drought, and monitoring these indicators over time, provides us with a crucial means of assessing drought risk. Several mitigation measures to be reviewed and considered by Arapahoe County for incorporation into future Plan updates include:

[17] http://www.ext.colostate.edu/pubs/consumer/09952.html

- Drought assessment programs
- Water supply augmentation and development of new supplies
- Public awareness and education programs
- Technical assistance on water conservation
- Reduction and water conservation programs
- Emergency response programs
- Drought contingency plans

Some of these mitigation actions can have long-term impacts, such as contingency plan development, and the development of water conservation and public awareness programs. As Arapahoe County gains more experience assessing and responding to drought, future actions will undoubtedly become more timely, effective, and less reactive.

New water and sewer systems or significant well and septic sites could use up more of the water available, particularly during periods of drought. Public water systems are monitored, but individual wells and septic systems are not as strictly regulated. Therefore, future development could have an impact on the drought vulnerabilities to new buildings and infrastructure.

Although drought conditions rarely affect existing buildings, infrastructure, and critical infrastructure, economic livelihoods could be negatively impacted due to crop loss, timberland damage, water shortages, and wildfires as a result of drought. Possible losses/impacts to critical facilities include the loss of critical function due to low water supplies.

As Arapahoe County continues to grow, it will consider practical guidelines for determining the impacts of drought such as measuring the economic value of water in alternative uses and objective methods for quantifying non-market impacts of drought on those uses. Additionally, Arapahoe County will continue to follow guidance found within the State of Colorado’s Multi-Hazard Mitigation Plan as well as the Colorado Drought Mitigation and Response Plan.

EARTHQUAKE

NATURAL HAZARDS	PROBABILITY	IMPACT	SPATIAL EXTENT	WARNING TIME	DURATION	RF RATING
Earthquake	1 (0.4)	2 (0.5)	2 (0.5)	4 (0.4)	1 (0.1)	1.9
LOW RISK (1.5 – 1.9)						

HAZARD IDENTIFICATION

An earthquake is the motion or trembling of the ground produced by sudden displacement of rock usually within the upper 10 – 20 miles of the Earth's crust. Earthquakes can affect hundreds of thousands of square miles, cause damage to property measured in the tens of billions of dollars, result in loss of life and injury to hundreds of thousands of people, and disrupt the social and economic functioning of the affected area. Most property damage and earthquake-related deaths are caused by the failure and collapse of structures due to ground shaking which is dependent upon amplitude and duration of the earthquake (FEMA, 1997).

Earthquake Mechanics

Regardless of the source of the earthquake, the associated energy travels in waves radiating outward from the point of release. When these waves travel along the surface, the ground shakes and rolls, fractures form, and water waves may be generated. Earthquakes generally last a matter of seconds but the waves may travel for long distances and cause damage well after the initial shaking at the point of origin has subsided.

Breaks in the crust associated with seismic activity are known as "faults" and are classified as either active or inactive. Faults may be expressed on the surface by sharp cliffs or scarps or may be buried below surface deposits.

"Foreshocks," minor releases of pressure or slippage, may occur months or minutes before the actual onset of the earthquake. "Aftershocks," which range from minor to major, may occur for months after the main earthquake. In some cases, strong aftershocks may cause significant additional damage, especially if the initial earthquake impacted emergency management and response functions or weakened structures.

Factors Contributing to Damage

The damage associated with each earthquake is subject to four primary variables:

- The nature of the seismic activity
- The composition of the underlying geology and soils
- The level and quality of development of the area struck by the earthquake
- The time of day

Seismic Activity: The properties of earthquakes vary greatly from event to event. Some seismic activity is localized (a small point of energy release), while other activity is widespread (e.g., a major fault shifting or slipping all at once). Earthquakes can be very brief (only a few seconds) or last for a minute or more. The depth of release and type of seismic waves generated also play roles in the nature and location of damage; shallow quakes will hit the area close to the epicenter harder, but tend to be felt across a smaller region than deep earthquakes.

Geology and Soils: The surface geology and soils of an area influence the propagation (conduction) of seismic waves and how strongly the energy is felt. Generally, stable areas (e.g., solid bedrock) experience less destructive shaking than unstable areas (e.g., fill soils). The siting of a community or even individual buildings plays a strong role in the nature and extent of damage from an event.

Development: An earthquake in a densely populated area which results in many deaths and considerable damage may have the same magnitude as a shock in a remote area that has no direct impacts. Large magnitude earthquakes that occur beneath the oceans may not even be felt by humans.

Time of Day: The time of day of an event controls the distribution of the population of an affected area. On work days, the majority of the community will transition between work or school, home, and the commute between the two. The relative seismic vulnerability of each location can strongly influence the loss of life and injury resulting from an event.

Types of Damage

Often, the most dramatic evidence of an earthquake results from the vertical and/or horizontal displacement of the ground along a fault line. This displacement can sever transportation, energy, utility, and communications infrastructure potentially impacting numerous systems and persons. These ground displacements can also result in severe and complete damages to structures situated on top of the ground fault. However, most damage from earthquake events is the result of shaking. Shaking also produces a number of phenomena that can generate additional damage

- Additional ground displacement
- Landslides and avalanches
- Liquefaction and subsidence
- Seismic Seiches

Shaking: During minor earthquake events, objects often fall from shelves and dishes rattle. In major events, large structures may be torn apart by the forces of the seismic waves. Structural damage is generally limited to older structures that are poorly maintained, poorly constructed, or improperly (or not) designed for seismic events. Un-reinforced masonry buildings and wood frame homes not anchored to their foundations are typical victims of earthquake damage.

Loose or poorly secured objects also pose a significant hazard when they are loosened or dropped by shaking. These “non-structural falling hazard” objects include bookcases, heavy wall hangings, and building facades. Home water heaters pose a special risk due to their tendency to start fires when they topple over and rupture gas lines. Crumbling chimneys may also be responsible for injuries and property damage.

Dam and bridge failures are significant risks during stronger earthquake events, and due to the consequences of such failures, may result in considerable property damage and loss of life. In areas of severe seismic shaking hazard, shaking Intensity levels of VII or higher (see Table 35) can be experienced even on solid bedrock. In these areas, older buildings especially are at significant risk.

Ground Displacement: Ground displacement can also occur due to shaking, resulting in similar damages as mentioned previously.

Landslides and Avalanches: Even small earthquake events can cause landslides. Rock falls are common as unstable material on steep slopes is shaken loose, but significant landslides or even debris flows can be generated if conditions are ripe. Roads may be blocked by landslide activity, hampering response and recovery operations. Avalanches are possible when the snowpack is sufficient.

Liquefaction and Subsidence: Soils may liquefy and/or subside when impacted by the seismic waves. Fill and previously saturated soils are especially at risk. The failure of the soils has the potential to cause widespread structural damage. The oscillation and failure of the soils may result in increased water flow and/or failure of wells as the subsurface flows are disrupted and sometimes permanently altered. Increased flows may be dramatic, resulting in geyser-like water spouts and/or flash floods. Similarly, septic systems may be damaged creating both inconvenience and health concerns.

Seiches: Seismic waves may rock an enclosed body of water (e.g., lake or reservoir), creating an oscillating wave referred to as a "seiche." Although not a common cause of damage in past Colorado earthquakes, there is a potential for large, forceful waves similar to a tsunami ("tidal waves") to be generated on the large reservoirs within and neighboring Arapahoe County. Such a wave would be a hazard to shoreline development and pose a significant risk on dam-created reservoirs. A seiche could either overtop or damage a dam leading to downstream flash flooding.

Environmental impacts of earthquakes can be numerous, widespread, and devastating, particularly if indirect impacts are considered. Some examples of impacts are listed below:

- Induced flooding and landslides
- Poor water quality
- Damage to vegetation
- Breakage in sewage or toxic material containments

HAZARD PROFILE

The impact an earthquake event has on an area is typically measured in terms of earthquake intensity. Intensity is most commonly measured using the Modified Mercalli Intensity (MMI) Scale based on direct and indirect measurements of seismic effects.

Another way to express an earthquake's severity is to compare its acceleration to the normal acceleration due to gravity. Peak ground acceleration (PGA) measures the strength of ground movements in this manner. PGA represents the rate in change of motion of the earth's surface during an earthquake as a percent of the established rate of acceleration due to gravity. PGA can be partly determined by what soils and bedrock characteristics exist in the region. Unlike the Richter scale, PGA is not a measure of the total energy released by an earthquake, but rather of how hard the earth shakes at a given geographic area (the intensity). PGA is measured by using instruments including accelerographs and correlates well with the Mercalli scale.

When the peak ground acceleration nears 0.04 – 0.092g, an earthquake can be felt by people walking outside. As PGA nears 0.19 – 0.34g the intensity is considered to be very strong. At this level, plaster can break off and fall away from structures and cracks in walls often occur. PGA magnitudes of 1.24g are considered to be very disastrous. This magnitude of ground acceleration represents an earthquake of roughly 6.9 to 8.1 on the Richter Scale. A detailed description of the Modified Mercalli Intensity Scale is shown in the table below.

Table 36. Modified Mercalli Intensity Scale

SCALE	INTENSITY	DESCRIPTION OF EFFECTS	PGA (g)	RICHTER SCALE MAGNITUDE
I	**Instrumental**	Detected only on seismographs	< 0.0017	< 4.2
II	**Feeble**	Some people feel it	0.0018 – 0.014	
III	**Slight**	Felt by people resting; like a truck rumbling by		
IV	**Moderate**	Felt by people walking	0.015 – 0.039	
V	**Slightly Strong**	Sleepers awake; church bells ring	0.040 – 0.092	< 4.8
VI	**Strong**	Trees sway; suspended objects swing; objects fall off shelves	0.093 – 0.18	< 5.4
VII	**Very Strong**	Mild alarm, walls crack, plaster falls	0.19 – 0.34	< 6.1
VIII	**Destructive**	Moving cars uncontrollable, masonry fractures, poorly constructed buildings damaged	0.34 – 0.65	< 6.9

SCALE	INTENSITY	DESCRIPTION OF EFFECTS	PGA (g)	RICHTER SCALE MAGNITUDE
IX	Ruinous	Some houses collapse, ground cracks, pipes break open	0.65 – 1.24	
X	Disastrous	Ground cracks profusely, many buildings destroyed, liquefaction and landslides widespread	> 1.24	< 7.3
XI	Very Disastrous	Most buildings and bridges collapse, roads, railways, pipes and cables destroyed, general triggering of other hazards	> 124	< 8.1
XII	Catastrophic	Total destruction, trees fall, ground rises and falls in waves	> 124	> 8.1

Studies indicate that there are about 100 potentially active fault lines in Colorado. Over 500 earthquake tremors of magnitude 2.5 or higher have been recorded across the state since 1870. It is likely that more earthquakes of similar magnitude occurred during that time, but were not recorded due to low population densities and limited coverage of sensors across most of the state. For comparison, over 20,500 similarly sized events have been recorded in the State of California since 1870.

Relative to other western states, Colorado's earthquake risk is higher than Kansas or Oklahoma, lower than Utah, and much lower than Nevada and California (Colorado OEM, 2003). Despite Colorado's lower earthquake risk, based on geologic observations and characteristics of faults located in the region, seismologists predict that Colorado will indeed experience a magnitude 6.5 earthquake at some point in the future.

Earthquakes are relatively infrequent in Colorado and records of historical earthquakes in and around Arapahoe County are limited. The following Table provides a list of Colorado's larger earthquakes recorded since 1870.

Table 37. Notable Earthquake Events in Colorado (1870 – 2013)

Date	Location	Magnitude	Intensity
1870	Pueblo/Ft. Reynolds		VI
1871	Lily Park, Moffat County		VI

Date	Location	Magnitude	Intensity
1880	Aspen		VI
1882	North central Colorado	6.6*	VII
1891	Axial Basin (Maybell)		VI
1901	Buena Vista		VI
1913	Ridgeway Area		VI
1944	Montrose/Basalt		VI
1955	Lake City		VI
1960	Montrose/Ridgeway	5.5	V
1966	NE of Denver	5.0	V
1966	CO-NM border, near Dulce, NM	5.5	VII
1967	NE Denver	5.3	VII
1967	NE Denver	5.2	VI
2011	Southwest of Trinidad	5.3	VIII

*Estimated, based on historical felt reports
Source: Colorado Geological Survey

The most economically damaging earthquake in Colorado's history occurred on August 9th, 1967 in the Denver metro area. The 5.3 magnitude earthquake caused more than a million dollars of damage in Denver and the northern suburbs. The August 1967 earthquake was followed by an earthquake of magnitude 5.2 three months later in November 1967. Although these two earthquake events cannot be classified as "major earthquakes" they are significant because of their location along the Front Range Urban Corridor, an area where nearly 75 percent of Colorado residents and many critical facilities are located. Historically, earthquake risk in Colorado has been rated lower than most subject experts consider justified. It is critically important that local emergency managers in and around Arapahoe County become fully aware of the size and consequences of an earthquake that could occur.

Earthquakes are extremely difficult to predict and their occurrence rate is determined in one of two ways. If geologists can find evidence of distinct, datable earthquakes in the past, the number of these ruptures is used to define an occurrence rate. If evidence of ruptures is not available, geologists estimate fault slip rates from accumulated scarp heights and estimated date for the oldest movement on the scarp. Because a certain magnitude earthquake is likely to produce a displacement (slip) of a certain size, we can estimate the rate of occurrence of earthquakes of that magnitude.

Recurrence rates are different for different assumed magnitudes thought to be "characteristic" of that fault type. Generally, a smaller magnitude quake will produce a faster recurrence rate, and for moderate levels of ground motion, a higher hazard risk. Future earthquakes are assumed to be likely to occur where earthquakes have produced faults in the geologically recent past. Quaternary faults are faults that have slipped in the last 1.8 million years and it is widely accepted that they are the most likely source of future large earthquakes. For this reason, quaternary faults are used to make fault sources for future earthquake models.

CLIMATE CHANGE IMPACTS

Climate change is not expected at this time to have any impacts on geological hazards such as earthquakes. There is potential for increased heat and reduced soil moisture to contribute to the instability of regional soils. In theory, these subtle changes to the surface of the earth may affect the damage profile of local earthquake events in the future. However, it is unlikely that earthquake events in Arapahoe County will be affected by climate change in a measurable way.

INVENTORY ASSETS EXPOSED

The most appropriate risk assessment methodology for the seismic hazard is to conduct scenario modeling using FEMA's Hazus loss estimation software. Hazus is a very useful mitigation planning tool, because it provides an acceptable means of forecasting earthquake damage, loss of function of infrastructure, and casualties, among many other factors. There are three levels of Hazus analysis, from Level 1, which uses the default FEMA-derived datasets and damage functions, to Level 3, which uses independently compiled and accurately verified structure and infrastructure inventories and damage functions.

Hazus Level 2 analysis was performed for the 2015 Arapahoe County Hazard Mitigation Plan, utilizing the latest Hazus version 2.1 software. This Level 2 analysis utilized enhanced locally-derived data inputs leveraged from a number of sources that allowed for improved loss estimation and analysis. Data inputs included:

- Improved county inventory data compiled by FEMA Region VIII and provided by the Arapahoe County GIS. This included facility and infrastructure data covering essential facilities, high potential loss facilities, rail, transportation, and utilities.
- Updated 2010 Census data in a Hazus-compliant database schema provided by FEMA. This data included demographic and building stock updates based upon the 2010 Censes, which are not yet available in the out-of-the-box Hazus 2.1 software.
- Seismic site survey data from CGS. Data included fault, soil, and landslide inputs.

Within Hazus, the lifeline inventory is divided between transportation and utility lifeline systems. There are five transportation systems in Hazus that include: highways, railways, light rail, bus, and airports.

There are six utility systems that include: potable water, wastewater, natural gas, crude & refined oil, electric power and communications. In Arapahoe County, the total value of the transportation and utility lifeline systems is estimated to be $3.3 billion and $700 million, respectively. This inventory includes over 386 kilometers of highways, 290 bridges, and 7,773 kilometers of pipes. The lifeline inventory data are summarized in the table below.

Table 38. Arapahoe County Transportation and Utility Lifeline Inventory

Transportation System Lifeline Inventory – Arapahoe County, CO			
System	**Component**	**# Locations/Segments**	**Replacement value (millions of dollars)**
Highway	Bridges	290	$392.20
	Segments	179	$2,600.90
	Tunnels	1	$0.30
	Subtotal:		**$2,993.30**
Railways	Bridges	10	$1.90
	Facilities	0	$0.00
	Segments	27	$63.90
	Tunnels	0	$0.00
	Subtotal:		**$65.80**
Light Rail	Bridges	0	$0.00
	Facilities	5	$13.30
	Segments	5	$19.10
	Tunnels	0	$0.00
	Subtotal:		**$22.40**
Bus	Facilities	1	$1.10
		Subtotal:	**$1.10**

Airport	Facilities	2	$21.30
	Runways	4	$151.90
	Subtotal:		**$173.20**
Total:			**$3,255.80**
Utility System Lifeline Inventory – Arapahoe County, CO			
System	**Component**	**# Locations/Segments**	**Replacement value (millions of dollars)**
Potable Water	Distribution Lines	N/A	$87.40
	Facilities	1	$32.30
	Pipelines	0	$0.00
		Subtotal:	**$119.70**
Waste Water	Distribution Lines	N/A	$52.40
	Facilities	4	$258.40
	Pipelines	0	$0.00
		Subtotal:	**$310.90**
Natural Gas	Distribution Lines	N/A	$35.00
	Facilities	8	$0.00
	Pipelines	493	$184.40
		Subtotal:	**$219.30**
Oil Systems	Facilities	0	$0.00
	Pipelines	54	$66.40
		Subtotal:	**$66.40**
Electrical Power	Facilities	16	$0.00

		Subtotal:	**$0.00**
Communication	Facilities	8	$0.80
		Subtotal:	**$0.80**
		Total:	**$717.10**

Hazus also utilizes a detailed inventory of structures that are assessed as part of the loss estimation analysis. According to the Hazus inventory, there are an estimated 249,000 buildings in Arapahoe County with a total building replacement value (excluding contents) of $52,216 M (millions of dollars). Approximately 94% of the buildings (and 77% of the building value) are associated with residential housing. In terms of building construction types found in the county, wood frame construction makes up 71% of the building inventory. The remainder of the building stock is distributed between other general building types.

POTENTIAL LOSSES

In Colorado, earthquakes are considered low probability, high-consequence events. Although earthquakes may occur infrequently they can have devastating impacts. Ground shaking can lead to the collapse of buildings and bridges; disrupt gas, life lines, electric, and phone service. Deaths, injuries, and extensive property damage are possible vulnerabilities from this hazard. Some secondary hazards caused by earthquakes may include fire, hazardous material release, landslides, flash flooding, avalanches, tsunamis, and dam failure. Moderate and even very large earthquakes are inevitable, although very infrequent, in areas of normally low seismic activity. Consequently, buildings in these regions are seldom designed to deal with an earthquake threat; therefore, they are extremely vulnerable.

Most property damage and earthquake-related injuries and deaths are caused by the failure and collapse of structures due to ground shaking. The level of damage depends upon the amplitude and duration of the shaking, which are directly related to the earthquake size, distance from the fault, site, and regional geology. Other damaging earthquake effects include landslides, the down-slope movement of soil and rock (mountain regions and along hillsides), and liquefaction, in which ground soil loses shear strength and the ability to support foundation loads. In the case of liquefaction, anything relying on the substrata for support can shift, tilt, rupture, or collapse.

Hazus is a regional earthquake loss estimation model developed by FEMA and the National Institute of Building Science. The primary purpose of Hazus is to provide a methodology and software application to develop earthquake loss at a regional scale. For the risk assessment conducted as part of the 2015 Plan, two separate 6.5 magnitude earthquake scenarios were simulated in Hazus. The two hazard scenarios that were analyzed are:

- 6.5-magnitude event with an epicenter on the Golden Fault*
- 6.5-magnitude event with an epicenter on the geographic center of Arapahoe County (also known as the "Random Fault" scenario)

*This scenario's event parameters and locations were chosen based on pre-existing scenarios outlined by the Colorado Geological Survey. The Front Range is defined by a 500- to 1,000-m-high, east-facing escarpment called the Golden Fault that is both a tectonic and erosional feature. The Golden Fault is a quaternary fault that bounds the eastern side of the Front Range near the town of Golden, adjacent to the Denver Metropolitan Area. The Golden Fault was selected as an epicenter because it is the closest proximity quaternary fault to Arapahoe County.

The map below depicts Arapahoe County, the location of the two earthquake scenario epicenters modeled for the Plan, and the location and magnitude of historical earthquake events in the region.

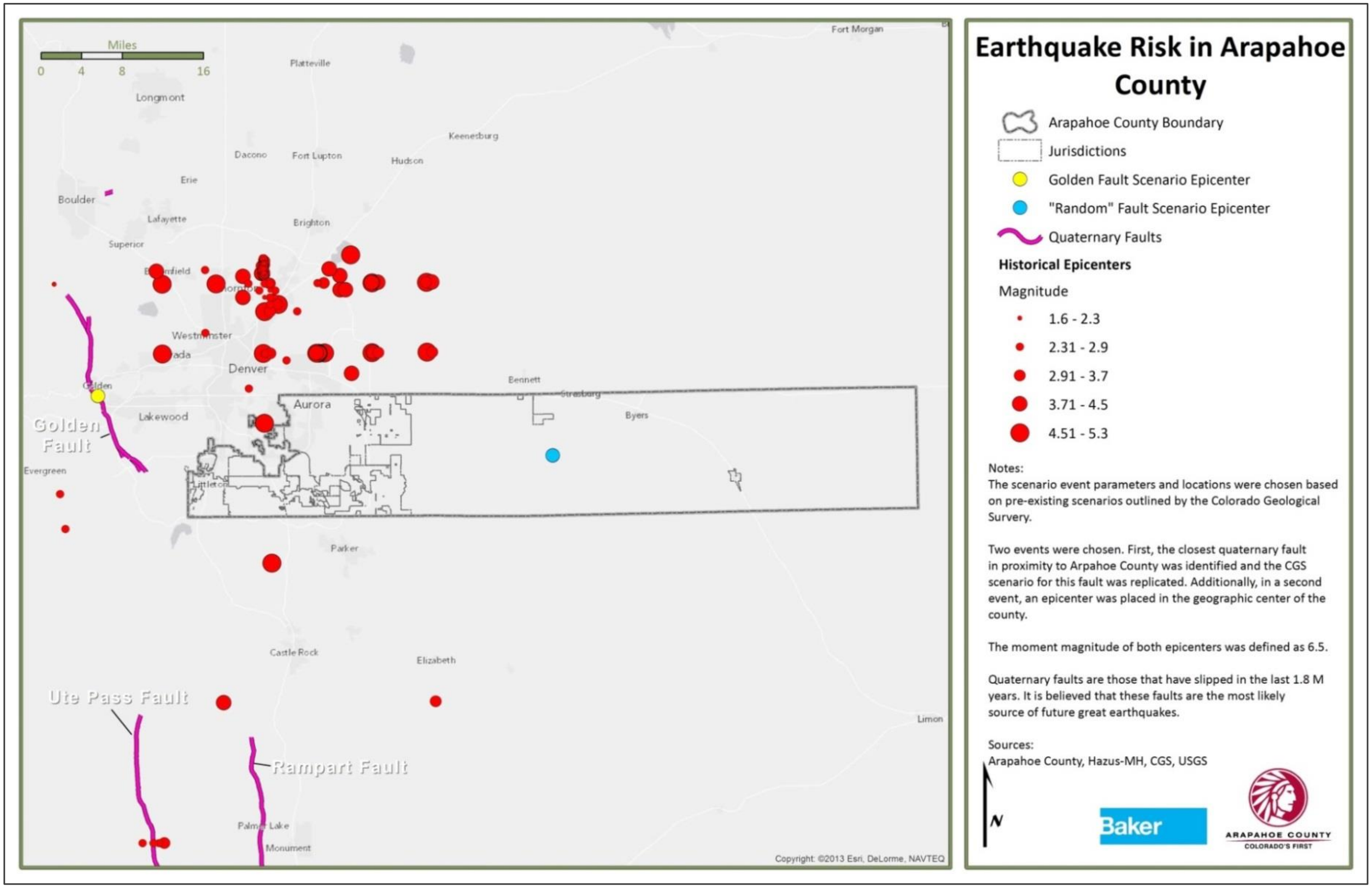


Figure 24. Map of Historical Earthquake Epicenters (1962 – 2014) and HAZUS Fault Scenarios

In the following maps (Figures 24 and 25) PGA for the Golden and Random Fault scenarios are represented as %g. The Golden Fault model shows relatively low PGA in the eastern part of Arapahoe County as the energy released from the Golden fault radiates away from the epicenter. The majority of the high PGA values are found in densely populated census tracts in the western part of the County. In the map from the Random Fault scenario we see higher PGA values, and higher ground shaking, in the less-densely populated central and eastern regions of Arapahoe County.

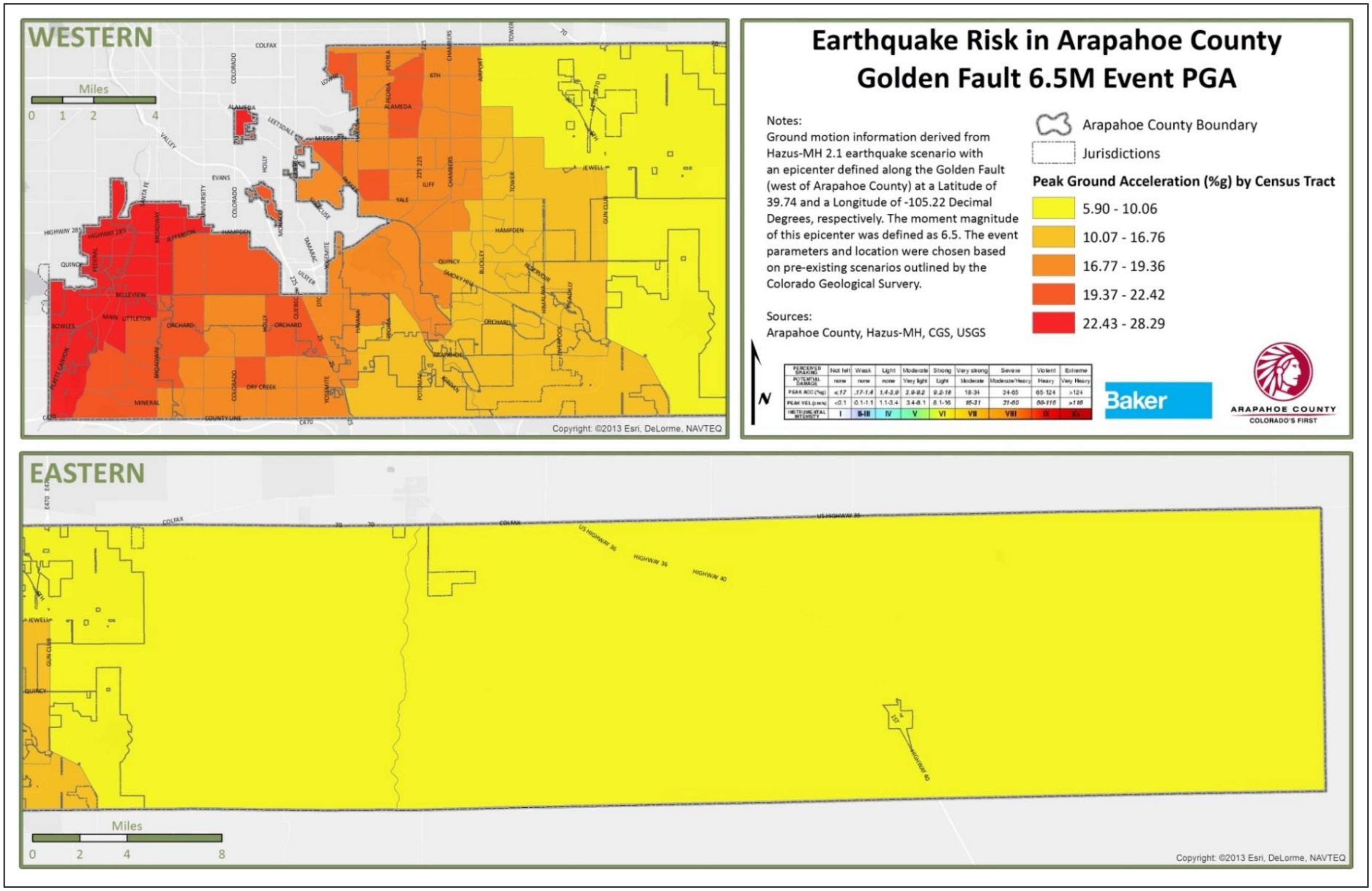


Figure 25. Map of PGA from Golden Fault Earthquake

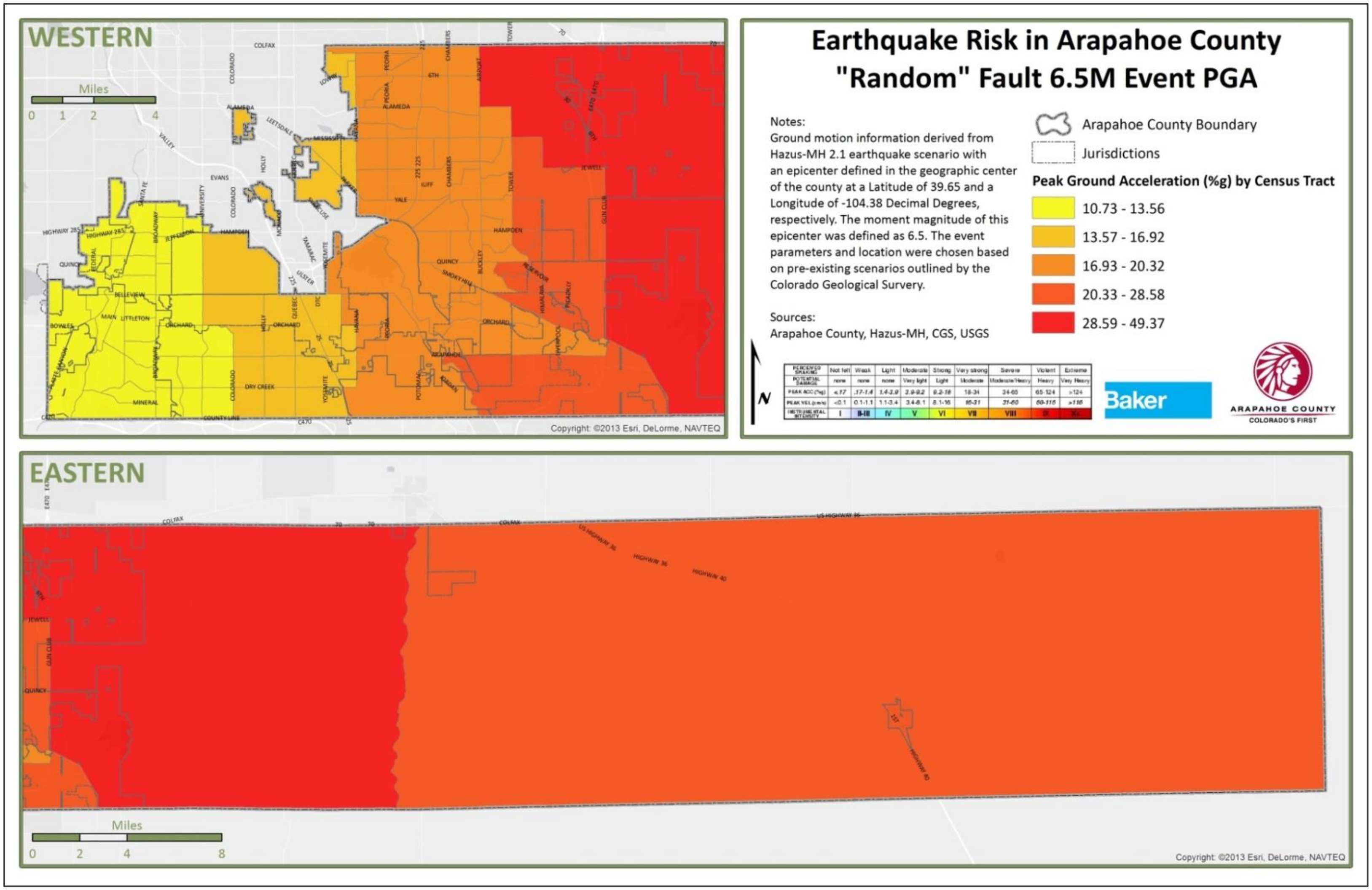


Figure 26. Map of PGA from Random Fault Earthquake

Loss estimates from the two Hazus scenarios are included in the following Tables and maps. Data summarized for each scenario includes the following:

- Expected building damage (number of structures) by occupancy
- Expected building damage (number of structures) by building type
- Expected damage to essential facilities (number of structures)
- Expected damage to transportation and utility lifeline systems (number of structures)
- Induced earthquake damages (fire and debris generation)
- Social Impacts (including shelter requirements and casualties)
- Expected building loss estimates ($)
- Expected business interruption loss estimates ($)

Economic Losses and Building Damage

The following Figure provides a map of total economic losses in Arapahoe County projected by the Golden Fault earthquake scenario. Total economic losses include losses from building/infrastructure damage, relocation, and business interruption. For the Golden Fault earthquake scenario, the total losses were estimated to be just over $2 billion. Twenty-five percent (25%) of the estimated losses were related to the business interruption of the county. By far, the largest estimated losses were sustained by the residential buildings which made up forty-six percent (46%) of the total economic losses. Spatially, a majority of the worst loss areas were located in the western, urban portion of the county. Generally, these are areas which are more densely/highly populated and more closely located to the Golden epicenter. But, the fact that large damage differences are seen across the western portion of the county show that other factors are influencing the Hazus loss estimations, most likely dealing with the underlying building stock data.

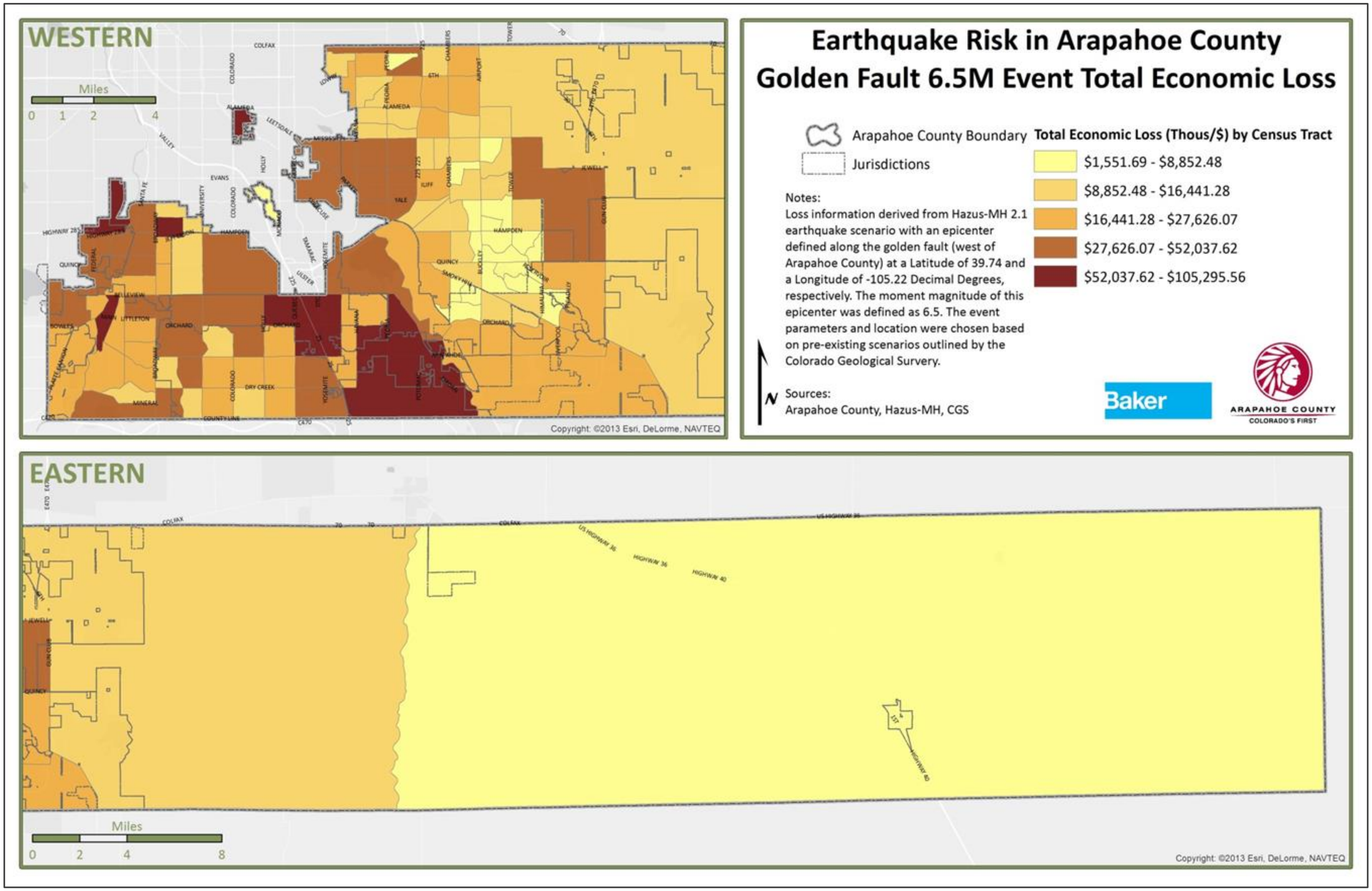


Figure 27. Map of Total Economic Losses from Golden Fault Scenario

Hazus breaks total economic losses into two categories: direct building losses and indirect (business interruption) losses. The direct building losses are the estimated costs to repair or replace the damage caused to a building and its contents. Indirect losses are the losses associated with the inability to operate a business because of the damage sustained during the earthquake. Indirect losses also include the temporary living expenses for people displaced from their homes because of the earthquake. The following Table details the Hazus loss estimates for the Golden Fault event.

Table 39. Economic Losses – Golden Fault Scenario (Losses in Millions of Dollars)

Category		Single Family	Other Residential	Commercial	Industrial	Other	Total
Indirect Losses							
	Wages	0.00	5.81	139.16	5.20	14.33	164.49
	Capital-Related	0.00	2.48	122.08	3.19	4.47	132.22
	Rental	17.52	36.10	67.70	1.84	5.46	128.61
	Relocation	65.53	26.22	110.77	9.13	60.31	271.97
	Subtotal	**$83.05**	**$70.61**	**$439.70**	**$19.36**	**$84.56**	**$697.29**
Direct Losses							
	Structural	132.27	57.76	125.72	25.99	54.88	396.62
	Non - Structural	430.19	270.84	295.53	65.15	140.73	1,202.44
	Content	150.62	64.05	134.97	39.57	61.81	451.00
	Inventory	0.00	0.00	3.00	98.90	0.37	12.28
	Subtotal	**$713.07**	**$392.65**	**$559.22**	**$139.61**	**$257.79**	**$2,062.34**
	TOTAL	**$796.12**	**$463.26**	**$998.92**	**$158.97**	**$342.36**	**$2,759.62**

The following Figure is a map of total economic losses in Arapahoe County projected by the Random Fault earthquake scenario. Total economic losses estimated for the simulated earthquake on the Random Fault is approximately $2 billion, which includes building and lifeline-related losses based on the County’s available inventory. Twenty-two percent (22%) of the estimated losses were related to the business interruption of the County. The largest estimated losses were sustained by the residential occupancies which made up fifty-five percent (55%) of the total estimated losses. Although the damage estimate totals are close between the two scenarios, spatially the two events differ greatly. For the Random scenario, it is seen that the worst losses are now located in the center portion of the county. This is expected as that is where the theoretical location of that event's epicenter is located.

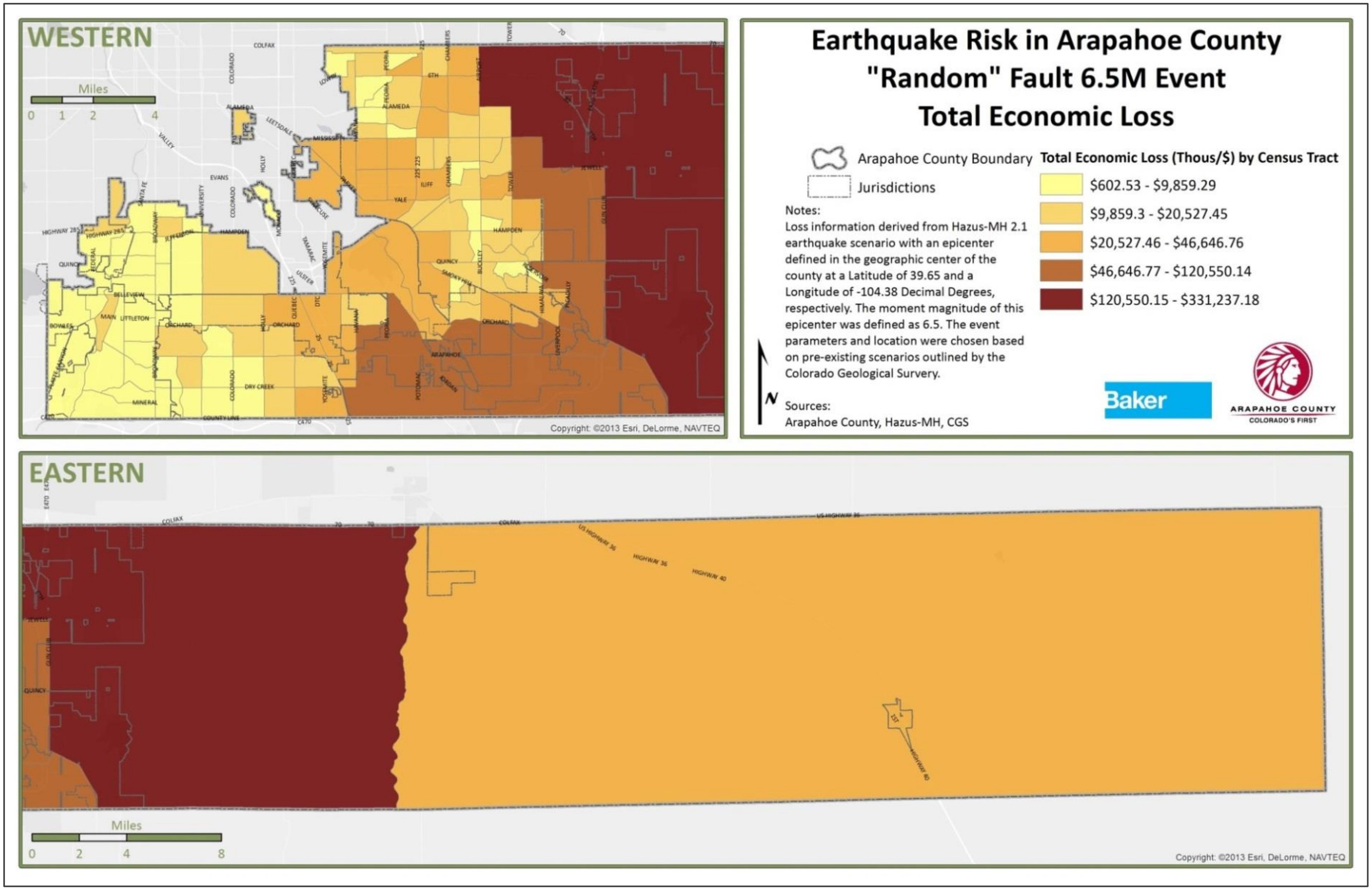


Figure 28. Map of Total Economic Losses from Random Fault Scenario

The following Table further breaks down the economic loss estimations for the Radom Fault earthquake scenario.

Table 40. Economic Losses – Random Fault Scenario (Losses in Millions of Dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Other	Total
Income Losses							
	Wages	0.00	4.01	90.79	2.96	12.96	110.72
	Capital-Related	0.00	1.72	84.17	1.78	4.14	91.81
	Rental	20.68	26.74	46.62	1.07	4.11	99.21
	Relocation	76.57	20.97	72.51	5.85	52.93	228.85
	Subtotal	**$97.26**	**$53.44**	**$294.09**	**$11.66**	**$74.14**	**$530.59**
Capital Stock Losses							
	Structural	161.14	44.70	81.78	15.65	52.54	355.81
	Non -Structural	523.13	207.32	193.13	40.01	140.28	1,103.87
	Content	176.05	49.29	90.02	23.83	60.89	400.09
	Inventory	0.00	0.00	2.09	4.97	0.29	7.35
	Subtotal	**$860.32**	**$301.31**	**$367.01**	**$84.47**	**$254.00**	**$1,867.11**
	TOTAL	**$957.58**	**$354.75**	**$661.10**	**$96.13**	**$328.14**	**$2,397.70**

Tables 40 and 41 summarize expected damages in Arapahoe County by general building occupancy for the Golden Fault and Random Fault scenarios. The damage levels are defined by the following parameters:

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

Hazus estimates that about 29,970 buildings in the County will be at least moderately damaged if a 6.5 earthquake were to occur on the Golden Fault. This is over 12% of the total buildings in the County. There are an estimated 1,282 buildings that are expected to be damaged beyond repair. Table 40 below summarizes the expected damage in Arapahoe County by general building type for the Golden Fault scenario.

Table 41. Golden Fault Scenario – Expected Building Damage by Occupancy

	None		**Slight**		**Moderate**		**Extensive**		**Complete**	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	280	0.16	78	0.19	79	0.37	40	0.56	10	0.82
Commercial	4,899	2.75	2,017	4.85	2,160	10.06	929	12.88	199	15.50
Education	109	0.06	33	0.08	36	0.17	16	0.23	4	0.28
Government	93	0.05	34	0.08	43	0.20	21	0.30	5	0.43
Industrial	1,322	0.74	565	1.36	693	3.23	347	4.80	86	6.70
Other Residential	55,239	31.03	14,605	35.11	8,201	38.19	3,381	46.84	795	62.02
Religion	370	0.21	124	0.30	135	0.63	62	0.86	14	1.07
Single Family	115,685	64.99	24,136	58.03	10,127	47.16	2,421	33.54	169	13.19
Total	**177,997**		**41,593**		**21,475**		**7,218**		**1,282**	

Somewhat similarly for the Random scenario, Hazus estimates that about 27,672 buildings will be at least moderately damaged if a 6.5 earthquake were to occur with an epicenter at the geographic center of Arapahoe County. This represents over 11% of the buildings in the County. There are an estimated 1,283 buildings that are expected to be damaged beyond repair. The following Table summarizes the expected damage in Arapahoe County by general building type for the Random Fault scenario.

Table 42. Random Fault Scenario – Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	294	0.16	76	0.19	72	0.36	35	0.54	11	0.86
Commercial	5,746	3.16	1,878	4.70	1,762	8.80	670	10.54	148	11.52
Education	117	0.06	32	0.08	32	0.16	14	0.22	4	0.30
Government	110	0.06	33	0.08	34	0.17	15	0.24	5	0.38
Industrial	1,593	0.88	540	1.35	573	2.86	247	3.89	60	4.65
Other Residential	59,109	32.48	12,980	32.51	6,925	34.57	2,580	40.59	628	48.92
Religion	430	0.24	115	0.29	109	0.54	41	0.65	10	0.75
Single Family	114,571	62.96	24,267	60.79	10,527	52.55	2,753	43.32	419	32.63
Total	**181,971**		**39,921**		**20,034**		**6,355**		**1,283**	

Although the Golden Fault Scenario is associated with slightly higher magnitudes of None, Slight, Moderate, and Extensive building damage, both fault scenarios anticipate nearly the same amount of damage to Arapahoe County's building stock. What this means is that the location of the earthquake epicenter within the county is expected to make a negligible difference to building damage outcomes.

Below, Tables 42 and 43 summarize the same building damage information, this time filtered by building type. In this data set buildings have been categorized by the following building types:

- Wood – Supporting, framed material used in construction of both commercial and residential buildings.
- Steel – Supporting, framed material used in construction of both commercial and residential buildings.
- Concrete – A composite conglomerate of coarse granular and hard matrix materials used in commercial and residential construction.
- Precast – Buildings with large wood or metal deck roof diaphragms that distribute lateral forces to precast concrete shear walls.

- Masonry – Any type of brick, concrete or other type of masonry that is used in construction of both commercial and residential buildings. Refers to both reinforced (RM) and unreinforced masonry buildings (URM).
- Manufactured Housing (MH) – Prefabricated homes built in factories elsewhere, shipped, and finally assembled on site. Majority of MH structures have a wheeled chassis attached.

Table 43. Golden Fault Scenario – Expected Building Damage by Building Type

	None		**Slight**		**Moderate**		**Extensive**		**Complete**	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	138,150	77.61	30,494	73.31	7,842	36.52	688	9.54	41	3.17
Steel	1,601	0.90	938	2.25	2,126	9.90	1,566	21.70	498	38.86
Concrete	3,984	2.24	1,657	3.98	1,661	7.74	624	8.65	93	7.27
Precast	1,395	0.78	476	1.14	772	3.60	489	6.78	83	6.51
RM	26,477	14.87	5,104	12.27	5,929	27.61	2,235	30.96	92	7.20
URM	3,912	2.20	,1653	3.97	1,376	6.41	520	7.20	141	11.02
MH	2,478	1.39	1271	3.06	1,768	8.23	1,095	15.17	333	25.99
Total	**177,997**		**41,593**		**21,475**		**7,218**		**1,282**	

Table 44. Random Fault Scenario - Expected Building Damage by Building Type

	None		**Slight**		**Moderate**		**Extensive**		**Complete**	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	139,797	76.82	29,117	72.94	7,539	37.63	716	11.26	46	3.60
Steel	2,349	1.29	1,046	2.62	1,897	9.47	1,138	17.91	299	23.32
Concrete	4,722	2.59	1,541	3.86	1,306	6.52	397	6.25	53	4.11
Precast	1,681	0.92	466	1.17	660	3.30	354	5.57	55	4.27
URM	26,733	14.69	4,883	12.23	5,645	28.18	2,282	35.91	292	22.79

	None		Slight		Moderate		Extensive		Complete	
RURM	4,027	2.21	1,597	4.00	1,307	6.52	501	7.89	170	13.25
MH	2,661	1.46	1,270	3.18	1,681	8.39	966	15.27	368	28.67
Total	**181,971**		**39,921**		**20,034**		**6,355**		**1,283**	

The two tables showing number of buildings damaged by building type highlight the following findings:

- For both the Golden Fault and Random Fault earthquake scenarios the largest percentage of “Moderately Damaged” buildings are wood framed structures (Golden Fault scenario = 36.52%; Random Fault scenario = 37.63%)
- In the “Extensive Damage” category, the largest percentage of buildings damaged in the Golden Fault earthquake scenario are categorized as reinforced (RM) masonry buildings (30.96%).
- In the “Extensive Damage” category, the largest percentage of buildings damaged in the Random Fault earthquake scenario are categorized as reinforced (RM) masonry buildings (35.91%).
- In the “Complete Damage” category, the largest percentage of buildings damaged in the Golden Fault scenario are categorized as steel framed buildings (38.86%).
- In the “Complete Damage” category, the largest percentage of buildings damaged in the Random Fault scenario are categorized as manufactured housing (MH) (28.67%).

In summary, the two earthquake loss scenarios estimate roughly the same overall damages as they relate to economic losses and building damages. Although the spatial pattern of the expected losses will change based upon the epicenter location, it seems that a magnitude 6.5 event will have a major impact on the County regardless of where it is located.

Damages to Critical Facilities/Infrastructure

The Hazus earthquake model also provides estimates relating to the expected damages to and functionality of the County’s critical facilities and critical infrastructure, as defined by Hazus. The following pages, containing Tables 44 through 49, detail these estimates.

For the Golden Fault scenario, the following Table provides post-event damage and functionality estimates for specific types of essential facilities within Arapahoe County. In addition to estimating the number of facilities what will suffer either moderate or complete damage to over 50% of the structure, the table shows the number of facilities that will be operating at or over 50% functionality almost immediately after the earthquake event.

Based on the results of the Hazus model, in the event of a magnitude 6.5 earthquake, it is estimated that:

- Seven out of eight hospitals will experience at least moderate damage to over 50% of their physical structure.
- Five schools will suffer complete damage to over 50% of their physical structure.
- Over half of the Emergency Operation Centers (EOCs) in Arapahoe County will be over 50% functional on the first day of the event.
- 60% of police stations in Arapahoe County will be over 50% functional on the first day of the event.
- 50% of fire stations in Arapahoe County will be over 50% functional on the first day of the event.

Table 45. Golden Fault Scenario – Expected Damage to Essential Facilities

Classification	Total	# of Facilities		
		At Least Moderate Damage >50%	Complete Damage >50%	With Functionality >50% on day 1
Hospitals	8	7	0	0
Schools	191	115	5	71
EOCs	9	0	0	6
Police Stations	16	0	0	10
Fire Stations	39	0	0	21

For the Random Fault scenario, the next Table provides similar damage estimates. For that event, it is estimated that:

- Seven out of eight hospitals will experience at least moderate damage to over 50% of their physical structure.
- Two schools will suffer complete damage to over 50% of their physical structure.
- Over half of the Emergency Operations Centers (EOCs) in Arapahoe County will be over 50% functional on the first day of the event.
- 90% of police stations in Arapahoe County will be over 50% functional on the first day of the event.
- 70% of fire stations in Arapahoe County will be over 50% functional on the first day of the event.

Table 46. Random Fault Scenario – Expected Damage to Essential Facilities

Classification	Total	# of Facilities		
		At Least Moderate Damage >50%	Complete Damage >50%	With Functionality >50% on day 1
Hospitals	8	7	0	0
Schools	191	120	2	60
EOCs	9	0	0	8
Police Stations	16	0	0	15
Fire Stations	39	1	0	28

Tables 46 and 47 provide damage estimates for the transportation and utility lifeline systems based on the Golden Fault and Random Fault earthquake scenarios, respectively. In reviewing the damage estimates, the good news is that either of these two earthquake scenarios would not be expected to have a large impact on transportation or utility systems. Hazus estimated that most all systems would be functioning with greater than 50% of capacity a day following the event. Within a week, almost 100% of systems would be functioning with greater than 50% of capacity, with the exception of a few highway segments affected by the Random Fault scenario.

Table 47. Golden Fault Scenario – Expected Damage to Transportation Systems

Transportation System Damage – Golden Fault						
System	Component	# of Locations				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50%	
					After Day 1	After Day 7
Highway	Bridges	290	19	0	272	281
	Segments	179	0	0	179	179
	Tunnels	1	0	0	1	1
Railways	Bridges	10	0	0	10	10

	Facilities	0	0	0	0	0
	Segments	27	0	0	27	27
	Tunnels	0	0	0	0	0
Light Rail	Bridges	0	0	0	0	0
	Facilities	5	0	0	5	5
	Segments	5	0	0	5	5
	Tunnels	0	0	0	0	0
Bus	Facilities	1	0	0	1	1
Airport	Facilities	2	0	0	2	2
	Runways	4	0	0	4	4

Utility System Damage – Golden Fault					
System	**# of Locations**				
	Total #	**With at Least Moderate Damage**	**With Complete Damage**	**With Functionality > 50%**	
				After Day 1	**After Day 7**
Potable Water	1	1	0	0	1
Waste Water	4	2	0	1	4
Natural Gas	8	0	0	8	8
Oil Systems	0	0	0	0	0
Electrical Power	16	5	0	9	16
Communication	8	4	0	8	8

Table 48. Golden Fault Scenario – Expected Damage to Transportation Systems

Transportation System Damage – Random Fault						
System	Component	# of Locations				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50%	
					After Day 1	After Day 7
Highway	Bridges	290	66	10	225	252
	Segments	179	0	0	179	179
	Tunnels	1	0	0	1	1
Railways	Bridges	10	0	0	10	10
	Facilities	0	0	0	0	0
	Segments	27	0	0	27	27
	Tunnels	0	0	0	0	0
Light Rail	Bridges	0	0	0	0	0
	Facilities	5	0	0	5	5
	Segments	5	0	0	5	5
	Tunnels	0	0	0	0	0
Bus	Facilities	0	0	0	0	0
Airport	Facilities	2	0	0	2	2
	Runways	4	0	0	4	4
Utility System Damage – Random Fault						

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	With Functionality > 50%	
				After Day 1	After Day 7
Potable Water	1	1	0	0	1
Waste Water	4	1	0	0	4
Natural Gas	8	7	0	0	4
Oil Systems	0	0	0	0	0
Electrical Power	16	7	0	7	15
Communication	8	2	0	7	8

Tables 48 and 49 provide estimates for the number of leaks and breaks expected along utility system pipelines for the two scenarios within Arapahoe County. These types of events can lead to secondary disaster events such as public health hazards, structure fires, wildfires, and ecological disasters. From the tables below, it is apparent that the Random Fault scenario would produce greater expected damages. This is likely due to the fact that many of the pipelines traversing Arapahoe County are sited in the central and eastern portions of the County, which places the Random Fault epicenter at a closer proximity to these utilities.

Table 49. Golden Fault – Expected Utility System Pipeline Damage

System	Total Pipeline Length	Number of Leaks	Number of Breaks
Potable Water	4,371	341	85
Waste Water	2,622	171	43
Natural Gas	535	14	4
Oil	246	9	2

Table 50. Random Fault – Expected Utility System Pipeline Damage

System	Total Pipeline Length	Number of Leaks	Number of Breaks

Potable Water	4,371	601	150
Waste Water	2,622	302	75
Natural Gas	535	350	87
Oil	246	71	18

Hazus performs a simplified system performance analysis for electric power and potable water. The results from each earthquake scenario are shown in Tables 50 and 51. The tables provide a summary of the system performance information for electric power and water by estimating the number of households without services over time. Similar to what was observed previously relating to pipelines, it seems that an epicenter in the middle of the county (Random Fault scenario) would result in larger damages to the power and water distribution systems of Arapahoe County.

Table 51. Golden Fault – Expected Potable Water and Electric Power System Performance

	Total # of Households	**Number of Households Without Service**				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	224,104	2,237	0	0	0	0
Electric Power		115,510	49,399	12,134	1,505	224

Table 52. Random Fault – Expected Potable Water and Electric Power System Performance

	Total # of Households	**Number of Households Without Service**				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	224,104	15,585	4,325	0	0	0
Electric Power		137,600	75,811	32,271	7,491	224

Fire and Debris Generation

Fires often occur after an earthquake event due to ruptured gas lines and disturbance of electrical systems. Fires often grow out of control after an earthquake event because of the sheer number of fires and the lack of water and resources to fight them. FEMA's Hazus tool uses a Monte Carlo simulation model to estimate the number of ignitions and the count of burnt areas post-earthquake. For the Golden Fault scenario, the model estimates that there will be four ignitions that will burn about 0.23 sq. miles (or 0.03% of the County's total area). The model also estimates that the fires will displace about 1,059 people and burn about $88 M (millions of dollars) of building value. For the Random Fault scenario, the model estimates that there will be three ignitions that will burn about 0.22 sq. miles (or 0.03% of the County's total area). The model also estimates that the fires for that scenario will displace about 1,044 people and burn about $87 M (millions of dollars) of building value.

Hazus models also estimate the amount of debris that will be generated by an earthquake. The Golden Fault scenario estimates that a total of 1.11 million tons of debris will be generated from that 6.5 magnitude event. Of the total amount, brick and wood make up 24% of the total, with the remainder of the debris being reinforced concrete and steel. When the debris tonnage is converted to an estimated number of truckloads, it will require 44,320 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

The Random Fault scenario estimates that a total of 0.96 million tons of debris will be generated from a 6.5 magnitude events. Of that total amount, brick and wood debris comprises 27% of the total, with the remainder of the debris being reinforced concrete and steel. When the debris tonnage is converted to an estimated number of truckloads, the County will require 38,240 truckloads (@25 tons/truck) to remove the debris generated by the earthquake. The following two Figures present maps showing the earthquake debris levels throughout the county predicted for each earthquake scenario.

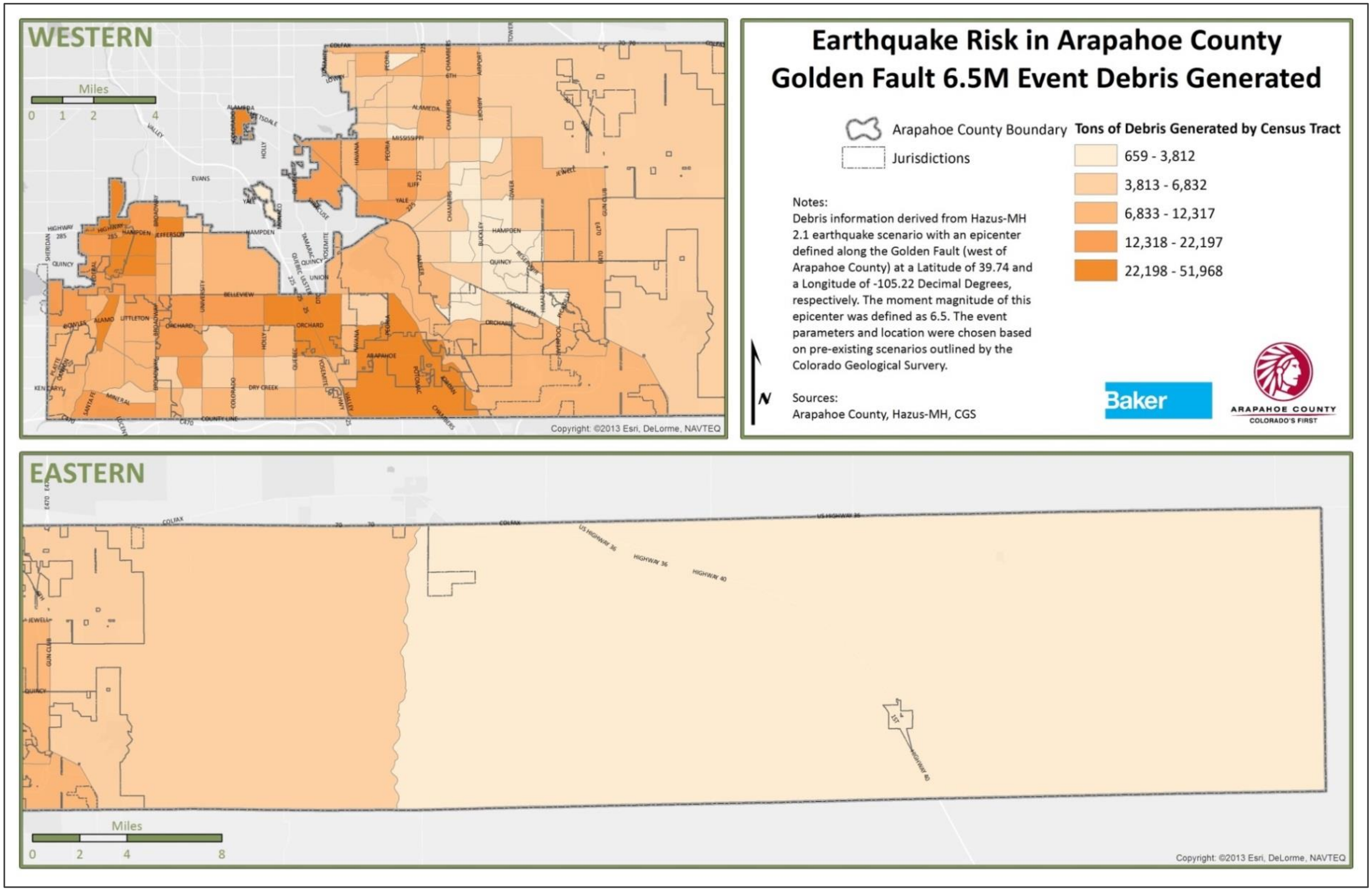


Figure 29. Map of Debris Generated from Golden Fault Scenario

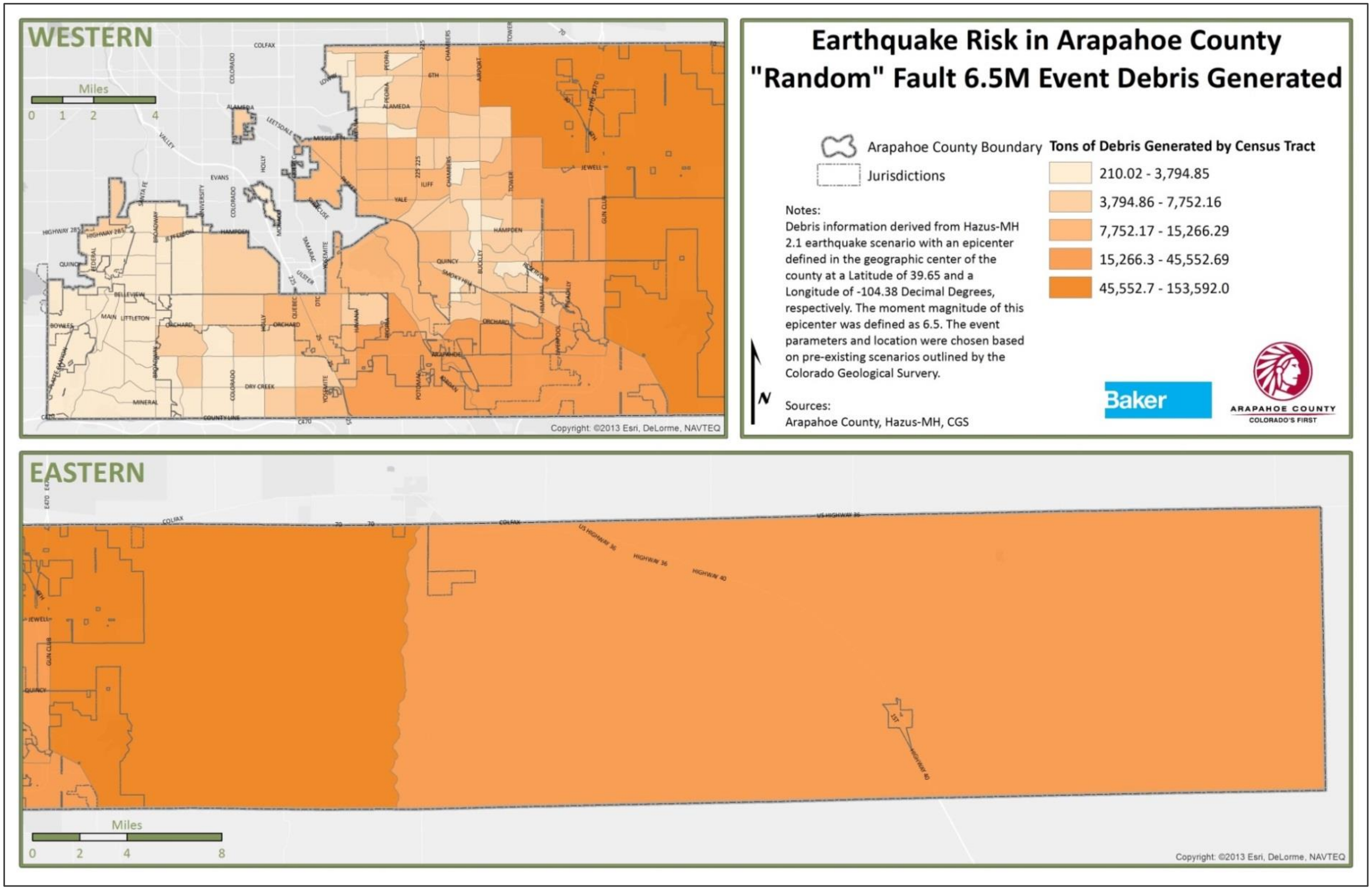


Figure 30. Map of Debris Generated from Random Fault Scenario

Shelter Requirements and Casualties

Hazus estimates the number of people that will be injured and killed by an earthquake scenario. The casualties are broken down into four severity levels that describe the extent of injuries. The levels are describes as follows:

- Severity Level 1 – Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2 – Injuries will require hospitalization but are not considered life-threatening.
- Severity Level 3 – Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4 – Victims are killed by the earthquake.

The casualty estimates are provided for three times of day: 2:00AM, 2:00PM, and 5:00PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads; the 2:00AM estimate considers that the residential occupancy load is at a maximum; the 2:00PM estimate considers that the educational, commercial, and industrial sector loads are at their maximum; and the 5:00PM estimate represents peak commute time. The following Tables provide summaries of the casualties estimated for the Golden Fault and Random Fault earthquake scenarios, respectively.

Table 53. Casualty Estimates – Golden Fault Scenario

		Level 1	**Level 2**	**Level 3**	**Level 4**
2 AM	Commercial	13	3	0	1
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	3	1	0	0
	Industrial	17	4	1	1
	Other-Residential	188	37	4	7
	Single Family	201	30	3	5
	TOTAL	**423**	**74**	**8**	**14**
2 PM	Commercial	714	160	22	43
	Commuting	1	1	1	0
	Educational	432	96	13	26

		Level 1	Level 2	Level 3	Level 4
	Hotels	1	0	0	0
	Industrial	125	30	4	8
	Other-Residential	33	7	1	1
	Single Family	32	5	0	1
	TOTAL	**1,338**	**298**	**41**	**78**
5 PM	Commercial	486	108	15	28
	Commuting	27	35	61	12
	Educational	67	15	2	4
	Hotels	1	0	0	0
	Industrial	78	19	3	5
	Other-Residential	70	14	1	2
	Single Family	78	12	1	2
	TOTAL	**807**	**202**	**82**	**54**

Table 54. Casualty Estimates – Random Fault Scenario

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	8	2	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	3	1	0	0
	Industrial	12	3	0	1
	Other-Residential	122	22	2	3

	Single Family	196	32	3	7
	TOTAL	**341**	**59**	**6**	**11**
2 PM	Commercial	441	93	12	24
	Commuting	1	1	1	0
	Educational	558	137	20	39
	Hotels	1	0	0	0
	Industrial	89	22	3	6
	Other-Residential	21	4	0	1
	Single Family	30	5	1	1
	TOTAL	**1,140**	**261**	**38**	**71**
5 PM	Commercial	339	73	10	18
	Commuting	27	34	60	11
	Educational	77	19	3	5
	Hotels	1	0	0	0
	Industrial	56	14	2	4
	Other-Residential	45	8	1	1
	Single Family	76	13	1	3
	TOTAL	**621**	**160**	**77**	**43**

In addition to providing loss estimation, debris models, and casualties HAZUS estimates the number of households that are expected to be displaced from their homes due to an earthquake and the number of displaced people that will require accommodations in temporary public shelters. The Golden Fault model estimates that 3,218 households will be displaced in Arapahoe County due to an earthquake and 1,946 people will seek temporary shelter in public shelters. In contrast, the Random Fault model estimates that 2,634 householders will be displaced due to that 6.5 magnitude earthquake and 1,621 people will seek temporary shelter in public shelters. The following two maps show displaced households at the Census Tract level for the Golden Fault and Random Fault earthquake scenarios. For both scenarios, debris generation and displaced households appear to be positively correlated.

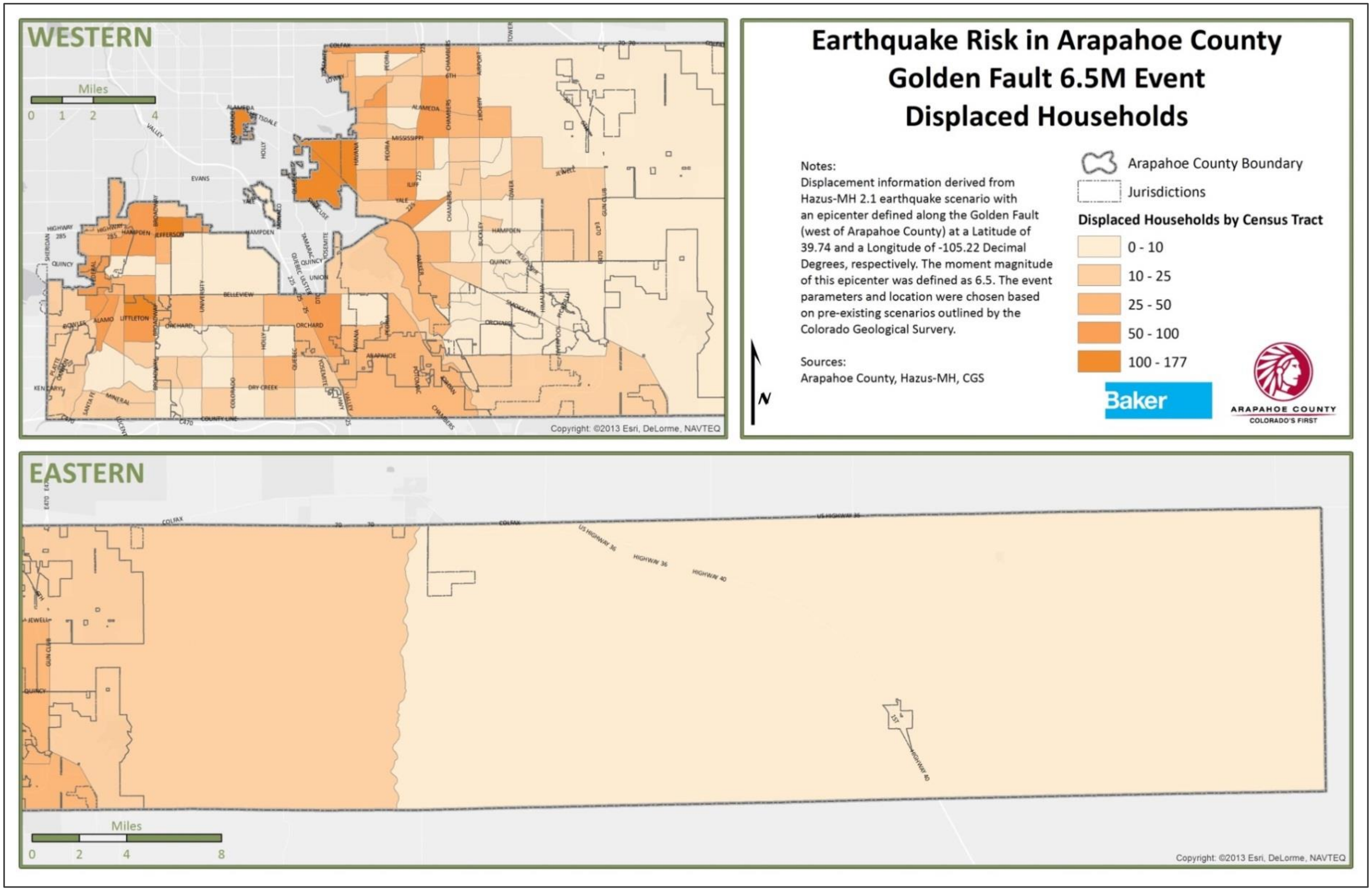


Figure 31. Map of Displaced Households – Golden Fault Scenario

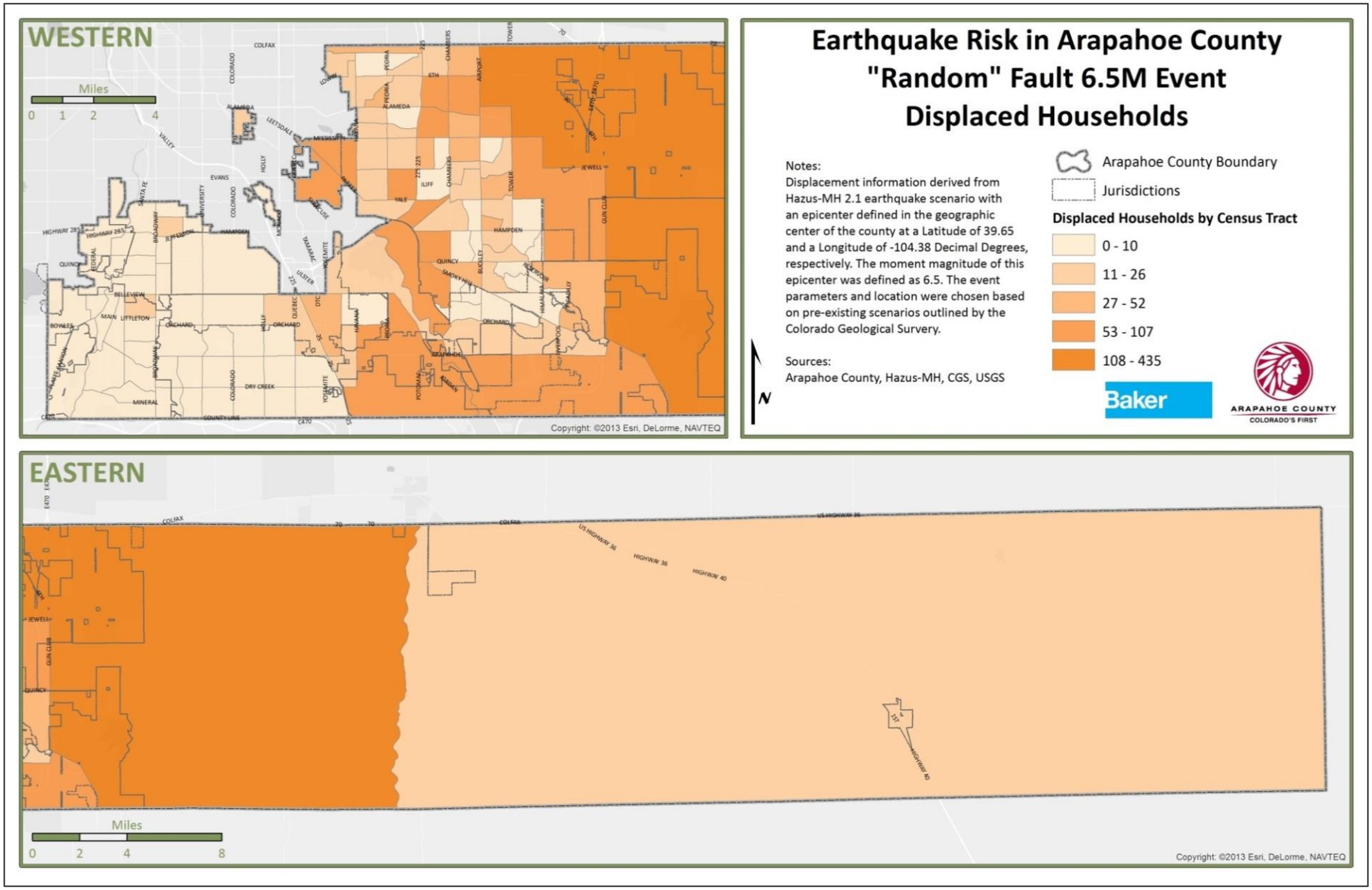


Figure 32. Map of Displaced Households -- Random Fault Earthquake Scenario

Scenario Summary Comparison

The following Table summarizes the results of the economic losses and casualty estimates from the two Hazus risk assessments. Impacts associated with the Golden Fault and the Random Fault scenarios have been juxtaposed to provide a clear picture of the differential consequences of a 6.5 magnitude earthquake occurring in two different locations across the region.

Table 55. Summary of Loss and Casualty Estimates

Scenario	Expected at Least 'Moderate' Building Damage (Total # of Structures)		Total Economic Loss ($ Millions)	Expected Building Loss Estimates ($ Millions)	Expected Level 4 Casualties (Total #)
Golden Fault 6.5	29,974 structures	+12% of total buildings in county	$2,822	$2,759	146
Random Fault 6.5	27,672 structures	+11% of total buildings in county	$2,486	$2,397	125

What stands out the most between the two earthquake scenarios is that the damage, loss, and casualty estimates are very similar despite the large distance between the two epicenters. Based on the results of the earthquake risk assessment it can be assumed that a 6.5 magnitude earthquake within or surrounding Arapahoe County will produce comparable results.

LAND USE & DEVELOPMENT TRENDS

With the unpredictable nature of earthquake epicenter locations, it is not feasible to identify specific areas where development may exacerbate the risk to an earthquake. It should be assumed that all development increases the risk to the County from the threat of earthquakes. As population and development continue to expand in Arapahoe County, continued enforcement of the unified construction code has great potential to mitigate increasing vulnerability and development pressure.

MULTI-JURISDICTIONAL DIFFERENCES

Earthquakes are relatively uncommon in Arapahoe County and the probability is low that they will occur regularly in the future. However, if an event was to occur within the county, there is potential for significant structural damage to occur near the epicenter. Due to the nature of earthquake hazards, areas in Arapahoe County with high population densities and large numbers of structures and critical facilities are expected to experience greater damage and loss from an earthquake event. This includes jurisdictions located primarily in the western portion of the County, such as:

- Aurora
- Centennial
- Cherry Hills Village
- Englewood
- Glendale
- Greenwood Village
- Littleton
- Sheridan

Communities located in the eastern part of the County, primarily along the I-70 corridor, may experience differential impacts from an earthquake event if transportation or utility infrastructure is damaged and prevents communities from responding or evacuating.

HIRA SUMMARY

Even though the seismic hazard in Arapahoe County is low to moderate, it is likely that earthquakes will occur in the county in the future. It is reasonable to expect future earthquakes as large as magnitude 6.5, the largest event on record in Colorado. Calculations based on the historical earthquake records and geological evidence of recent fault activity suggest that an earthquake of magnitude 6 or greater may be expected somewhere in Colorado every several centuries.

Earthquakes strike with little to no warning and they are capable of having multiple impacts on an area. After-effects from an earthquake can include impacted roadways, downed power and communication lines, fires, and damages to structures (especially poorly built, or those already in disrepair). Earthquakes are not a seasonal hazard, and thus can be experienced year round. This fact presents its own set of planning and preparedness concerns.

Ultimately, the probability of an earthquake occurring in Arapahoe County is low. Additionally, if an earthquake were to occur in the near future it is likely to be of a low magnitude, with expected damages to property and people to be minimal. History has shown, however, that Arapahoe County and Colorado are at risk to a larger magnitude seismic event. Should that type of event occur, major damages and losses should be expected. This fact makes these low probability, high impact hazards a challenge to deal with when planning a mitigation strategy to combat all hazards faced by a community.

Standard building codes have the opportunity to provide Arapahoe County with reasonable guidance for development throughout unincorporated and incorporated areas. Contractors and builders should be aware of applicable codes and regulations designed to reduce losses sustained by new and existing construction due to seismic hazards.

For example, the light weight of wood frame buildings results in less force from inertia. Less force means less damage. Wood's natural flexibility also is an advantage when seismic forces are brought to bear and the nailed joints in wood frame buildings dissipate energy and motion. Wood's inherent earthquake resistance must be accompanied by design and construction techniques that take advantage of those characteristics.

Structural wood panels nailed to wall framing add rigid bracing, help resist lateral loads and help tie framing members together. Bolted connections at the sill plate/foundation joint help keep the structure in one spot. Securely connected wall, floor, and roof framing also help tie a structure together and make it a single, solid structural unit. Proper connections will do more to hold a house together during an earthquake than any other single seismic design element.

As development grows in the County and its municipalities, it will be important for citizens to consult with local building codes as modern building codes generally require seismic design elements for new construction.

EROSION/LAND SUBSIDENCE

NATURAL HAZARDS	PROBABILITY	IMPACT	SPATIAL EXTENT	WARNING TIME	DURATION	RF RATING
Erosion/Land Subsidence	2 (0.6)	1 (0.3)	1 (0.5)	2 (0.2)	3 (0.3)	**1.5**
LOW RISK (1.5 – 1.9)						

HAZARD IDENTIFICATION

Erosion is the removal and transportation of earth materials from one location to another by water, wind, waves, or moving ice. It occurs when soil is removed at a greater rate than it is formed. The natural geologic process of erosion has occurred since the Earth's formation and continues at a very slow and uniform rate. Soil erosion hazard is the term used to describe how likely it is for soil in a given area to erode. It depends on the inherent properties of the soil, the topography, vegetative cover, soil disturbance (including over-grazing, drought, flooding, wind, etc.), and rainfall intensity.

Although soil erosion is a natural process, rapid erosion can lead to a serious loss of topsoil and a reduction of cropland productivity. It can also contribute to the pollution of adjacent watercourses, wetlands, and lakes. During the processes of wind and water erosion, infrastructure and mechanical equipment can be damaged by soil build-up and dust. Additionally, blowing soils can affect human and animal health and create public safety hazards.

Land Subsidence describes any depressions, cracks, and/or sinkholes in the earth's surface which can threaten people and property. Causes of subsidence include, but are not limited to, the removal or reduction of sub-surface fluids (water, oil, gas, etc.), mine subsidence, and hydro compaction. Of these causes, hydro compaction and mine subsidence usually manifest as localized events, while fluid removal may occur either locally or regionally.

HAZARD PROFILE

Soil erosion has the potential to cause substantial losses to Arapahoe County assets. Erosion alone poses little harm to the county; however, when assets are placed in close proximity to erosion-prone environments such as a valley near a stream or riverbed, hazard vulnerability increases significantly. For example, when heavy rain and snowmelt result in increased stream flow, the erosion of riverbanks can pose significant risks to transportation infrastructure, including roads and bridges. Severe erosion can remove earth from beneath bridges, roads, and foundations of structures adjacent to streams. In Arapahoe County, the deposition of material can block culverts, aggravate flooding, destroy crops and lawns, and reduce capacity in water reservoirs.

Land subsidence can occur rapidly due to a sinkhole or the collapse of an underground mine, or during a major earthquakes. Subsidence can also take place slowly, becoming evident over the time span of many years. Soils that tend to collapse and settle are those characterized by low-density materials that shrink in volume when they become wet and/or are subjected to weight from development. Subsidence events, depending on their location, can pose significant risks to health, safety, and local agricultural economies and interruption to transportation, and other services.

There are hundreds of abandoned underground coal mines scattered throughout Colorado that present potential subsidence hazards to structures and surface improvements. The Colorado Geological Society (CGS) operates the Colorado Mine Subsidence Information Center (MSIC) which is the repository for all of the known existing maps of inactive or abandoned coal mines in the state. Subsidence tends to be problematic along the Colorado Front Range, Western Slope, and in the central mountains near Eagle and Garfield Counties.[18] Based on data provided by CGS, there are no areas identified within Arapahoe County that are at high risk of land subsidence due to soil-type. However, there are a small number of potentially undermined areas in central Arapahoe County that may be more vulnerable to subsidence. The following Figure presents a map identifying the locations within Arapahoe County that have potential for subsidence due to historical clay and coal mining activity.

[18] 2013 Colorado Natural Hazards Mitigation Plan

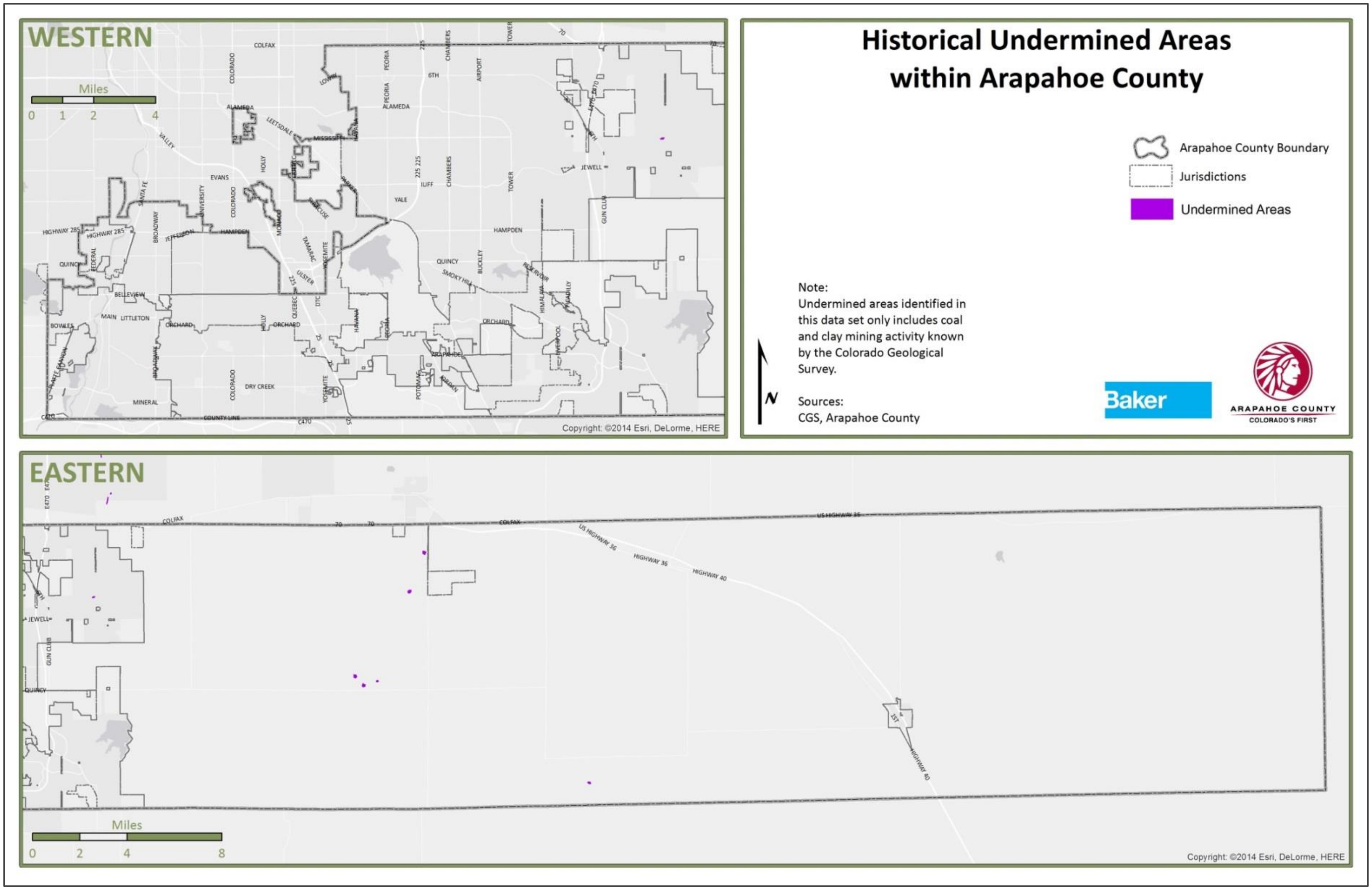


Figure 33. Map of Historically Undermined Areas

The risk analysis indicates that Arapahoe County has limited exposure to land subsidence. Not only have there been no previous land subsidence events reported in the County, CGS data of at-risk areas shows very few areas of historical undermining, none of which intersect with critical facilities or future development areas.[19]

As the population of Arapahoe County grows, there is a possibility that some development will encroach into these subsidence hazard areas. These hazards include the potential for sagging ground, sinkholes, and the collapse of mine shafts that have not been adequately closed. Any of these hazards can cause damage to property, structures, transportation infrastructure, utility lines, and in some cases, can threaten human life. Only a few inches of differential settlement beneath a structure could cause many thousands of dollars of damage. It is important that subsidence risk is considered in the designs and plans of future development proposals.

Due to the difficulties in truly defining an “erosional” event and the lack of identified subsidence occurrences, it is not possible to attempt to calculate any type of probability for future events. It can be assured though, that erosion will continue to slowly alter the landscape of Arapahoe County going forward.

CLIMATE CHANGE IMPACTS

Changing climate norms are expected to affect soil resources in many ways. During hot, dry years annual grasses that stabilize and protect topsoil often fail to germinate or do not grow well. This leaves soil surfaces highly vulnerable to erosion from wind and precipitation.[20] Without the availability of nutrient-rich topsoil, crops struggle to survive and flourish. As discussed previously, higher rates of erosion can have a profound effect on agricultural production and on the economies of rural areas of the county.

In areas where climate change results in decreased precipitation in the summer months and reduced surface-water supplies, communities are often forced to pump more ground water to meet their needs. In Colorado, the major aquifers are composed primarily of compressed clay and silt, soil types that are prone to compact when ground-water is pumped. In the past, major land subsidence has occurred in agricultural settings where ground-water has been pumped for irrigation. It is probable that the eastern region of Arapahoe County will experience more intense erosion and land subsidence hazards over time as a result of local climate change. It is important that Arapahoe County consider future mitigation actions that will address these slow-onset hazards, particularly in its rural agricultural communities.

INVENTORY ASSETS EXPOSED

A structure may be subject to land subsidence if it is located over or close to an undermined area. Therefore, an important first step in determining the subsidence potential at a specific location is to determine if the area is undermined or near an area where underground mining took place. The map

[19] CGS; Colorado Natural Hazards Mitigation Plan (2013)
[20] Belnap, J., and D.J. Eldridge. (2003). *Disturbance and recovery of biological soil crusts*.

below identifies the locations within Arapahoe County that have elevated potential for subsidence due to historical mining activity (shown in blue). Most of the locations within Arapahoe County that are vulnerable to subsidence are located in the eastern portion of the county, located away from infrastructure, hazardous locations, and/or other identified critical facilities. As population growth brings new development into available land in the eastern portion of the county, more inventory assets may become exposed to subsidence and erosion hazard.

POTENTIAL LOSSES

Damages to structures due to land subsidence and erosion are usually classified as cosmetic, functional, or structural. Cosmetic damages refer to slight problems where only the physical appearance of the structure is affected (e.g. cracking in plaster or drywall). Functional damage refers to situations where the use of a structure has been impacted due to subsidence. Structural damages include situations where entire foundations require replacement due to subsidence-caused cracking of supporting walls and footings.

Although there are no critical facilities located in areas identified as vulnerable to land subsidence, buildings and infrastructure Across the County may be vulnerable to the impacts of erosion. In September of 2013, Colorado's Front Range (including parts of Arapahoe County) experienced a catastrophic flood event. This flood event provides a benchmark for infrastructure losses associated with a large-scale flood and the associated erosion hazards. Although the final damages were still being accounted for during the creation of this plan, initial estimates within Arapahoe County indicate that Public Assistance projects were estimated at over $300,000. The Individual Assistance program verified over $3 million in losses.[21]

LAND USE & DEVELOPMENT TRENDS

Rapid and sustained population growth across Colorado and the Front Range has contributed to increasing trends in geologic hazard risk, exposure, and vulnerability across Arapahoe County. Arapahoe County and the surrounding areas are rich in natural resources and the continued development of industries related to these natural resources is a distinct possibility. Continued water and mineral resource extraction has the potential to exacerbate geologic hazards further and planning efforts should remain pro-active towards assessing changing geologic hazard risks.

MULTI-JURISDICTIONAL DIFFERENCES

Due to the nature of erosion and land subsidence hazards in Arapahoe County, all jurisdictions within the planning area are expected to be impacted equally, although minimally. Based on the best available data relating to undermined areas, most all identified areas fell in the unincorporated areas of the County, with a single area also located in Aurora.

[21] FEMA Modeling Task Force (MOTF) Colorado Floods Situational Viewer (March 13, 2014)

HIRA SUMMARY

The natural process of erosion will continue in Colorado and subsidence may become more common as water use intensifies in and around Arapahoe County. While erosion and land subsidence have been categorized as low-risk hazards in Arapahoe County, there have been property and infrastructure damages associated with these hazards within Colorado. In the semi-arid climate of Colorado, increases in seasonal precipitation, coupled with periods of prolonged drought, may accelerate processes of erosion and/or further destabilize areas already at-risk of subsidence.

Based on past and projected population growth, it is very likely that future development will lead to the intersection of erosion-prone soils and high-hazard subsidence areas. As development pressures continue in un-developed areas of the county, vulnerability to subsidence and erosion may increase along the I-70 corridor and the central region of eastern Arapahoe County.

Typically, the process of erosion does not limit land use, especially if efforts are made to minimize it. Erosion impacts can be reduced and controlled by surface drainage management, re-vegetation or disturbed lands, controlling stream-carried eroded materials in sediment catchment basins, and riprapping of erosion-prone stream banks (especially adjacent to structures). Avoidance is generally the best mitigation solution where areas of subsidence are exposed and properly identified. Ground modification and structural solutions can help mitigate the threats of localize subsidence and erosion. Proper drainage and water management are also important to prevent increasing vulnerability to erosion and subsidence hazards.

EXTREME TEMPERATURES

NATURAL HAZARDS	PROBABILITY	IMPACT	SPATIAL EXTENT	WARNING TIME	DURATION	RF RATING
Extreme Temperatures	3 (1.0)	2 (0.5)	4 (0.7)	1 (0.1)	3 (0.3)	**2.7**
HIGH RISK (2.5 or higher)						

HAZARD IDENTIFICATION

Cold temperatures are considered hazardous when they drop well below what is considered normal for an area during the winter months. Combined with increases in wind speed, such temperatures can be life threatening to those who are exposed for extended periods of time.

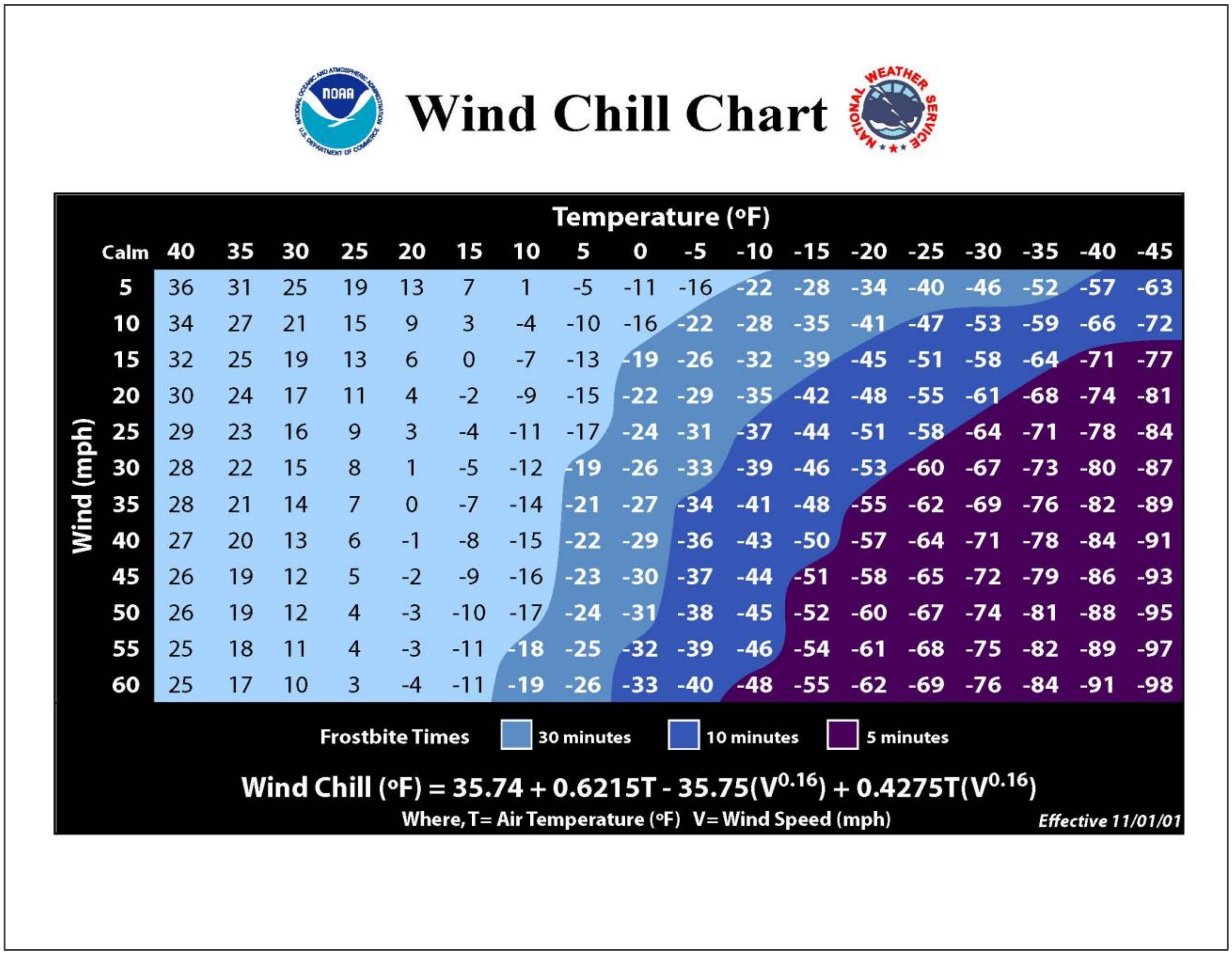
Extreme heat can be described as temperatures that hover 10°F or more above the average high temperature for a region at least for several weeks. A heat wave is a period of excessive heat, which can lead to illness and other stress to vulnerable people and those who experience prolonged exposure to the heat. High humidity, which rarely accompanies heat waves in Arapahoe County, can make the effects of heat even more harmful. While heat-related illness and death can occur from exposure to intense heat in just one afternoon, heat stress on the body has a cumulative effect. Consequently, the persistence of a heat wave increases the threat to public health.

HAZARD PROFILE: Extreme Cold

The majority of Arapahoe County is located in the flat, grass-covered eastern plains – the high plains of the Great Plains. Summer temperatures on the eastern plains average in the mid-70s °F for July and August. However, daily minimum and maximum temperatures can vary as much as 40-50 °F. Winters on the eastern plains are typically dry, cold, and windy. Although snowfall is usually light, winter blizzards do affect Arapahoe County residents. Average January nighttime low temperatures range from around 10 to 30 °F, with daily highs averaging from the mid-30s to 50°F. Sudden and frequent changes in temperature occur quite often in Colorado. Prolonged periods of extremely cold or hot weather are unusual; however, temperatures above 100 °F have occurred as well temperatures below 0 °F.

Extended periods of extreme cold, although infrequent, can occur throughout the winter months in Arapahoe County. When cold temperatures and wind combine, dangerous wind chills can develop. Wind chill is how cold it “feels” and is based on the rate of heat loss on exposed skin from wind and cold. As the wind increases, it draws heat from the body, driving down skin temperature, and eventually, internal body temperature. This makes the environment feel much colder than the actual temperature.

As depicted in the figure below, the National Weather Service’s Wind Chill Chart shows the difference between actual air temperature and perceived temperature, as well as the amount of time until frostbite occurs.



Wind Chill Chart

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

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

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

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

Effective 11/01/01

Figure 34. NOAA Wind Chill Chart

The elderly, young children, the homeless, outdoor laborers, the infirm, and low-income communities are the most likely to suffer the negative effects of extreme cold. When conditions are appropriate, the National Weather Service issues wind chill warnings. The table below describes the criteria for these warnings.

Table 56. National Weather Service Wind Chill Warnings

Warning	Description
Wind Chill Watch	Issued by the NWS when there is a chance that wind chill temperatures will decrease to at least 24°F below zero during the next 24 to 48 hours.
Wind Chill Advisory	Issued when the wind chill could be life threatening if action is not taken. The criteria for this advisory are expected wind chill readings from 15°F to 24°F below zero.

Wind Chill Warning	Issued when wind chill readings are life threatening. Wind chill readings of 25°F below zero or lower are expected.

Source: NWS

The State of Colorado experiences winter cold events fairly frequently, although extended periods of sub-zero temperatures are rare. The NCDC storm database includes winter weather and cold/wind chill hazards, both of which represent periods of prolonged cold temperatures. The database defines "significant" extreme cold/wind chill events as periods of extremely low temperatures or wind chill temperatures reaching or exceeding locally/regionally defined warning criteria on a widespread or localized basis. The table below lists the significant winter weather and cold/wind chill events reported to NCDC for Arapahoe County.

Table 57. Extreme Cold Events in Arapahoe County (1950 – 2013)

Date	Event Type	Area	Injuries	Deaths	Property Damage	Crop Damage
Feb. 2012	Winter Weather	Arapahoe County	0	0	0	0
Nov. 2012	Winter Weather	Central and Eastern Adams and Arapahoe Counties	0	0	0	0
Dec. 2012	Winter Weather	Arapahoe County	0	0	0	0
Jan. 2011	Winter Weather	Arapahoe County	0	0	0	0
Feb. 2011	Winter Weather	Arapahoe County	0	0	0	0
Dec. 2011	Winter Weather	Central and Eastern Adams and Arapahoe Counties	0	1	0	0
Dec. 2011	Winter Weather	Central and Eastern Adams and Arapahoe Counties	0	0	0	0

Date	Event Type	Area	Injuries	Deaths	Property Damage	Crop Damage
Nov. 2010	Winter Weather	Central and Eastern Adams and Arapahoe Counties	0	0	0	0
Dec. 2010	Winter Weather	Arapahoe County	0	0	0	0
Jan. 2009	Winter Weather	Arapahoe County	0	0	0	0
Mar. 2009	Winter Weather	Central and Eastern Adams and Arapahoe Counties	2	2	0	0
Oct. 2009	Winter Weather	Arapahoe County	0	0	0	0
Dec. 2009	Winter Weather	Central and Eastern Adams and Arapahoe Counties	0	0	0	0
Nov. 2008	Winter Weather	Central and Eastern Adams and Arapahoe Counties	0	0	0	0
Dec. 2008	Winter Weather	Arapahoe County	0	0	0	0
Oct. 2007	Winter Weather	Arapahoe County	0	0	0	0
Dec. 1998	Extreme Cold/Wind Chill	Central and Eastern Adams and Arapahoe Counties	15	3	0	0
Jan. 1997	Extreme Cold/Wind Chill	Central and Eastern Adams and Arapahoe Counties	0	0	0	0

Date	Event Type	Area	Injuries	Deaths	Property Damage	Crop Damage
Dec. 1996	Extreme Cold/Wind Chill	Central and Eastern Adams and Arapahoe Counties	0	0	0	0
Dec. 1996	Extreme Cold/Wind Chill	Central and Eastern Adams and Arapahoe Counties	0	0	0	0
		TOTAL:	**17**	**6**	**0**	**0**

Source: NOAA, NCDC Storm Events Database; SHELDUS

The first extreme cold/winter weather event reported in Arapahoe County and listed in the NCDC database was in 1996. The NCDC database indicates that since then there have been 17 injuries and 6 deaths reported from 20 extreme cold/winter weather events in Arapahoe County. There are most likely additional extreme cold/winter weather events prior to 1996 that have not been captured by the database specifically for Arapahoe County.

Understanding the historical frequency of extreme cold temperatures in Arapahoe County assists in determining the likelihood of future occurrences. The characteristics of past extreme cold and significant winter weather events provide a benchmark for projecting similar conditions into the future. The probability that Arapahoe County will experience extreme cold temperatures in the future can be difficult to quantify, but based on historical record of 20 events since 1996, it can reasonably be assumed that this type of event has occurred once every year from 1996 through 2013.

[(Record Year) 2013] subtracted by [(Historical Year) 1996] = 17 Years on Record

[(Years on Record) 17] divided by [(Number of Historical Events) 20] = 0.85

Furthermore, the historic frequency calculates that there is a 100% chance of a hazardous extreme cold/winter weather event occurring each year.

HAZARD PROFILE: Extreme Heat

Extreme heat events are a considerable public health concern and are one of the leading weather-related killers in the United States. Although extreme heat events can occur in May or September, they are most common between June and August when above average temperatures are sustained for a prolonged period. During extended periods of very high temperatures , or high temperatures coupled with high humidity, individuals can suffer a variety of health problems, including heatstroke, heat exhaustion, heat syncope, and heat cramps.

The Heat Index measures the severity of hot weather by estimating how hot it feels to humans. By combining air temperature and relative humidity, the Heat Index is directly related to skin temperature. The ambient temperature is quantified by examining the relation between relative humidity versus skin temperature. If the relative humidity is higher (or lower) than the base value, the apparent temperature is higher (or lower) than the ambient temperature. The following Table outlines the heat disorders associated with apparent temperature values during extreme heat events.

Table 58. Heat Index and Associated Heat Disorders

Danger Category	Heat Disorders	Apparent Temperature (°F)
I Caution	Fatigue possible with prolonged exposure and physical activity	80-90
II Extreme Caution	Sunstroke, heat cramps, and heat exhaustion possible with prolonged exposure and physical activity	90-105
III Danger	Sunstroke, heat cramps, and heat exhaustion likely; heatstroke possible with prolonged exposure and physical activity	105-130
IV Extreme Danger	Heatstroke or sunstroke imminent	>130

Source: NOAA

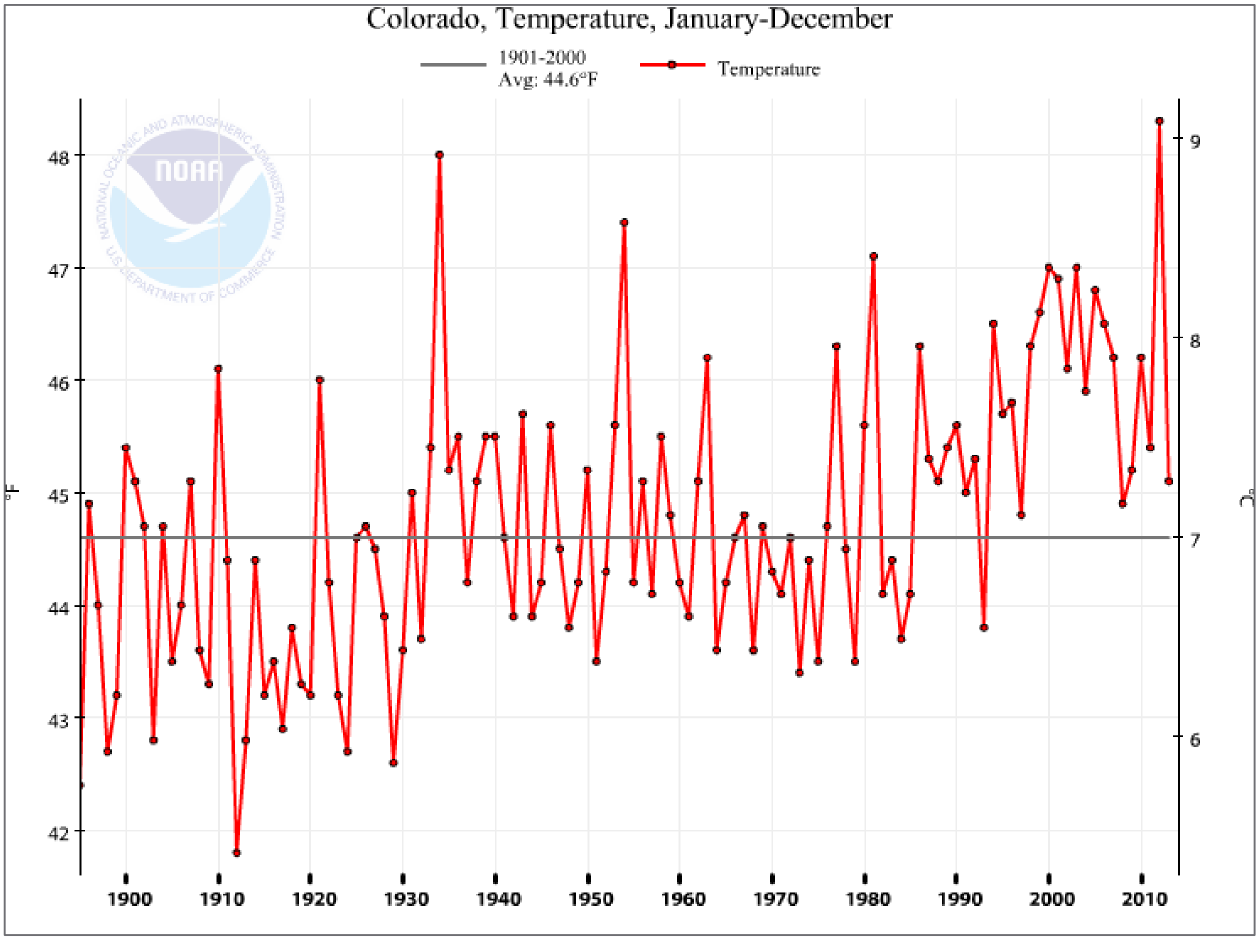
Like extreme cold events, young children, the elderly, outdoor laborers, low-income families, the homeless, and the infirm are the most likely to suffer the negative effects of extreme heat. The National Weather Service initiates alerts based on the Heat Index as shown in the table below.

Table 59. Extreme Heat Warnings

Intensity	Detailed Description
Heat Advisory	Typically between 105°F to 110°F (41°C to 43°C) for 3 hours or more during the day and at or above 75°F (24°C) at night.
Excessive Heat Warning	Typically above 105°F (41°C) for 3 hours or more during the day and at or able 80°F (27°C) at night.

Source: National Weather Service

Data supports a shift towards a warmer climate with an increase in extreme high temperatures across the United States. The graph below depicts annual statewide average temperature history for the state of Colorado from 1895 to 2014. The probability of continued (and more frequent) extreme heat events across Colorado is supported by the clear upward trend in high temperatures since 1895.



Source: NOAA, NCDC

Figure 35. Colorado Temperature Trends (1895 – 2014)

During 2008, the Denver Metro Area's record for the number of consecutive days above 90°F was broken. The new record (24 days) surpassed the previous record by almost a week. The summer of 2012 was the hottest on record for the Denver Metro Area. In 2012, the 24 day record was reached yet again. On August 1st, 2012, temperatures in the Denver Metro Area reached 104°F, breaking a 74 year record set in 1938. The next day, temperatures reached 103°F. The average number of 90°F days in the Denver Metro Area is 33 days. In 2012 the number of days was over double the average with 76 days of 90°F or higher. The table below shows the number of days that temperatures in the Denver Metro Area reached 90 degrees or higher for over 33 days since 1960.

Table 60. Count of >90°F Days in the Denver Metro Area (1960-2013)

Year	Total Days
2012	73
2000	61
1994	60
2002	56
2005	55
2007	54
2006	54
2013	54
1978	52
1974	51
1965	50
1960	50
2011	50
TOTAL:	720

Source: NWS

Based on data provided by the NWS and NCDC, it is likely that Arapahoe County will continue to experience hazardous extreme heat events in the future, and for more prolonged periods of time. Based on historical record of 720 >90° days in the Denver Metro Area since 1960, it can reasonably be assumed that this type of event has occurred at least once every year from 1960 through 2013.

[(Record Year) 2013] subtracted by [(Historical Year) 1960] = 53 Years on Record

[(Years on Record) 53] divided by [(Number of Historical Events) 720] = 0.07

Furthermore, the historic frequency calculates that there is a 100% chance of a hazardous extreme heat event occurring each year in the Arapahoe County region.

CLIMATE CHANGE IMPACTS

Although climate change may not be responsible for the national trend in increasing costs of natural disasters, it is very likely that it will impact future catastrophes. Climate models provide a preview of the future, and while they do not agree on all of the details, there are a few general trends that most climate models predict. One of these trends is an increase in temperature variability that will extend the extremes of high temperature events. An increase in average regional temperatures combined with increased variance will make extended extreme heat events more likely in Colorado.

Based on current climate models, average summer temperatures in Colorado could rise by 5°F by 2050[22] due to regional climate change. Periods of extreme heat are likely to increase in frequency, duration and intensity, worsening health risks for young, elderly, and poor Coloradans. Projected regional temperature increases, combines with the way cities amplify heat, will pose increased threats and costs to public health in Colorado communities. Moreover, disruptions to urban electricity and water supplies will exacerbate these health problems.[23]

[22] University of Colorado, Boulder. Climate Change in Colorado, 2008.
[23] *Third U.S. National Climate Assessment,* 2014. U.S. Global Change Research Program.

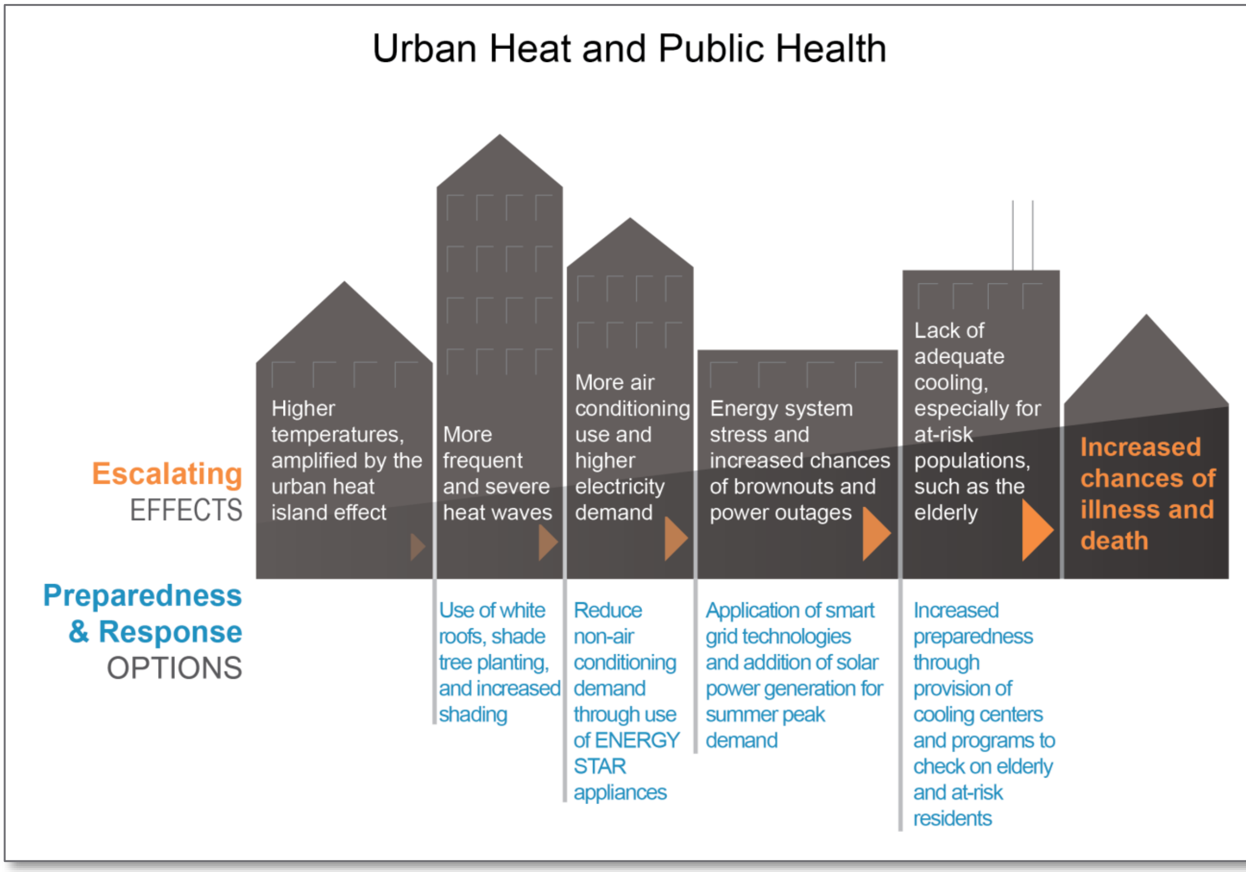


Figure 36. Urban Heat Hazards: Effects and Adaptation Options[24]

The projected increase in extreme heat events in Colorado increases the chances that a chain of escalating effects could lead to serious increases in death and illness dues to heat stress. In the figure above, the top describes some of the links in that chain (including more severe heat waves, energy system stress due to increased air conditioning use, and lack of adequate cooling). The bottom of the diagram highlights local adaptation strategies and improved governance options that can be implemented to reduce local vulnerability and improve the resilience of Arapahoe County infrastructure and community members.

INVENTORY ASSETS EXPOSED

Unlike other natural hazards that affect Arapahoe County, extreme temperatures have limited physical destructive force. However, damages to inventory assets exposed to extreme cold is dependent on the age of the building, type, construction material used, and condition of the structure. Heavy snow loads on roofs, particularly large span roofs, can cause roofs to leak or even collapse depending on their construction. Extremely cold temperatures may cause pipes to freeze and subsequently burst, causing

[24] *Third U.S. National Climate Assessment,* 2014. U.S. Global Change Research Program.

water damage. During the winter months, freezing temperatures and repeated freeze-thaw events can cause potholes, which may damage vehicles. Hazardous travel conditions may result if potholes are not tended to promptly. Frozen pipes, a common occurrence during extreme cold events, can cause service interruptions in water supply, gas supply, and drainage.

Most likely the greatest issue for critical facilities during significant extreme cold events is the inaccessibility of such facilities due to poor roadways, utility outages, or dangerous wind chills. During periods of heavy snow, ice, or blizzards, roads can quickly become impassable, stranding motorists and isolating communities. Long term road closures during an extended cold period may diminish and threaten propane and fuel supplies. Possible losses to critical infrastructure include:

- Electric power disruption
- Communication disruption
- Water and fuel shortages
- Road closures
- Damaged infrastructure components, such as sewer lift stations and treatment plants

Extended power outages during extreme cold events may make many homes and offices unbearably cold. Additionally, during extended winter-time power outages, people often make the mistake of bringing portable generators inside or not venting them properly, leading to carbon monoxide poisoning. With poor road conditions, sheltering residents may present significant logistical challenges with getting people to heated facilities, feeding, and providing medical care. These situations, accompanied by stranded motorists that need to be rescued, represent significant threats to the population of Arapahoe County. Additional information on construction type and building codes enforced at time of construction would allow a more thorough assessment of the vulnerability of structures to extreme cold impacts.

Extreme heat can cause pavement of roads and bridges, or railroad tracks, to crack or buckle, resulting in service disruptions and potentially hazardous travel conditions. The most significant impact of extreme heat on general building stock and critical facilities within Arapahoe Count is the increased demand on air conditioning equipment. Surges in air conditioning demand can sometimes strain electrical systems and energy resources. Public utility infrastructure (including electrical generating and conveyance systems) may become damaged and break down causing localized and/or widespread power outages.

All assets located in Arapahoe County can be considered to be exposed to extreme temperatures. This includes 100 percent of the County's population and all buildings and critical infrastructure located within the County. Most structures, including the county's critical facilities, should be able to provide adequate protection in the event of an extreme temperature event. Facilities with back-up generators are better equipped to handle a severe weather situation should the power go out. Additionally, public buildings with cooling systems are ideal shelters for at-risk individuals and families during heat waves.

POTENTIAL LOSSES

Although estimated property losses associated with extreme temperature hazards are anticipated to be minimal across the planning area, extreme heat and cold events do present a significant life and safety threat to the population of Arapahoe County. Heat casualties are usually caused by lack of adequate air conditioning and/or heat exhaustion. Extreme heat tends to affect the elderly, infirm, homeless, or low-income families the most, as these populations frequently live on low fixed incomes and cannot afford to run air conditioning on a regular basis. These socially vulnerable populations are often isolated, with no immediate family and/or limited mobility, which makes it more difficult for them to remove themselves from danger.

Casualties caused by extreme cold events can result from a lack of adequate heating, carbon monoxide poisoning from unsafe or unventilated heating systems, and frostbite from exposure to the elements. Again, the most vulnerable populations to extreme cold are the elderly, infirm, homeless, and low-income families. Often, these individuals do not have access to a heat source or are unable to afford to operate one on a regular basis.

Because there is no defined geographic boundary for extreme temperature hazards, all of the people and infrastructure within Arapahoe County are exposed to extreme temperatures. Those with elevated risk and potential loss are the homeless, infirm, elderly, and low income families. Given the lack of historical data and limited likelihood of structural losses in Arapahoe County resulting from extreme heat or cold, and that placing a dollar amount on the cost of a human life are beyond the scope of the Plan, annualized economic losses for Arapahoe County due to extreme temperatures are currently considered unquantifiable.

LAND USE & DEVELOPMENT TRENDS

All future structures built in Arapahoe County will likely be exposed to severe seasonal temperature extremes. As with other large extent hazards, increased development trends in and around Arapahoe County will increase the vulnerability of growing areas to extreme heat and cold. Arapahoe County and its jurisdictions must continue to adhere to building codes to facilitate new development that is built to current standards to account for future climate extremes. Additionally, as homes go up in more rural parts of the county, accessing those rural residents will present new emergency management and response challenges should sheltering or emergency services be needed in an extreme event.

MULTI-JURISDICTIONAL DIFFERENCES

Due to the regional nature of extreme temperatures hazards, jurisdictions with higher numbers of socially vulnerable residents are expected to experience magnified impacts of extreme temperatures. This includes places with high numbers of elderly residents, low income families and homeless individuals/outdoor laborers.

The table below shows data related to population vulnerable to extreme temperatures by local jurisdiction. Based on Census information and knowledge of social vulnerability to hazards, jurisdictions with high numbers of elderly residents, a high poverty rate and/or large numbers of rental properties can plan accordingly to provide appropriate services and mitigation assistance during extreme temperature events.

Table 61. Populations Vulnerable to Extreme Temperatures

Jurisdiction	Age: 65 and Over (%)	Persons Below Poverty Level (%)	Renter-occupied housing units (%)
Colorado	**10.9**	**12.9**	**34.5**
Aurora	8.9	16.2	40.1
Bennett	7.2	5.8	25.5
Bow Mar	16.3	0.2	2.8
Centennial	11.9	4.6	16.5
Cherry Hills Village	14.7	1.9	4.6
Columbine Valley	22.3	5.1	3.1
Deer Trail	14.8	5.8	33.9
Englewood	12.5	14.4	50.9
Foxfield	16.5	10.5	5.4
Glendale	2.8	17.2	90.5
Greenwood Village	11.7	3.3	34.8
Littleton	15.8	11.1	38.1
Sheridan	11.7	24.6	51.3

Source: DOLA: Census 2010

HIRA SUMMARY

During extreme temperature events, inadequate protection from the elements is especially hazardous. A combination of more frequent heat waves and changing demographics (e.g. an increase in the elderly population) is likely to result in higher rates of temperature-related deaths in Arapahoe County. In order to mitigate the impacts of extreme temperature hazards it is important that Arapahoe County prioritize outreach and services to specific populations who are most vulnerable. High-vulnerability groups typically experience a disproportionate number of health impacts from extreme heat and cold, often due to physical, social, and economic limitations to adequate participation in mitigation and response activity. In the context of extreme temperature events, the most vulnerable members of Arapahoe County are:

- The elderly (people over 65 years of age)
- Infants (under 1 year old)
- The homeless
- Low income families
- Socially isolated individuals
- People with mobility restrictions and/or mental impairments
- The infirm
- Outdoor laborers

Although stopping extreme temperature events is impossible, limiting their effect on people and property in Arapahoe County is feasible. Ongoing mitigation activities should focus on protecting lives and preventing injuries during periods of extreme heat and cold. This includes, but is not limited to pre-season community outreach campaigns to educate the public about risks and available support; establishing cooling and heating centers; reaching out to vulnerable populations and care givers; and issuing advisories and warnings.

FLOODING

NATURAL HAZARDS	PROBABILITY	IMPACT	SPATIAL EXTENT	WARNING TIME	DURATION	RF RATING
Flooding	2 (0.7)	2 (0.5)	3 (0.5)	3 (0.3)	2 (0.2)	**2.2**
MODERATE RISK HAZARD (2.0 – 2.4)						

HAZARD IDENTIFICATION

A flood is a naturally occurring event for rivers and streams and occurs when a normally dry area is inundated with water. Excess water from snowmelt or rainfall accumulates and overflows onto the stream banks and adjacent floodplains. As illustrated in the figure below, floodplains are lowlands, adjacent to rivers, streams, and creeks that are subject to recurring floods. Flash floods, usually resulting from heavy rains or rapid snowmelt, can flood areas not typically subject to flooding, including urban areas. Additionally, extreme cold temperatures can cause streams and rivers to freeze, causing ice jams and creating flood conditions.

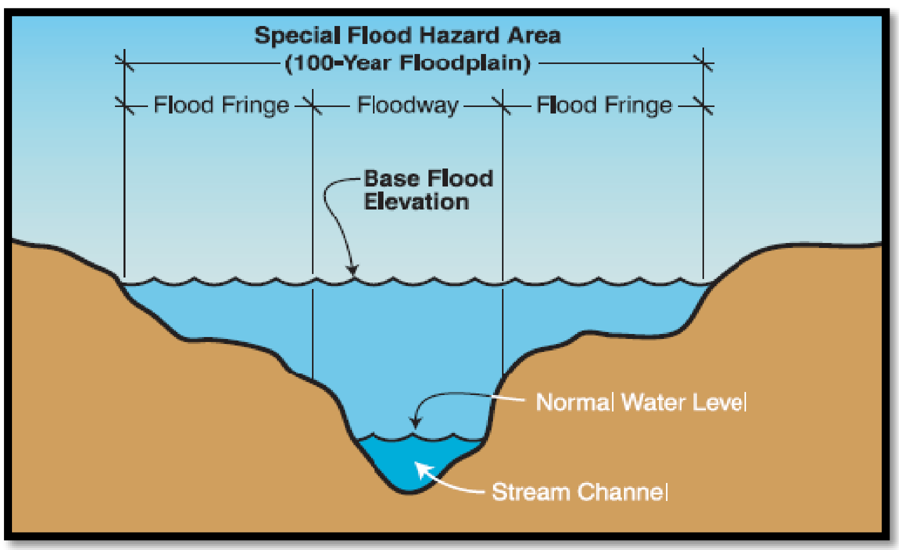


Figure 37. Floodplain Terminology

Floods are considered hazards when people and property are affected. Nationwide, hundreds of floods occur each year, making it one of the most common hazards in all 50 states and U.S. territories. Most injuries and deaths from flooding happen when people are swept away by flood currents and most property damage results from inundation by sediment-filled water. Fast-moving water can wash buildings off of their foundations and sweep vehicles downstream. Pipelines, bridges, and other infrastructure can be damaged when high water combines with flood debris. Basement flooding can also cause extensive damage. Flooding can cause extensive damage to crop lands and bring about the loss of livestock. Several factors determine the severity of floods including rainfall intensity and duration, topography, and ground cover.

Riverine flooding originates from a body of water, typically a river, creek, or stream, as water levels rise onto normally dry land. Water from snowmelt, rainfall, freezing streams, ice flows, or a combination thereof, causes the river or stream to overflow its banks into adjacent floodplains. Winter flooding usually occurs when ice in the rivers creates dams or streams freeze from the bottom up during extreme cold spells. Spring flooding is usually the direct result of melting winter snow packs, heavy spring rains, or a combination of the two.

Flash floods can occur anywhere when a large volume of water flows or melts over a short time period, usually from slow moving thunderstorms or rapid snowmelt. Because of the localized nature of flash floods, clear definitions of hazard areas do not exist. These types of floods often occur rapidly with significant impacts. Rapidly moving water, only a few inches deep, can lift people off their feet, and only a depth of a foot or two, is needed to sweep cars away. Most flood deaths result from flash floods.

Previous flash flooding events have occurred within Arapahoe County, and an area of Greenwood Village along Belleview and I-25 has been identified as a high-incidence zone. Although data does not currently exist to perform robust assessments of flash flood risk within Arapahoe County, local jurisdictions have expressed a desire and a need for data and information specifically related to flash flooding so that appropriate mitigation strategies can be identified and implemented.

Urban flooding is the result of development and the ground's decreased ability to absorb excess water without adequate drainage systems in place. Typically, this type of flooding occurs when land uses change from fields or woodlands to roads and parking lots. Urbanization can increase runoff two to six times more than natural terrain. The flooding of developed areas may occur when the amount of water generated from rainfall and runoff exceeds a storm water system's capability to remove it.

Stream Bank Erosion is measured as the rate of the change in the position or horizontal displacement of a stream bank over a period of time. It is generally associated with riverine flooding and discharge, and may be exacerbated by human activities such as bank hardening and dredging.

Ice Jams are stationary accumulations of ice that restrict flow through a waterway. Ice jams can cause considerable increases in upstream water levels, while at the same time, downstream water levels may drop. Types of ice jams include freeze up jams, breakup jams, or combinations of both. When an ice jam releases, the effects downstream can be similar to that of a flash flood or dam failure. Ice jam flooding generally occurs in the late winter or spring.

Flooding events are typically measured in terms of magnitude and the statistical probability that they will occur. The 1% annual chance flood event is the standard national measurement for flood mitigation and insurance. A 1% annual chance flood, also known as the '100-year flood', has a 1 in 100 chance of being equaled or exceeded in any 1 year and has an average recurrence interval of 100 years. It is important to note that this recurrence interval is an average; it does not necessarily mean that a flood of such a magnitude will happen exactly every 100 years. Sometimes, only a few years may pass between one 1% annual chance flood and another while two other 1% annual chance floods may be separated by 150 years. The 0.2% annual chance flood event, or the '500-year flood', is another measurement which represents a 0.2% chance (or 1 in 500 chance) of occurring in a given year.

According to the NFIP's Community Information System (CIS) Arapahoe County has been mapped for flood hazards and participates in the National Flood Insurance Program (NFIP). Details of local jurisdiction participation status are shown in the table below.

Table 62. Communities Participating in the FEMA NFIP

CID	COMMUNITY NAME	COUNTY	INITIAL FIRM IDENTIFIED	CURRENT EFFECTIVE MAP DATE
080011	Arapahoe County	Arapahoe County	12/20/1974	12/17/2010
080002	City of Aurora	Arapahoe County/Adams County	7/26/1974	12/17/2010
080315	City of Centennial	Arapahoe County	07/26/1974	12/17/2010
080013	City of Cherry Hills Village	Arapahoe County	05/10/1975	12/17/2010
080014	Town of Columbine Valley	Arapahoe County	01/25/1974	12/17/2010
080015	City of Deer Trail	Arapahoe County	11/29/1974	NSFHA
085074	City of Englewood	Arapahoe County	02/09/1972	12/17/2010
080247	City of Glendale	Arapahoe County	04/17/1989	12/17/2010
080195	City of Glenwood Village	Arapahoe County	12/27/1974	12/17/2010
080017	City of Littleton	Arapahoe County	02/01/1974	12/17/2010
080018	City of Sheridan	Arapahoe County	05/03/1974	12/17/2010

Table 63. Communities Not Currently Participating in the FEMA NFIP*

CID	COMMUNITY NAME	COUNTY	STATUS
080003	Town of Bennett**	Arapahoe County/Adams County	Mapped
080232	Town of Bow Mar	Arapahoe County/Jefferson County	Mapped
080091	Town of Foxfield	Arapahoe County	Not Mapped

*Participation status current as of July 1, 2014
**The Town of Bennett began the NFIP enrollment process in June, 2014

Arapahoe County has a total of 173 NFIP policies. In addition to participating in the NFIP, Arapahoe County participates in the Community Rating System (CRS). CRS is a voluntary program for NFIP participating communities. The goals of the CRS are to reduce flood damages to insurable property, to strengthen and support the insurance aspects of the NFIP, and to encourage a comprehensive approach to floodplain management.

The CRS was developed to provide incentives in the form of insurance premium discounts to communities that go above and beyond the minimum floodplain management requirements and develop extra measures to reduce flood risk. There are 10 CRS classes and the classification determines the insurance premium discount for policy holders. The discounts range from 5% to a maximum of 45%.

Table 64. CRS Premium Discounts

Class	Discount	Class	Discount
1	45%	6	20%
2	40%	7	15%
3	35%	8	10%
4	30%	9	5%
5	25%	10	--

SFHA (Zones A, AE, A1-A30, V, V1-V30, AO, and AH): Discount varies depending on class.

SHFA (Zones A99, AR/A, AR/AE. AR/A1-A30, AR/AH, and AR/AO): 10% discount for Classes 1-6; 5% discount for Classes 7-9.*

Non-SFHA (Zones B, C, X, D): 10% discount for Classes 1-6; 5% discount for Classes 7-9.

*In determining CRS premium discount, all AR and A99 Zones are treated as non-SFHAs.

All CRS participating communities start out with a Class 10 rating (which provides no premium discount). Class 1 requires the most credit points and offers the largest premium discount. Within the CRS program, there are 18 activities recognized as measures for eliminating local exposure to flooding. Credit points are assigned to each activity, which have been organized under four main categories:

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

Arapahoe County entered the CRS in October of 1991. Currently, Arapahoe County is a Class 8 CRS community. The community enjoys a 10% premium discount for properties in the SFHA and a 5% discount for properties in the non-SFHA.

HAZARD PROFILE

Seasonally, Arapahoe County is confronted with the possibility of flooding and flood-related hazards. Floods have the potential to inflict tremendous damages with significant losses of life and property. They can also pose a threat to the health, safety, and welfare of Arapahoe County citizens. Previous flooding events have caused thousands of dollars in damage in just a few hours or days in the region and current development and population growth trends necessitate a heightened awareness that the impact of flooding may likely increase in Arapahoe County over time. The map below depicts the current special flood hazard areas (SFHA) for Arapahoe County. The SFHA areas span roads, infrastructure, property, and jurisdictions across the county.

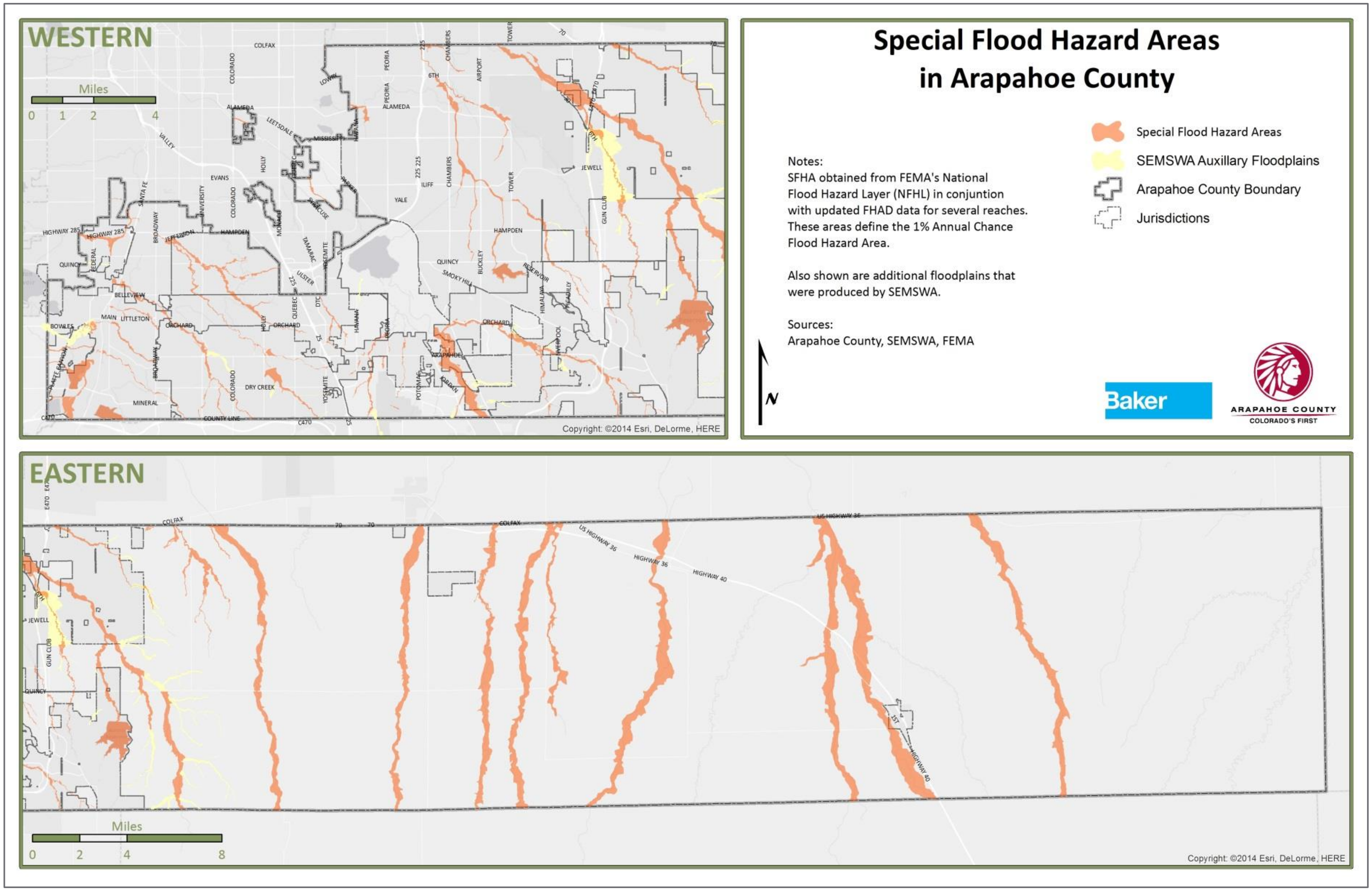


Figure 38. Map of Arapahoe County Special Flood Hazard Areas

The additional “SEMSWA Auxiliary Floodplain” areas shown on the SFHA map were generated along all major drainage ways located in and near South East Metro Storm Water Authority’s (SEMSWA's) service area. Drainage ways are defined as streams with greater than 130 acres of contributing drainage area. SEMSWA provided the 2008 DEMs (Digital Elevation Models) generated by the U.S. Geological Survey for use as the base data for this project. The floodplain delineations were generated using one of two methods: Hazus or HEC-RAS. Both methods used the base data provided by SEMSWA.

Hazus is a regional multi-hazard loss estimation model developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Buildings Sciences (NIBS). The Hazus delineations developed for this Plan were generated using the fully-automated tools within the software, which use generalized regional regression equations to estimate flows and normal depth calculations to estimate flood depths. Hazus floodplain delineations were post-processed to remove artifacts and flow areas less than 0.5 feet deep. Where Hazus could not determine floodplain delineations, the automated tools within HEC-GeoRAS were used to generate geometry data that was then used in HEC-RAS to model the floodplain. Flows used in HEC-RAS were either taken from the Hazus analysis or were developed using the U.S. Geological Survey's online StreamStats tool to implement the Colorado regional regression equations. HEC-GeoRAS was used to post-process the HEC-RAS model results and produce floodplain delineations.

The type of property damage caused by flood events depends on the depths and velocity of the floodwaters. Faster moving floodwaters can wash buildings off their foundations and sweep cars downstream. Pipelines, bridges, and other infrastructure can be damaged when high waters combine with flood debris. Extensive damage can be caused by basement flooding and landslide damage related to soil saturation from flood events. Seepage into basements is common during flood events. Most flood damage is caused by water saturating materials susceptible to loss (e.g., wood, insulation, wallboard, fabric, furnishings, floor coverings, and appliances). Homes in flooded areas can also suffer damage to septic systems and drain fields. In many cases, flood damage to homes renders them uninhabitable.

Flood events impact businesses by damaging property and by interrupting business. Flood events can cut off customer access to a business as well as close a business for repairs or permanently. A quick response to the needs of businesses affected by flood events can help a community maintain economic vitality in the face of flood damage. Responses to business damages can include funding to assist owners in elevating or relocating flood-prone business structures.

During flooding events, homes, businesses, and people face the threat of explosions and fires caused by leaking gas lines along with the possibility of being electrocuted. Domestic and wild animals forced out of their homes and brought into contact with humans by floodwaters can also pose a threat. In rural areas, property damage caused by flooding can be devastating to ranchers and farmers. When flooding occurs during the growing season, farmers can suffer widespread crop loss. Stock growers may lose livestock if they are unable to find safety from rising floodwaters. Flooding may also cause damage to pasture land, fences, barns, and out buildings.

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

Mitigation against flood events is accomplished through sensible floodplain management and regulations as well as identifying flood prone areas, tributary watersheds that experience instability or sediment loading problems, and channel instability hazards. This involves strategies to modify flooding and to modify infrastructure to decrease the likelihood of damage. To modify the impact of flooding, measures must be taken to decrease susceptibility to flood damage and disruptions. Natural and cultural resources must also be protected and managed. Coordination with mitigation plans by Flood Plain Managers will increase effectiveness of flood mitigation projects. City and County Planners will be valuable resources to incorporate flood mitigation plans into their respective plans.

Documentation of flooding in Colorado collected by the National Climatic Data Center (NCDC) and the University of South Carolina's Hazards and Vulnerability Research Institute (HVRI) goes back to 1950. The table below provides a history of major flood events that affected Arapahoe County between 1950 and 2013.

Table 65. Arapahoe County Historical Flood Events (1950 – 2013)

Date	Hazard Type	Injuries	Deaths	Property Damage	Crop Damage
9/12/2013	Flooding	0	0	$50,000,000	$10,000,000
6/6/2012	Flooding	0	0	$50,000	$50,000
7/14/2011	Flooding	0	0	$10,000	0
7/6/2010	Flooding	0	0	$10,000	0
8/8/2008	Flooding	0	0	$10,000	0
7/16/2000	Flooding	0	0	0	0
8/19/1999	Flooding	0	0	0	0
8/4/1999	Flooding	0	0	0	0
7/29/1997	Flooding	0	0	$30,000	0
6/1/1997	Flooding	0	0	$35,000	0

Date	Hazard Type	Injuries	Deaths	Property Damage	Crop Damage
7/20/1990	Flooding	0	0	$5,000	0
7/30/1985	Flooding	0	0	$555	$5,555
7/18/1985	Flooding	0	0	$5,555	$5,555
6/7/1979	Flooding	0	0	$793	0
	TOTAL:	**0**	**0**	**$50,156,903**	**$10,061,110**

Source: SHELDUS; NOAA (NCDC Storm Events Database)

The most significant flooding event to collectively impact the State of Colorado occurred during September 2013. During the week beginning on September 9th, a slow moving cold front circulated over the state, clashing with warm, humid monsoonal air from the south. While damages are still being assessed for the 2013 flooding event, NOAA's National Climatic Data Center (NCDC) Storm Events Database estimates that Arapahoe County sustained $50 million in property damage and another $10 million in crop damage. It should be noted, however, that the 2013 flooding was not a worst-case event for Arapahoe County.

According to the National Climatic Data Center (NCDC) and the University of South Carolina's HVRI, Arapahoe County has been impacted by 14 major flood events since 1950. Aggregate loss data for these events is included in the "Historical Flood Impacts" table below.

Table 66. Historical Flood Impacts in Arapahoe County

Location	Date	Type	Events	Injuries	Deaths	Property Damage	Crop Damage
Arapahoe County	1950-2013	Flooding	14	0	0	$50,156,903	$10,061,110

Repetitive Loss properties (RL) are structures covered by a contract for flood insurance made available under the National Flood Insurance Program (NFIP) that: (a) have incurred flood-related damage on two occasions, in which the cost of repair, on the average, equaled or exceeded 25% of the market value of the structure at the time of each flood event; and (b) at the time of the second incidence of flood-related damage, the contract for flood insurance contains increased cost of compliance coverage. As of June 2014, there is one repetitive loss property (RL) within Arapahoe County.

A Severe Repetitive Loss property (SRL) is defined as a residential property that is covered under an NFIP flood insurance policy and: a) has at least four NFIP claim payments (including building and contents) over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000; or, b) a property for which at least two separate claim payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building. For both a) and b) above, at least two of the referenced claims must have occurred within any ten-year period, and must be greater than ten days apart. As of June 2014, there are no severe repetitive loss (SRL) structures located within Arapahoe County.

Reported flood events in Arapahoe County over the past 63 years provide an acceptable framework for determining the future occurrence of floods in terms of frequency for such events. The probability that the County and its municipalities will experience a flood event can be difficult to predict or quantify. However, based on historical records of 14 flood events since 1950, it can reasonably be assumed that this type of event has occurred once every 5 years from 1950 through 2013.

[(Current Year) 2013] subtracted by [(Historical Year) 1950] = 63 Years on Record

[(Years on Record) 63] divided by [(Number of Historical Events) 14] = 4.5

The historic frequency calculates that there is a 25% chance of a major flooding event occurring in Arapahoe County each year.

CLIMATE CHANGE IMPACTS

In addition to increasing drought potential (and therefore increasing runoff), climate change has the potential to intensify rain events and storms in the Colorado region. These events can lead to increased infrastructure damage, injury, illness, and death. Additionally, warmer temperatures in the winters may cause increased precipitation to fall as rain instead of snow in mountain regions of Colorado. This may lead to elevated stream flows and increased flood risk across the state. As climate science and data evolves it will be important for communities in and around Arapahoe County to address how our changing climate will affect how water moves through local streams and regional landscapes.

INVENTORY ASSETS EXPOSED

The map below shows the flooding threat to critical facilities in Arapahoe County by layering identified special flood hazard areas (SFHA) with the locations of community-defined critical facilities. Critical facilities are essential to the health and welfare of the whole population and are especially important both during and after hazard events. Critical structures or areas that overlap or touch the SFHA are considered “flood prone.”

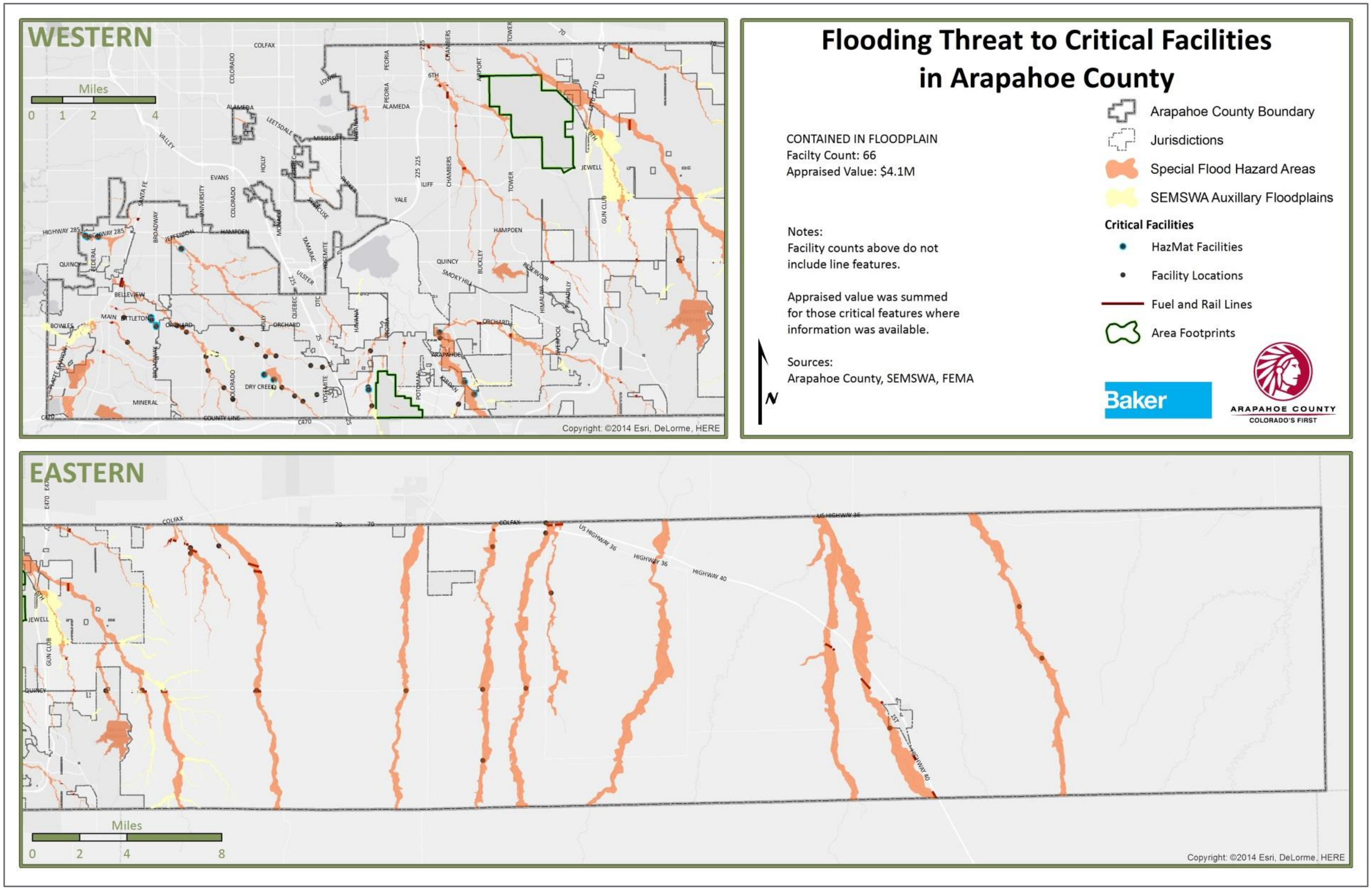


Figure 39. Map of Flooding Threat to Critical Facilities

The critical facility exposure analysis estimates that there are 66 critical facilities in Arapahoe County that are flood prone (not including the total miles of flood prone infrastructure). The appraised value of these exposed structures is approximately $4.1 million.

The tables below summarize the results of the critical facility flood exposure analysis and include information concerning appraised value and mileage of flood prone fuel and rail lines.

Table 67. Flood Prone Critical Areas

CRITICAL FACILITIES	TOTAL # OF STRUCTURES	# OF FLOOD PRONE STRUCTURES
HISTORIC AREAS	18	0
AIRPORTS	2	2
TOTAL STRUCTURES	**20**	**2**

Table 68. Flood Prone Critical Facilities – Fuel and Rail Lines

CRITICAL FACILITIES	TOTAL MILES OF INFRASTRUCTURE	MILES OF FLOOD PRONE INFRASTRUCTURE
FUEL	113.19	6.02
LIGHT RAIL	37.71	0.69
RAILROAD	78.49	3.43
TOTAL MILEAGE	**229.39**	**10.14**

Table 69. Flood Prone HAZMAT Facilities

CRITICAL FACILITIES	TOTAL # OF STRUCTURES	# OF FLOOD PRONE STRUCTURES
HAZMAT FACILITIES	1631	14
TOTAL STRUCTURES	**1631**	**14**

Table 70. Flood Prone Critical Facilities – City and County Facilities

	City Facility		**County Facility**	
	Count	*Appraised Value*	*Count*	*Appraised Value*
Within SFHA	1	$400,000	0	$ -
Total	16	$74,040,321	25	$206,520,075
% Flood Prone	6%	< 1%	0	0

Table 71. Flood Prone Critical Facilities – Emergency Services

	Hospital		Military Facility		Police/Sheriff		Fire Station	
	Count	*Appraised Value*	*Count*	*Appraised Value*	*Count*	*Appraised Value*	*Count*	*Appraised Value*
Within SFHA	0	$ -	0	$ -	1	$400,000	0	$ -
Total	10	$148,618,454	149	$ -	16	$50,479,712	40	$66,384,642
% Flood Prone	0	0	0	0	6%	< 1%	0	0

Table 72. Flood Prone Critical Facilities – Community Services

	Church		Library		School	
	Count	*Appraised Value*	*Count*	*Appraised Value*	*Count*	*Appraised Value*
Within SFHA	2	$3,028,195	0	$ -	0	$ -
Total	236	$651,491,498	15	$78,243,520	251	$2,552,311
% Flood Prone	< 1%	< 1%	0	0	0	0

Table 73. Flood Prone Critical Facilities – Infrastructure and Transportation

	Light Rail Station		Bridge		Fuel Depots		Water Facility	
	Count	*Appraised Value*	*Count*	*Count*	*Count*	*Appraised Value*	*Count*	*Appraised Value*
Within SFHA	0	$ -	43	$ -	1	$48,000	2	$205,283
Total	9	$ -	140	$ -	36	$18,735,584	16	$24,045,574
% Flood Prone	0	0	30%	$ -	3%	< 1%	13%	< 1%

POTENTIAL LOSSES

The methodology used to determine potential losses to flooding was conducted using FEMA's Hazus loss estimation software. For this Plan, a 100-year flood scenario was modeled for the County. The results are presented below.

HAZUS 100-YEAR FLOOD SCENARIO

In addition to the SFHA boundaries, the flood risk analysis for this Plan integrates DFIRM depth grids, a digital dataset that shows flood depths at various locations within the floodplain. This enhanced data input allows Hazus to more accurately approximate floodplain boundaries and their associated flood depths for a 100-year flood event.

Due to the availability of LiDAR elevation data, as well as complete countywide floodplain coverage, a detailed depth grid was locally developed for this planning effort. This depth grid was developed by combining the effective FEMA 100 year floodplains with several Urban Drainage Flood Control District FHADs (Flood Hazard Area Delineations) that covered the area of analysis. The resulting floodplain represents the most detailed and temporally accurate depiction of the current flood hazards in Arapahoe County. A water surface elevation surface was created from the aforementioned floodplains and this surface was intersected with the most accurate elevation data available (2013 LiDAR and NED data) to obtain a flood depth surface. The map below shows the SFHA and the associated flood depths within Arapahoe County generated for the 100-year risk analysis.

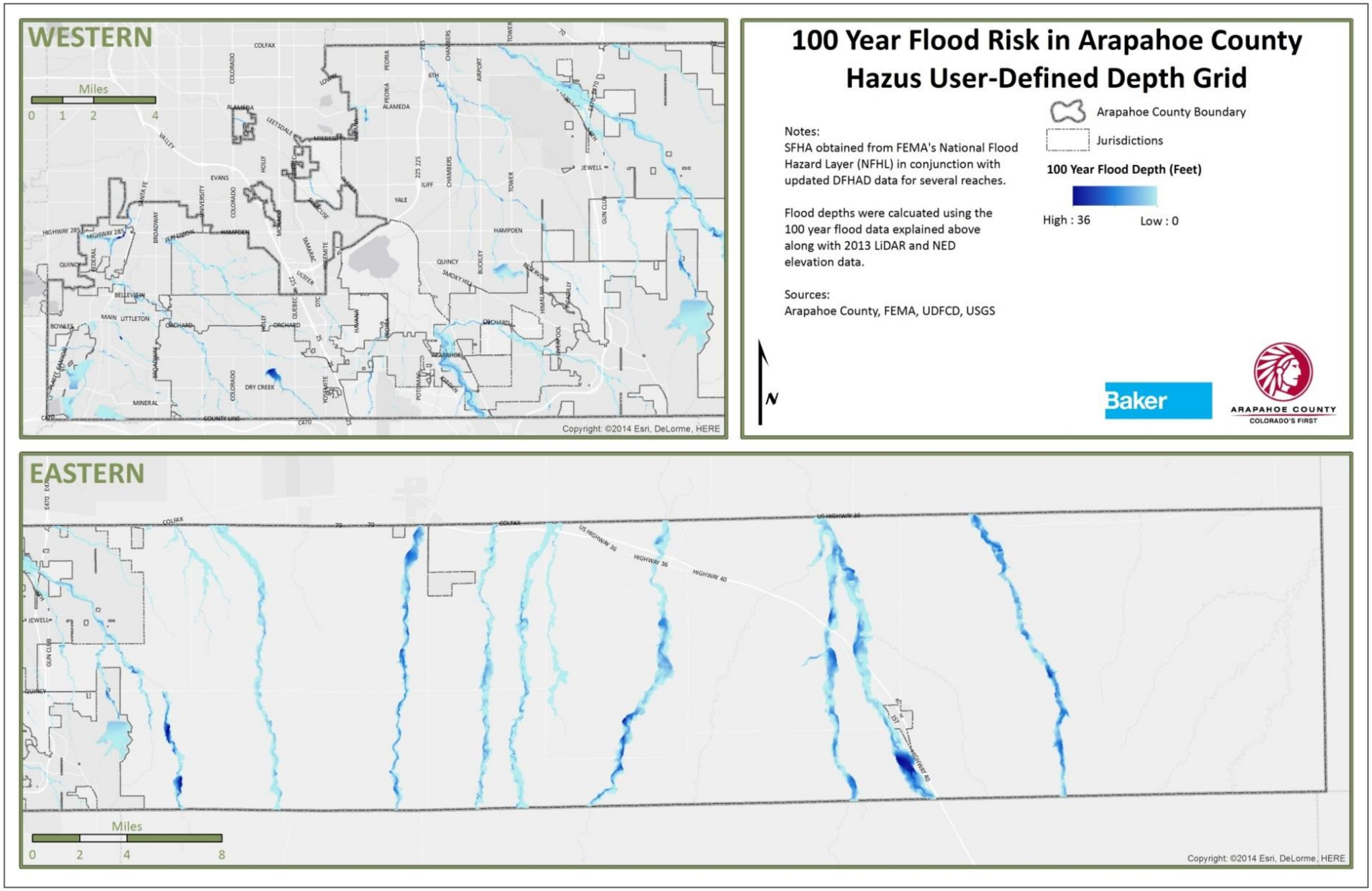


Figure 40. DFIRM Depth Grid – Arapahoe County

The flood depth grid and the parcel centroid points served as the primary inputs into Hazus. The parcel centroid points were produced by utilizing parcel and assessor data provided by Arapahoe County GIS. This data was converted to parcel centroid (point) data and spatially corrected to ensure geographical accuracy of the points and the associated structures in all areas within the designated 100-year floodplain. In some cases there were multiple, distinctly different, structures within a single designated parcel. In these cases, points were generated on top of each individual structure and the total appraised value of the parcel was divided up equally among the structures. Important attributes such as year built and land use were missing for many parcels throughout the county. In these cases the average value of the associated census block was used in the risk assessment.

A 100-year flood scenario was defined in Hazus and losses were calculated for each point that intersected the depth grid based on the Hazus depth damage curves for specific structure attributes (such as foundation type, building type, and first flood height). The map below shows the results of the Hazus 100-year flood scenario economic loss analysis for Arapahoe County.

Future flood risk assessments conducted within Arapahoe County (including Hazus-based assessments) should ensure that they continue to incorporate additional floodplain data sets that were not able to be fully utilized as part of the 2015 Plan. This includes floodplains generated by SEMSWA that supplement the FEMA floodplain (which was used partially in this risk assessment) in addition to any applicable UDFCD FHAD that have not yet been incorporated into FEMA's National Flood Hazard Layer (NFHL).

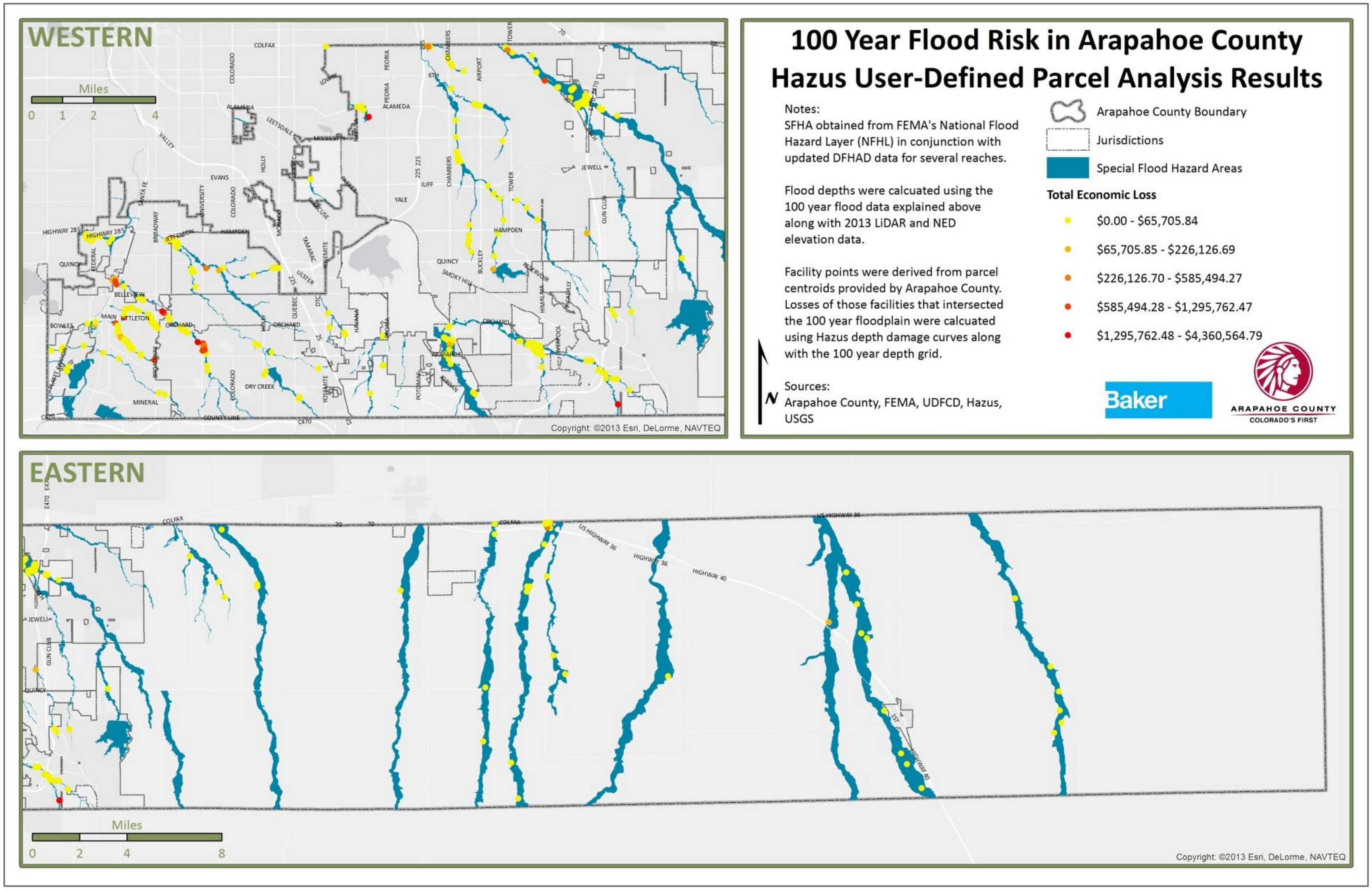


Figure 41.Total Building Losses (100-Year Flood Scenario)

The map of total building losses illustrates a clear loss pattern in which damages are clustered around the most populated areas of the county. These places represent areas where resources and people are concentrated, making those areas of high potential loss and clear priority areas for focused mitigation action.

Hazus estimates for Arapahoe County estimate that for a 100-year flood event, approximately 294 buildings will be at least moderately damaged. The total economic loss estimated for the 100-year flood is over $41 million dollars. A number of variables are included in Hazus analyses in order to arrive at the estimated values of loss due to flooding. For this reason, it is important to note that the Hazus loss estimates detailed below should not be used as a precise measure, but rather viewed from the perspective of the potential magnitudes of expected losses.

When calculating building losses Hazus breaks loss values into two categories: direct economic losses and indirect economic losses. Direct economic losses are the estimated costs to repair or replace the damage caused to a building and its contents. These values are organized in terms of Building Losses and Building Content Losses. Indirect economic losses include Inventory Losses and other losses associated with business interruption and the inability to operate a business because of the damage sustained during the flood.

The total building losses for the 100-year flood event were estimated to be over $9.4 million. This represents over 20% of total economic losses in the county. Building content losses were estimated to be over $31 million, representing roughly 75% of total economic losses. Inventory losses were estimated to be over $937,000. This represents roughly 2% of total economic losses due to the 100-year flood modeled in the Hazus scenario.

The table below provides a summary of the economic losses associated with building damage by jurisdiction. Only those jurisdictions with expected losses are included in the table (unlisted jurisdictions do not have structures that are expected to sustain damage from the 100-year flood scenario).

Table 74. Economic Loss Estimates by Jurisdiction (Hazus 100-year Flood Scenario)*

Jurisdiction	Total Building Count	Number of Damaged Buildings	Building Losses	Building Content Losses	Inventory Losses	Total Losses
Aurora	112,172	94	$2,000,000	$8,000,000	$23,000	$10,023,000
Bennett	1,078	1	0	$10	$0	$10
Byers	1,540	1	$73,000	$47,000	$0	$120,000
Centennial	39,917	57	$2,000,000	$6,000,000	$0	$8,000,000
Deer Trail	1,042	13	$50,000	$73,000	$95,000	$218,000
Englewood	21,716	54	$4,000,000	$8,000,000	$640,000	$12,640,000
Greenwood Village	5,547	4	$36,000	$2,000	$700	$38,700
Littleton	16,032	51	$2,000,000	$8,000,000	$24,000	$10,024,000
Strasburg	809	14	$59,000	$130,000	$154,000	$343,000

Jurisdiction	Total Building Count	Number of Damaged Buildings	Building Losses	Building Content Losses	Inventory Losses	Total Losses
Watkins	345	4	$34,000	$1,000	$2,000	$37,000
Unincorporated	10,132	1	$0	$200	$200	$400
Total	**210,330**	**294**	**$10,252,000**	**$30,253,210**	**$938,900**	**$41,444,110**

*Loss estimates have been rounded to the nearest $10, $1,000, and $1,000,000

Urban Drainage Flood Control District – Flood Risk Assessment, 2015

Flood risk assessment data was developed for a portion of Arapahoe County as part of a FEMA Risk MAP project for Urban Drainage and Flood Control District (UDFCD). This work was completed in 2015, as the County finalized their local hazard mitigation plan update. The data provided in this section is meant to compliment, and not replace, the flood exposure and loss estimation information that was developed for this plan and presented above. FEMA's Risk MAP program provides high quality flood risk datasets and products that should enhance mitigation plans and help achieve more flood resistant and resilient communities.

The UDFCD flood risk datasets and products were created by FEMA Region VIII risk analysts and provided to Arapahoe County for awareness and for inclusion in this plan. This assessment only covers areas within the UDFCD district boundaries in Arapahoe County, which is essentially the western third of the County and areas with highest population.

Similar to the County's risk assessment approach, FEMA used Hazus 2.2 to estimate losses to a site-specific building inventory using user-supplied flood depth grids. FEMA created depth grids for 1% annual chance (100-year) and 0.2% annual chance (500-year) flood events that conform to DFIRM flood zone boundaries. Water surface elevations were interpolated using DFIRM base flood elevations as well as adjacent land surface elevations, then subtracted from land surface elevations to arrive at flood depth. Depth grids were created separately for AO and AH zones using constant water depths as designated by the DFIRM, and then merged back into the overall 1% depth grid. FEMA used 2013/2014 LiDAR terrain data exclusively. Structure inventory used for this analysis is the same as described on page 156. This data was collected and rerun in Hazus 2.2 using the refined flood hazard data.

The final datasets include 1% annual chance (100-year) and 0.2% annual chance (500-year) depth grids and site specific loss estimates associated with each of the return periods. 1% annual chance dollar loss estimates are very similar to those derived from the County risk assessment listed in Table 74. The full final datasets are available on FEMA's FTP site here:
https://content.femadata.com/Region8/RiskMAP/States/Colorado/Projects/Arapahoe_County/

The datasets can be downloaded and used for further understanding, visualization, and flood risk analysis.

The three maps shown on the following pages show areas of highest risk, or 'hot spots', to the 1% annual chance flood. Flood sources are labeled on the map and residential structures are colored by percent damage and labeled with depth of modeled flood at that location. High risk areas are shown in Centennial, Englewood, Cherry Hills Village, and Sheridan. Note the mobile home park on the east side of the map in Sheridan. Communities can use this information to direct and prioritize mitigation activities to help achieve flood risk reduction goals. Activities may include, but are not limited to, restricting development in floodplain areas, adopting and enforcing building codes, implementing floodplain techniques as required by the NFIP and beyond, upsizing culverts, modifying bridges, and elevating or flood proofing structures.

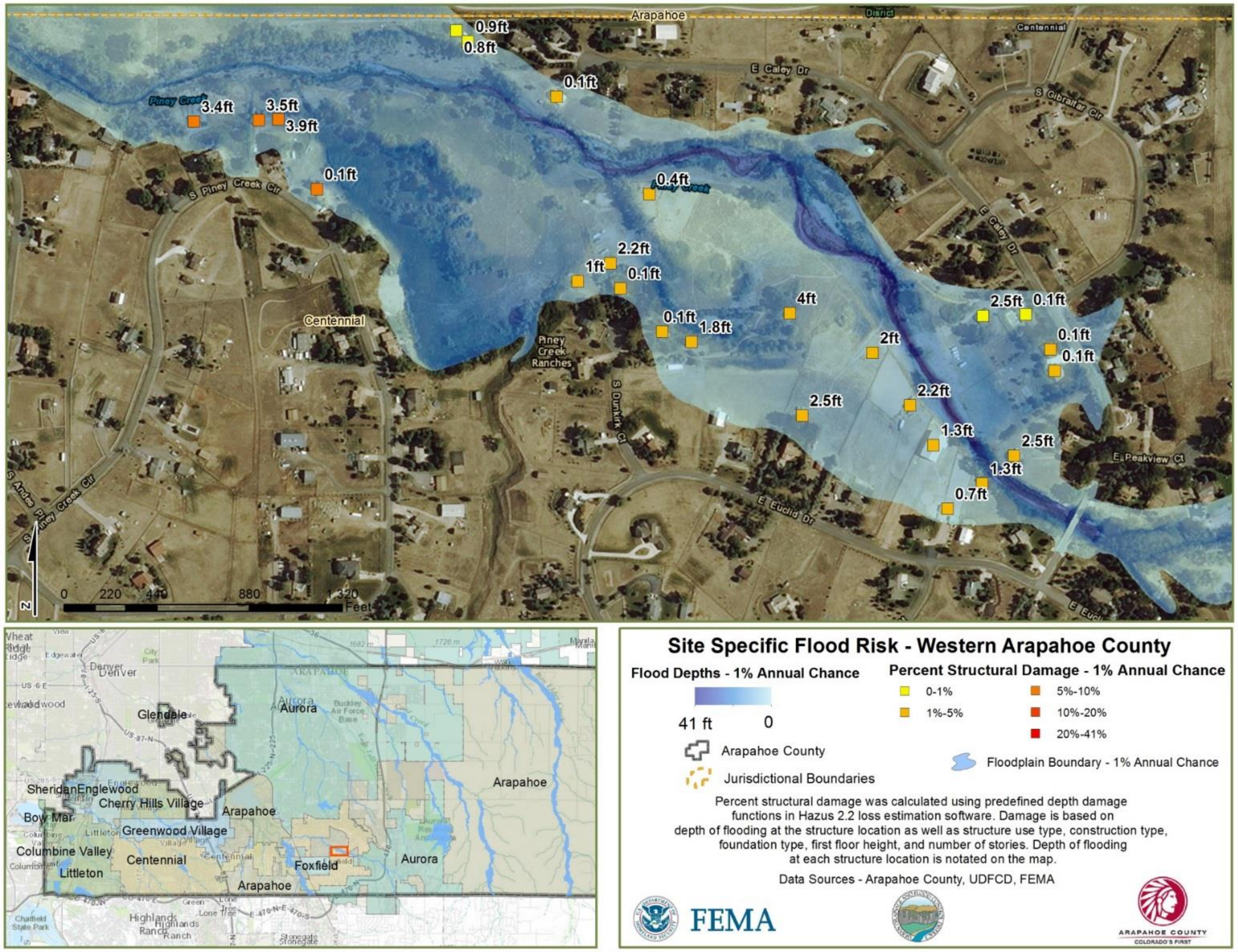


Figure 42. Site Specific Flood Risk – Western Arapahoe County (Map 1)

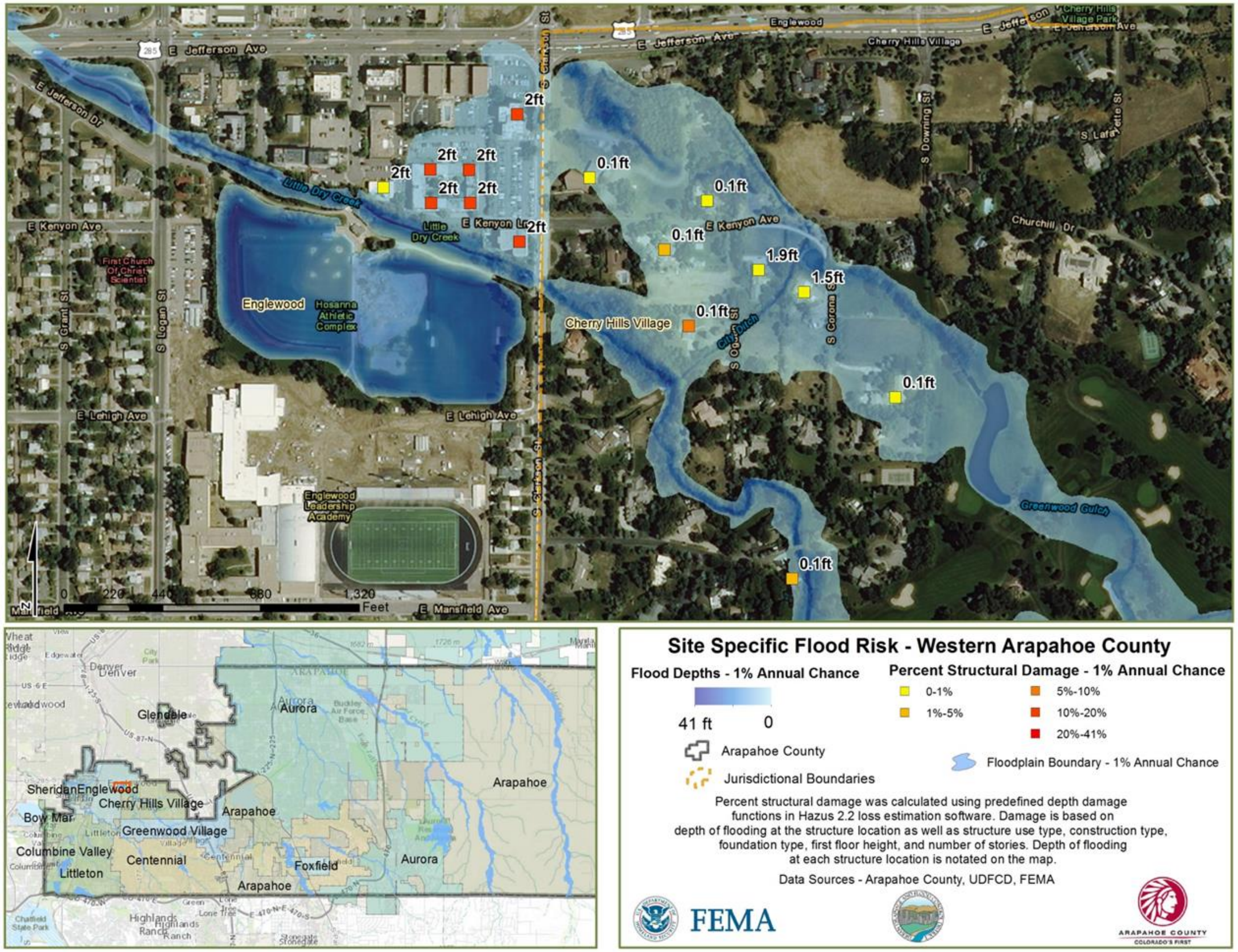


Figure 43. Site Specific Flood Risk – Western Arapahoe County (Map 2)

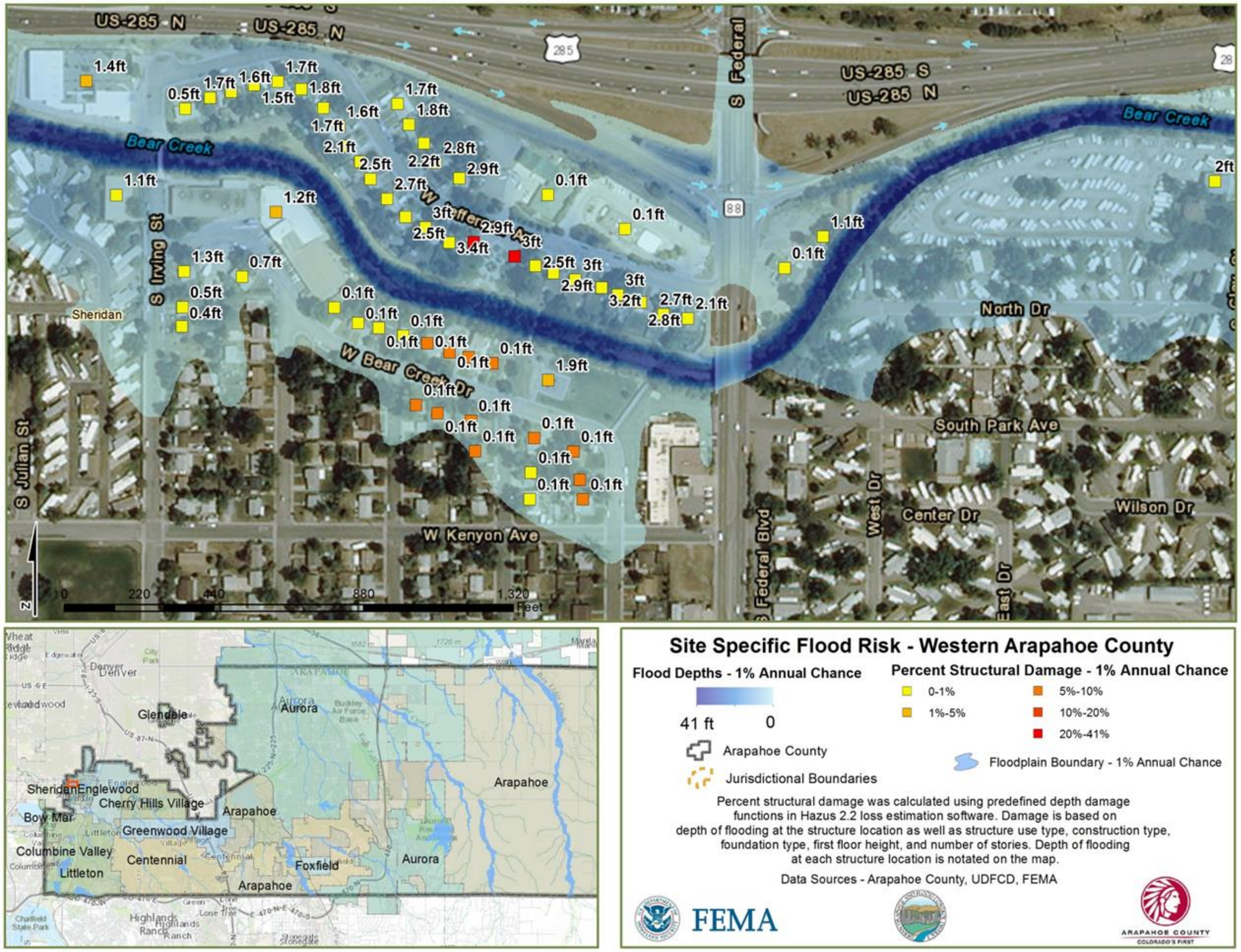


Figure 44. Site Specific Flood Risk – Western Arapahoe County (Map 3)

LAND USE & DEVELOPMENT TRENDS

As population continues to increase in Arapahoe County, future development trajectories can be expected to put more people and property, both private and public, at risk of flooding. It is essential that zoning and land use plans take into account not only the dollar amount of damage that buildings near waterways could incur, but also the added risk of floodplain development activity that alters the natural flood plain of the area (for example, narrowing the floodplains by building new structures close to rivers and streams). The county as a whole should plan for the likelihood of increased exposure of property and humans to flood events.

MULTI-JURISDICTIONAL DIFFERENCES

The previous Table presented estimated losses summarized by jurisdiction. It shows a large range of expected damaged buildings due to a 1% annual chance flood event. Portions of Aurora within Arapahoe County were estimated to have almost 100 structures damaged. While affecting less than 0.08% of the building stock in that area, the losses still were expected to total over $10 million. Englewood, Littleton, and Centennial each had roughly 50 structures estimated to be damaged, with total losses in the range of $8 - $10 million dollars. Damaged buildings affected 0.2%, 0.3%, and 0.1% of all buildings in those jurisdictions, respectively.

Loss estimations for some of the less populated jurisdictions in Arapahoe County were all relatively minor when compared to the scale of losses mentioned above. However, nearly 2% of all buildings in Strasburg were estimated to be damaged and the same can be said for over 1% of all buildings in both Deer Trail and Watkins.

HIRA SUMMARY

Severe flooding has the potential to inflict significant damage to people and property in Arapahoe County. Mitigating flood damage requires that communities throughout the County remain diligent and notify local officials of potential flood (and flash flood) prone areas near infrastructure such as roads, bridges, and buildings. While the potential for flooding is always present, Arapahoe County has existing land-use policies and regulations for development to help lessen potential damage due to floods.

Existing floodplain management ordinances are intended to addresses methods and practices to minimize flood damage to new and substantial home improvement projects as well as to address zoning and subdivision ordinances and state regulations. Additionally, Arapahoe County is a National Flood Insurance Program (NFIP) participant and continues to support floodplain management activity at the county and local scale.

The greatest protection against flooding is afforded by quality construction and compliance with local ordinances which exceed NFIP requirements. Code adoption by local jurisdictions, compliance by builders, and local government inspection of new homes can greatly reduce the risk of flooding. Moving forward, Arapahoe County will continue to support monitoring, analysis, modeling, and the development of decision-support systems and geographic information applications for floodplain management activities.

In addition to land-use planning, zoning, and codes applicable to new development, flood mitigation measures include structural and non-structural measures to address susceptibility of existing structures. Flood mitigation measures such as acquisition, relocation, elevation-in-place, wet/dry flood proofing, and enhanced storm drainage systems all have the potential to effectively reduce the impact of flood in Arapahoe County.

PUBLIC HEALTH HAZARDS

NATURAL HAZARDS	PROBABILITY	IMPACT	SPATIAL EXTENT	WARNING TIME	DURATION	RF RATING
Public Health Hazards	2 (0.6)	2 (0.5)	3 (0.5)	2 (0.2)	3 (0.3)	**2.2**
MODERATE RISK HAZARD (2.0 – 2.4)						

HAZARD IDENTIFICATION

Public health hazards, including epidemics and pandemics, have the potential to cause serious illness and death, especially among those who have compromised immune systems due to age or underlying medical conditions. There are several contagious and infectious diseases present in the Denver Metro Region that constitute a public health risk. Emergency Support Function 8 (ESF 8) of the State Emergency Operations Plan provides an organizational framework for public health and medical service preparedness, response, and recovery efforts for various emergency epidemics. For the 2015 Plan, pandemic flu has been identified as the key public health hazard in the county. This hazard risk assessment includes an analysis of pandemic flu risk in Arapahoe County and an analysis of the impacts of the hazards profiled in this plan on public health.

A pandemic can be defined as a disease that attacks a large population across great geographic distances. Pandemics are larger than epidemics in terms of geographic area and number of people affected. Epidemics tend to occur seasonally and affect much smaller areas. Pandemics, on the other hand, are most often caused by new subtypes of viruses or bacteria for which humans have little or no natural resistance. Consequently, pandemics typically result in more deaths, social disruption, and economic loss than epidemics.

Influenza viruses represent the most common agent for pandemics in Arapahoe County. Seasonal influenza (often referred to as the flu) is a common infection that affects large numbers of people in Colorado every year. Influenza is an acute respiratory disease caused by influenza type A or B viruses. The typical features of seasonal influenza include abrupt onset of fever and respiratory symptoms such as cough, sore throat, as well as headache, muscle ache, and fatigue. For seasonal influenza, the incubation period ranges from 1 to 4 days and the clinical severity of infection can range from asymptomatic infection to primary viral pneumonia and death. Most people experience influenza as a very-uncomfortable but ultimately benign illness. However, the influenza virus can mutate, causing it to be much more dangerous to humans. Yearly seasonal influenza remains a significant disease in the U.S. and Colorado, and seasonal epidemics can result in high morbidity and mortality, as well as create strains on the health care system and communities.

Unlike influenza viruses that have achieved ongoing transmission in humans, the sporadic human infections with avian A (H5N1) viruses are far more severe with high mortality. Initial symptoms include high fever and other influenza-like symptoms. It also appears that the incubation period in humans may be longer for avian (H5N1) viruses, ranging from 2 to 8 days, and possibly as long as 17 days. Diarrhea, vomiting, abdominal pain, chest pain, and bleeding from the nose and gums have also been reported. The disease often manifests as a rapid progression of pneumonia with respiratory failure ensuing over several days.

With the increase in global transport, as well as urbanization, epidemics due to new influenza viruses are likely to occur in and around Arapahoe County. A new flu virus, which eventually became known as H1N1, came to the world's attention in March 2009. The symptoms of pandemic H1N1 2009 influenza were similar to those of seasonal influenza. Illness in most cases was mild but there were cases of severe disease requiring hospitalization and a number of deaths. The initial experience with the emerging pandemic of H1N1 prompted the World Health Organization (WHO) to redefine their phase descriptions for an influenza pandemic.

The six-phase approach was designed for the easy incorporation of recommendations into existing national and local preparedness and response plans. Phases 1—3 correlate with preparedness in the **pre-pandemic interval**, including capacity development and response planning activities, while Phases 4—6 signal the need for response and mitigation efforts during the **pandemic interval**.

Pre-Pandemic Interval

In nature, influenza viruses circulate continuously among animals (primarily birds). Even though such viruses might develop into pandemic viruses, in Phase 1 no viruses circulating among animals have been reported to cause infections in humans.

- **Phase 1** is the natural state in which influenza viruses circulate continuously among animals but do not affect humans.

In Phase 2 an animal influenza virus circulating among domesticated or wild animals is known to have caused infection in humans, and is thus considered a potential pandemic threat.

- **Phase 2** involves cases of animal influenza that have circulated among domesticated or wild animals and have caused specific cases of infection among humans.

In Phase 3 an animal or human-animal influenza virus has caused sporadic cases or small clusters of disease in people, but has not resulted in human-to-human transmission sufficient to sustain community-level outbreaks. Limited human-to-human transmission may occur under some circumstances, for examples, when there is close contact between an infected person and an unprotected caregiver. Limited transmission under these circumstances does not indicate that the virus has gained the level of transmissibility among humans necessary to cause a pandemic.

- **Phase 3** represents the mutation of the animal influenza virus in humans so that it can be transmitted to other humans under certain circumstances (usually very close contact between individuals). At this point, small clusters of infection have occurred.

Pandemic Interval

Phase 4 is characterized by verified human to human transmission of the virus able to cause “community-level outbreaks.” The ability to cause sustained disease outbreaks in a community marks a significant upward shift in the risk for a pandemic.

- **Phase 4** involves community-wide outbreaks as the virus continues to mutate and become more easily transmitted between people (for example, transmission through the air)

Phase 5 is characterized by verified human to human spread of the virus into at least two countries in one World Health Organization (WHO) region. While most countries will not be affected at this stage, the declaration of Phase 5 is a strong signal that a pandemic is imminent and that the time to finalize the organization, communication, and implementation of the planned mitigation measures is short.

- **Phase 5** represents human-to-human transmission of the virus in at least two countries

Phase 6, the pandemic phase, is characterized by community-level outbreaks in at least one other country in a different WHO region in addition to the criteria defined in Phase 5. Designation of this phase will indicate that a global pandemic is underway.

- **Phase 6** is the pandemic phase, characterized by community-level influenza outbreaks.

HAZARD PROFILE

Public health hazards can manifest as primary events by themselves, or they may be secondary to another disaster or emergency, such as a flood, a severe storm, or a hazardous materials incident. The common characteristic of most public health emergencies is that they adversely impact, or have the potential to adversely impact, a large number of people.

The Colorado Department of Public Health and Environment releases an annual reportable disease summary for each county. The events with the highest incidences in Arapahoe County are summarized in the table below.

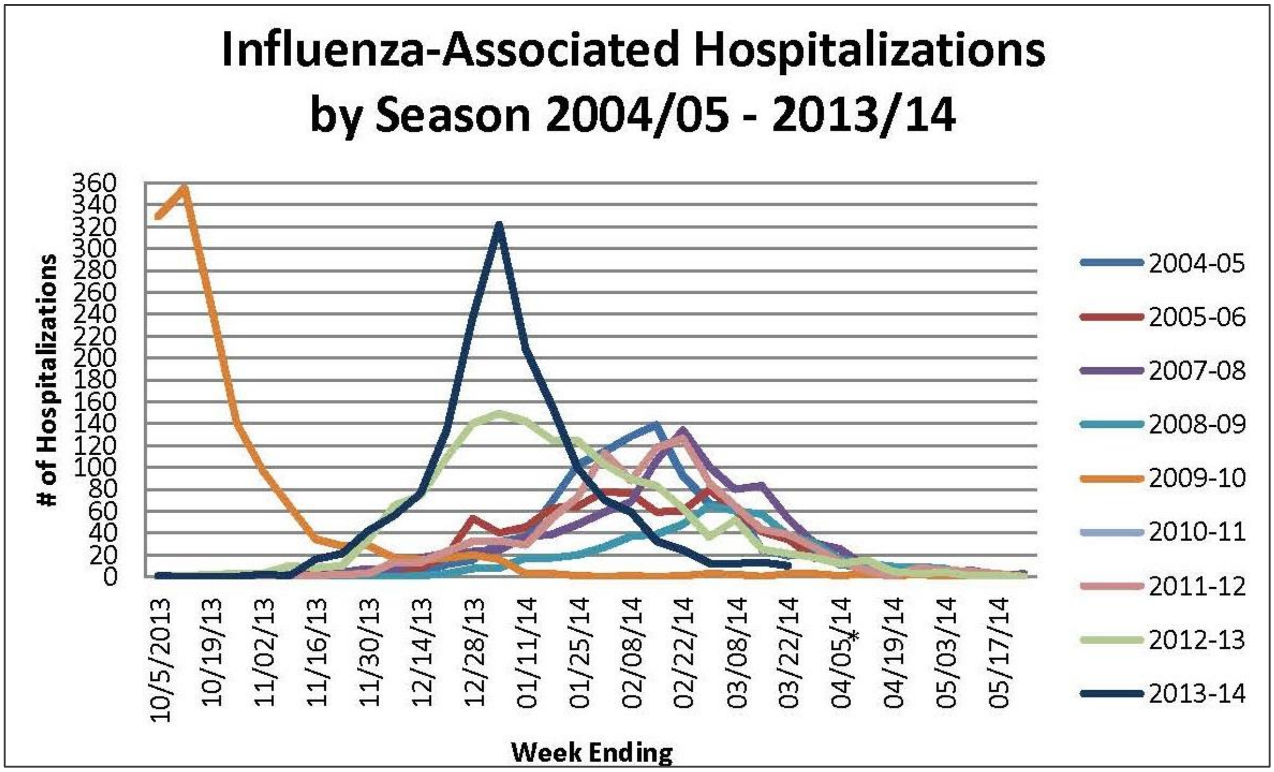
Table 75. Colorado Reportable Disease Statistics (CDPHE)

	Year				
Disease	**2009**	**2010**	**2011**	**2012**	**2013**
Campylobacter	69	71	62	72	58
Giardiasis	56	120	40	40	59
Group A & B Strep (Invasive)	73	82	73	69	86

	Year				
Hepatitis A	5	4	2	3	7
Hepatitis B (acute)	3	6	4	2	--
Hepatitis B (chronic)	105	84	114	87	86
Hepatitis C (acute)	4	4	3	1	1
Hepatitis C (chronic)	260	236	213	191	170
Influenza (hospitalized)	397	21	136	115	225
Influenza (pediatric death)	1	2	--	--	--
Malaria	9	6	6	6	8
Meningitis (viral)	43	43	22	25	12
Pertussis	26	64	83	170	190
Strep Pneumo (invasive)	65	64	58	39	45
Varicella (Chicken Pox)	32	36	35	34	25
West Nile Virus	--	7	--	--	--
Total:	1279	980	988	962	1120

Source: Division of Disease Control and Environmental Epidemiology, CDPHE

Hospitalizations from influenza represent the largest disease incidence in Arapahoe County between 2009 and 2013. The following figure shows the relative incidence levels of influenza-associated hospitalizations in Colorado between 2004 and 2014.



Source: Colorado Flu Report (2014), Colorado Department of Public Health and Environment

Figure 45. Influenza- Associated Hospitalizations in Colorado, 2004 – 2014

Based on influenza surveillance carried out by the Colorado Department of Public Health and Environment, the most recent influenza season (2013/14) peaked during the week ending on January 4th, 2014 with 317 hospitalizations reported. This is the highest number of hospitalizations reported during a single week since hospitalizations started being reported (in 2004/05), excluding the influenza pandemic (2009/2010 season) when 355 hospitalizations were reported during a week in October.

During the drafting of the 2015 Arapahoe County Multi-Hazard Mitigation Plan local and regional stakeholders expressed concern that there is a high probability of a dangerous new strain of influenza virus sometime in the future.

Based on historical record of 5,329 public health hazard events since 2009, it can reasonably be assumed that an event of this type occurred more than once every year from 2009 through 2013.

[(Record Year) 2013] subtracted by [(Historical Year) 2009] = 5Years on Record

[(Years on Record) 5] divided by [(Number of Historical Events) 5,329] = 0.0009

Furthermore, the historic frequency calculates that there is a 100% chance of some type of public health hazard affecting Arapahoe County every year.

CLIMATE CHANGE IMPACTS

Climate change threatens to increase the spread of infectious diseases because changing heat, rain, and humidity levels allow disease carrying vectors and pathogens to come into closer contact with humans. Climate change has the potential to expand the habitats and infectivity of disease-carrying insects and rodents, thus increasing the risk of disease transmission. For example, mosquitoes capable of transmitting West Nile virus are already present in Colorado. If Colorado's climate becomes warmer, mosquito populations could swell, making the region more favorable for disease transmission.

Hantavirus is another infectious disease that may pose a higher risk to Arapahoe County residents in the future. Deer mice are the primary reservoir for Hantaviruses and climate change (warmer weather) plays a role in elevated seasonal deer mouse populations.

INVENTORY ASSETS EXPOSED

The information in the table below is from the Impact Analysis of Potential for Detrimental Impacts of Hazards for the Emergency management Accreditation Program (EMAP). The table explains possible impacts to various subjects due to public health emergencies.

Table 76. Impacts to Subjects Impacted by Public Health Emergencies

Subject	Detrimental Impacts
Health and Safety of Persons in the Area as the Time of Incident	Adverse impacts are expected to be severe for unprotected personnel and moderate to light for protected personnel.
Health and Safety of Persons Responding to the Incident	Adverse impacts are expected to be severe for unprotected personnel and uncertain for trained and protected personnel, depending on the nature of the incident.
Continuity of Operations	Danger to personnel in the area of the incident may require relocation of operations and lines of succession execution.
Property, Facilities, and Infrastructure	Access to facilities and infrastructure in the area of the incident may be denied until decontamination is complete.
Delivery of Services	Stress on resources and facilities due to increased volume and demand may overwhelm and/or extensively postpone delivery of services.

Subject	Detrimental Impacts
The Environment	Incident may cause denial or delays in the use of some areas.
Economic and Financial Condition	Local economy and finances may be adversely affected, possibly for an extended period of time.
Regulatory and Contractual Obligations	Regulatory waivers may be needed. Fulfillment of contracts may be difficult. Demands may exceed the ability to deliver.
Reputation of, or Confidence in, Management and Response Authorities	Ability to respond and recover may be questioned and challenged if planning, response, and recovery are not timely and effective.

POTENTIAL LOSSES

FluWorkLoss 1.0 is a tool developed by the CDC to estimate the potential impact of pandemic influenza on a community in terms of cost. Based on local demographic data, the tool allows communities to estimate the potential number of days lost from work due to a pandemic. Users of FluWorkLoss can change input values, such as the number of workdays lost due to a worker staying come to care for a family member. Users can also change the length and virulence of the pandemic so that a range of possible impacts can be estimated.

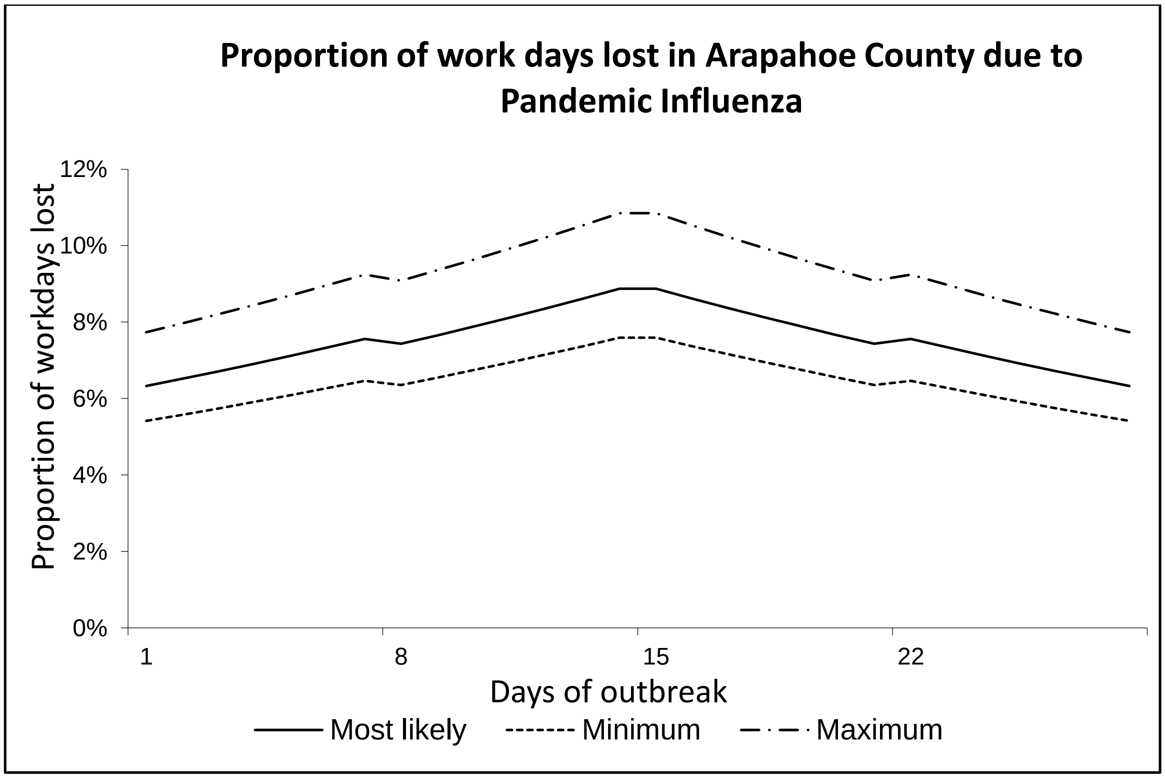
Days missed from work are a cost to both employees (in lost wages) and employers (in work not completed). The following table shows the total estimated number of days lost from work in Arapahoe County due to a four-week long influenza pandemic with a 25% clinical attack rate. The available workdays are calculated as a product of the total population in the working age group (Census 2010), the employment rate of Arapahoe County (Census 2010), and the number of workdays in a week (5).

Table 77. Total Workdays Lost

Scenario	Workdays Lost
Most Likely Scenario	275,178
Minimum Loss Scenario	235,420
Maximum Loss Scenario	336,351

The number of workdays lost includes the workdays lost for both self-care and care of sick family members due to the pandemic. Although the workdays lost do not include those lost due to factors such as fear and school closings, the model does provide a general picture of the impact on the productivity of the local economy due to an influenza pandemic. Results are estimated to create three scenarios of pandemic impact: the minimum (the best case scenario), which estimates the fewest possible number of hospitalizations/outpatient visits/deaths (i.e., the fewest possible days lost from work); the mean (the most likely scenario); and the maximum (the worst case scenario).

The following graph shows the proportion of workdays lost for each day of the modeled influenza outbreak for the three loss scenarios. Again, the scenario assumes a four-week long pandemic with a 25% clinical attack rate.



Source: Census 2010; CDC

Figure 46. Proportion of Workdays Lost due to Pandemic Influenza

The numbers and projections generated through FluWorkLoss are not considered predictions of what *will* happen during an influenza pandemic. Rather, the results should be treated as estimates of what *could* happen.

LAND USE & DEVELOPMENT TRENDS

Future development in and around Arapahoe County has the potential to change how infectious diseases spread through the community and impact human health in both the short and long term. New development may increase the number of people and facilities exposed to public health hazards and greater population concentrations (often found in special needs facilities and businesses) put more people at risk. During a disease outbreak those in the immediate isolation area would have little to no warning, whereas, the population further away in the dispersion path may have some time to prepare and mitigate against disease depending on the hazard, its transmission, and public notification.

MULTI-JURISDICTIONAL DIFFERENCES

Due to the nature of public health hazards, jurisdictions within Arapahoe County with higher numbers of vulnerable individuals are expected to be impacted to a greater extent than others. In the context of extreme temperature events, the most vulnerable members of Arapahoe County are:

- The elderly (people over 65 years of age)
- Children (under 5 years old)
- The infirm

The communities of Bow Mar, Columbine Valley, Cherry Hills Village, Centennial, Deer Trail, Englewood, Foxfield, Greenwood Village, Littleton, and Sheridan all have higher percentages of elderly residents than the average for the State of Colorado. The communities of Aurora, Bennett, and Sheridan have higher percentage of residents who are children, as compared to the State's average.

Although communities located in the eastern region of Arapahoe County are less populated than most communities located to the west, the largely agricultural area is more susceptible to the impacts of health hazards that affect livestock and plants. In these communities, the spread of a highly destructive livestock disease or plant pest/disease could have devastating consequences to the local economy and environment. Early detection and a rapid response to a pest or disease infestation are critical to limiting the economic, social, and environmental impacts of such an incident.

One of the key responsibilities of the Animal Health Division, a branch of the Colorado Department of Agriculture, is to prepare for, control, and mitigate livestock disease outbreaks. The division has a number of preparedness and response plans for the various livestock sectors in Colorado. The sectors and their associated plans include:

- *Cow-Calf* – Emergency Disease Response Plan (Nov. 2010)
- *Dairy* – Emergency Disease Response Plan (Aug. 2010)
- *Dairy Industry Manual* – Foreign Animal Disease Preparedness and Response Plan: National Animal Health Emergency Management System (March 2011)
- *Feedlot* – Emergency Disease Response Plan (Nov. 2010)
- *Feedlot Industry Manual* –- Foreign Animal Disease Preparedness and Response Plan: National Animal Health Emergency Management System (May 2011)
- *Poultry* – Colorado Department of Agriculture Poultry Emergency Disease Plan
- *Swine* – Emergency Disease Response Plan (Aug. 2010)
- *Swine Industry Manual* – Foreign Animal Disease Preparedness and Response Plan: National Animal Health Emergency Management System (March 2011)

As stated in Colorado Revised Statutes (CRS) 35-50-105, "The Commissioner of the Colorado

Department of Agriculture is responsible for regulation related to livestock disease or other livestock emergencies among or affecting livestock in the state." As such, the CDA will serve as the State's lead agency during an outbreak of a highly contagious disease affecting livestock in Colorado. Although CDA serves as the lead agency during an animal disease outbreak in Colorado, natural disasters, such as blizzards, floods or wildland fires, affecting livestock are managed at the local level. When local resources reach their capacity in responding to natural disasters, counties may request assistance from the State of Colorado. The State may earmark specific funds to assist local response.

Since local resources are limited, beef producers are encouraged to work with their local emergency manager on how to better prepare their operations for an animal emergency. County emergency managers can assist producers with developing animal emergency response plans for their premises. Additionally, emergency managers can assist with coordinating resources between beef producers – neighbor helping neighbor. History has repeatedly shown the effectiveness of neighbor helping neighbor during an animal health emergency. When responding to a natural disaster or an outbreak of a highly contagious disease in cattle, local area producers will be immediately informed of the situation and may become a critical response component by providing resource provisions and communicating the threat to area neighbors.

Plant Pest and Disease Emergency Response Plan (Sept. 2010)

The Colorado Department of Agriculture (CDA) Plant Pest and Disease Emergency Response Plan provides the response actions that will be implemented by the CDA in collaboration with the United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS), Plant Protection Quarantine (PPQ), other state and federal agencies, and industry partners to swiftly detect, assess, and eradicate a critical plant pest and disease infestation in Colorado.

For the purpose of this document the term "rapid response" is defined as a series of coordinated activities involving one or more organizations that are initiated by the discovery of a plant pest or disease of concern. Rapid response actions may include, delimiting survey activities, specific control activities, quarantine, eradication, public outreach and education and inter-agency communication and coordination.

1.1 Purpose & Scope

The purpose of this document is to outline an effective rapid response to the detection, identification, and mitigation of a plant pest or disease incursion in Colorado. The goal of this plan is three-fold: to prevent the establishment and spread of plant pest or disease before the population becomes established; to provide effective and timely communication between local, regional, state and federal government agencies, academia, and plant industry professionals when response actions are needed; and, to protect and maintain business continuity on unaffected property during a plant health emergency.

1.4 Legal Authority

As stated in Colorado Revised Statutes (CRS) 35-4-101.5, “The Commissioner of Agriculture is directed and authorized to control and prevent by such means as shall be prescribed and provided by law, rule, or order of the commissioner, all contagious, infectious, and plant pests destructive to the state's agricultural, forestry, or horticultural interests or to the state's general environmental quality”. As such, during an emergency incident, any actions implemented by the CDA will be in accordance with the authority granted to the Commissioner of Agriculture in the Colorado Revised Statutes (CRS). CRS related to plant pest and diseases are listed below (see Appendix C for additional information on CRS as they relate to a plant pest or disease emergency response):

State Authority

- CRS 35-4, Pest Control Act
- CRS 35-5, Pest Control District
- CRS 35-26, Colorado Nursery Act
- CRS 35-27, Colorado Seed Act
- Federal Authority
- Federal Plant Protection Regulations ,Code of Federal Regulations (CRF 300-399)
- Plant Protection Act of 2000, Public Law 106-244
- Agriculture Bioterrorism Protection Act of 2002, Public Law 107-188
- Other Agreements
- CDA/USDA-APHIS-PPQ Cooperative Pest Control Memorandum of Understanding

HIRA SUMMARY

Preparing for, responding to, and recovering from pandemic influenza will require a strategy that includes a holistic suite of public health activities designed to lessen the impact on morbidity and mortality. These activities include education, vaccination, prophylaxis, isolation/quarantine, and the closure of public facilities. In addition, clear, concise communication with the public, within the Tri-County Health Department, and with other agencies remains a critical component, as does the ability of the involved agencies to achieve collaboration and coordination. By its very nature, an influenza pandemic, once started, will not be stopped until it has run its course. This course can be shortened and weakened by a number of factors, with vaccination being the gold standard for protecting the population. Pandemic plans describe strategies of preparedness, response, and recovery to attempt to decrease illnesses and deaths during the pandemic period to manageable levels (i.e., that do not overwhelm the critical infrastructures of the State), and to promote community resiliency and rapid recovery.

The Colorado Department of Public Health and Environment has developed a number of resources related to pandemic health hazards to supplement the State Emergency Operations Plan. Listed below are a number of pandemic response plans, health alert networks, and resources currently available for residents and planners in the State of Colorado and Arapahoe County.

Table 78. Influenza Planning Resources and Guidelines

Title	Agency
Pandemic Influenza Action Plan for Schools (2009)	Colorado Department of Public Health and Environment
Infectious Diseases in Child Care and School Settings: Guidelines for Childcare Providers, School Nurses and Other Personnel (2013)	Colorado Department of Public Health and Environment
Pandemic Influenza Planning Guidelines for Hospitals (2009)	Colorado Department of Public Health and Environment
Home Care Guide: Providing Care at Home During Pandemic Flu (2009)	Colorado Department of Public Health and Environment
Guidelines for Medical Office Pandemic Readiness (2007)	Colorado Department of Public Health and Environment
Social Distancing Support Guidelines for Pandemic Readiness (2008)	Colorado Department of Public Health and Environment
Colorado Health Alert Network (HAN)	Colorado Department of Public Health and Environment

Where necessary, details or public information templates unique to pandemic influenza have been included in the plans listed above. The guidelines and plans provide background information related to pandemic influenza and infectious diseases, outline concepts of operations for response, list primary and support functional areas, and outline available resources and tools to mitigate a pandemic and promote community resilience recovery.

Ongoing mitigation activities should focus on preventing infection during flu season. This includes, but is not limited to pre-season community outreach campaigns to educate the public about risks and available support; establishing convenient vaccination centers; reaching out to vulnerable populations and care givers; and issuing advisories and warnings.

SEVERE STORMS

(Lightning, Hail, and Snow)

NATURAL HAZARDS	PROBABILITY	IMPACT	SPATIAL EXTENT	WARNING TIME	DURATION	RF RATING
SEVERE STORM	4 (1.1)	2 (0.5)	3 (0.6)	2 (0.2)	2 (0.2)	**2.7**
HIGH RISK HAZARD (2.5 and higher)						

HAZARD IDENTIFICATION

Severe storms can occur during any season in Arapahoe County. Lightning strikes can all be hazardous under the right conditions and locations. Large hail can damage crops, dent vehicles, break windows, and injure or kill livestock, pets, and people. Snow storms can take down trees and damage property and infrastructure.

Thunderstorms affect relatively small areas when compared with the size of typical winter storms. Despite their small size, all thunderstorms are dangerous. The typical thunderstorm is 15 miles in diameter and lasts an average of 30 minutes. Of the estimated 100,000 thunderstorms that occur each year in the United States, about 10 percent are classified as severe. The National Weather Service considers a thunderstorm severe if it produces hail at least 3/4 inch in diameter, winds of 58 MPH or stronger, or a tornado. Every thunderstorm needs three basic components: (1) moisture to form clouds and rain, (2) unstable air which is warm air that rises rapidly, and (3) lift, which is a cold or warm front capable of lifting air to help form thunderstorms.

Lightning, although not considered severe by the National Weather Service definition, can accompany heavy rain during thunderstorms. Lightning develops when ice particles in a cloud collide with other particles. These collisions cause a separation of electrical charges. Positively charged ice particles rise to the top of the cloud and negatively charged ones fall to the middle and lower sections of the cloud. The negative charges at the base of the cloud attract positive charges at the surface of the Earth. Invisible to the human eye, the negatively charged area of the cloud sends a charge called a stepped leader toward the ground. Once it gets close enough, a channel develops between the cloud and the ground. Lightning is the electrical transfer through this channel. The channel rapidly heats to 50,000 degrees Fahrenheit and contains approximately 100 million electrical volts. The rapid expansion of the heated air causes thunder.

Hail is precipitation that is formed when updrafts in thunderstorms carry raindrops upward into extremely cold areas of the atmosphere. The super cooled raindrops grow into balls of ice, which pose a hazard to property, people, livestock, and crops when they fall back to the earth.

Severe winter weather can cause hazardous driving conditions, communications and electrical power failure, community isolation, and can adversely affect business continuity. This type of snow-related weather may include one or more of the following winter factors:

Blizzards, as defined by the National Weather Service, are a combination of sustained winds or frequent gusts of 35 mph or greater and visibilities of less than a quarter mile from falling or blowing snow for 3 hours or more. A blizzard, by definition, does not indicate heavy amounts of snow, although they can happen together. The falling or blowing snow usually creates large drifts from the strong winds. The reduced visibilities make travel, even on foot, particularly treacherous. The strong winds may also support dangerous wind chills. Ground blizzards can develop when strong winds lift snow off the ground and severely reduce visibilities.

Figure 47. A photo of Centennial Airport after a 1980s blizzard

Heavy snow, in large quantities, may fall during winter storms. Six inches or more in 12 hours or eight inches or more in 24 hours constitutes conditions that may significantly hamper travel or create hazardous conditions. The National Weather Service issues warnings for such events. Smaller amounts can also make travel hazardous, but in most cases, only results in minor inconveniences. Heavy wet snow before the leaves fall from the trees in the fall or after the trees have leafed out in the spring may cause problems with broken tree branches and power outages.

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

Extreme Cold, in extended periods, although infrequent, could occur throughout the winter months in Arapahoe County. Heating systems compensate for the cold outside. Most people limit their time outside during extreme cold conditions, but common complaints usually include pipes freezing and cars refusing to start. When cold temperatures and wind combine, dangerous wind chills can develop.

Addition information pertaining to extreme cold can be found in the Extreme Temperatures section of the Plan.

HAZARD PROFILE: LIGHTNING

The following Figure depicts average cloud-to-ground lightning incidence in the US (or lightning flash densities) between 1997 and 2012.

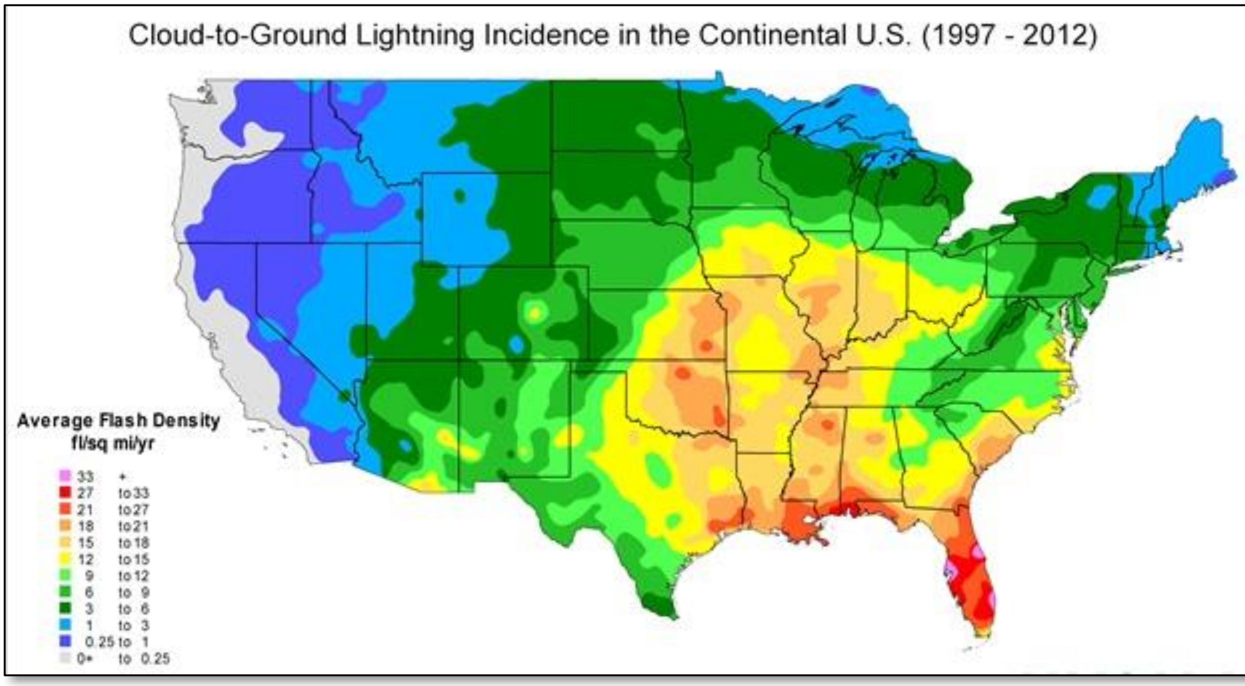


Figure 48. Average Lightning Flash Density in the U.S.[25]

Although the state of Colorado ranks 32nd in terms of its cloud-to-ground lightning flash densities between 1997-2012, the state ranks 2nd in the country in terms of death rate from lightning per million people (between 2003 - 2012). Colorado's lightning death rate per million people from 2003-2012 is 0.51, second only to the state of Wyoming.

The following figure shows lightning flash densities for the State of Colorado for the years 1994 through 2011. Produced by National Weather Service, using data from Vaisala, the image is the result of contouring over 8 million cloud-to-ground lightning flashes for the State of Colorado and averaging annually. The result of the analysis is a picture of average lightning flashes/km^2 per year from 1994 through 2011 (the year 2000 was not included in the dataset).

[25] Source: http://www.lightningsafety.noaa.gov/statistics.htm0

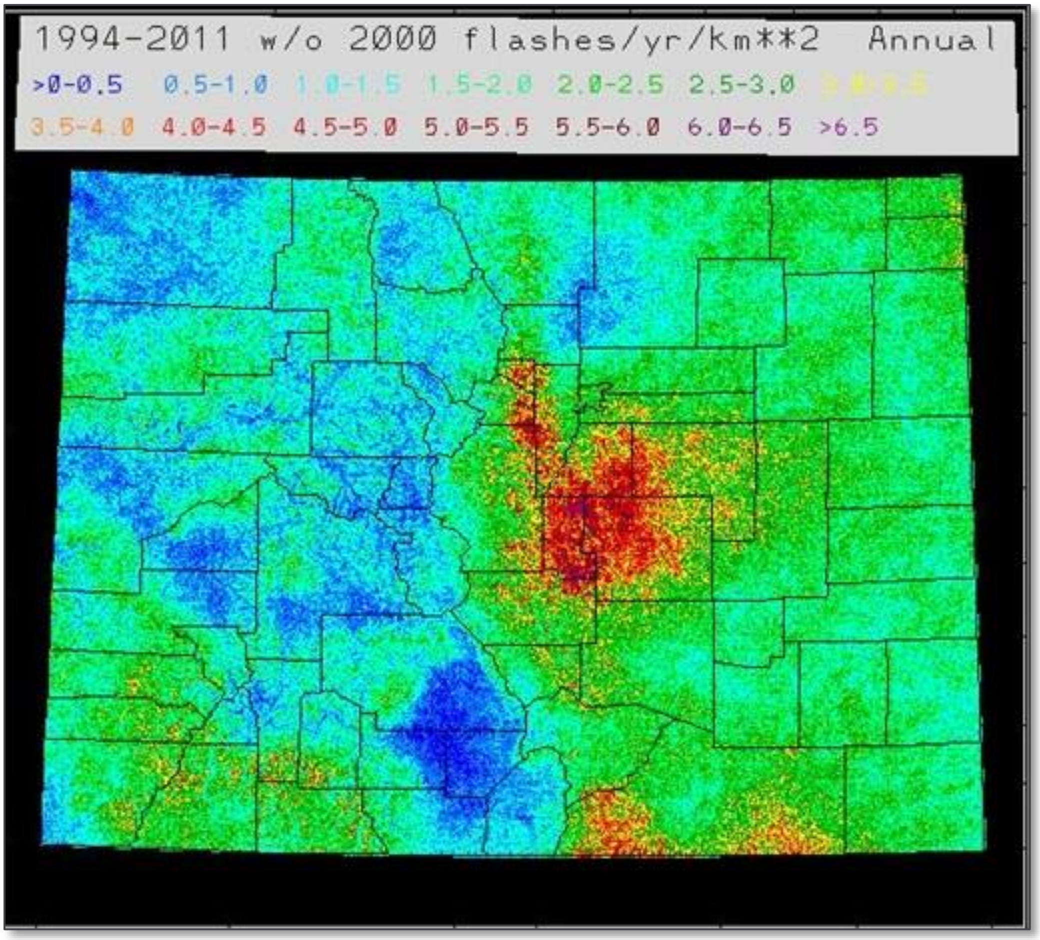


Figure 49. Colorado Lightning Flash Density Map

In general, the flash density map shows a wide range of values across the State of Colorado, ranging from less than 0.5 flashes/year/km^2 over the south central portion of the state to over 6.5 flashes/year/km^2 over the east central part of the state (including the western portion of Arapahoe County). The higher density of lightning flashes located in the central area of the state is driven by the topography of the area. Where the higher terrain of the Plains intersects with the Rocky Mountains conditions are ripe for lightning events. Here, moist air from lower altitudes initiates and sustains convection systems as they move off of the mountain slopes, generating thunderstorms. Arapahoe County experiences almost the entire range of flash density, from 1.5 to 6.5 flashes/year/ km^2.

Except in cases where significant forest or range fires are ignited, lightning generally does not result in disasters. Data from NOAA's NCDC Storm Events Database was used to complete the lightning risk assessment for Arapahoe County. Currently, the Storm Events Database only includes lightning events that result in a fatality, injury and/or property or crop damage. Below is a list of the reported lightning strikes for Arapahoe County since 1996.

Table 79. Lightning Strikes in Arapahoe County (1960 -2013)

JURISDICTION AFFECTED	DATE OF EVENTS	# OF INJURIES	# OF FATALITIES	RECORDED PROPERTY DAMAGES	RECORDED CROP DAMAGES
Arapahoe County	6/29/2011	2	0	0	0
Arapahoe County	6/20/2011	0	0	$50,000	0
Arapahoe County	7/21/2011	0	0	$70,000	0
Arapahoe County	7/14/2011	0	0	$50,000	0
Arapahoe County	8/16/2010	1	0	0	0
Arapahoe County	8/8/2010	0	0	$100,000	0
Arapahoe County	7/3/2009	6	0	0	$1,000
Arapahoe County	8/3/2009	0	0	0	0
Arapahoe County	9/9/2009	1	0	0	0
Arapahoe County	2/2/2008	0	0	$1,000	0
Arapahoe County	8/15/2008	0	0	$20,000	0
Arapahoe County	8/25/2008	0	0	$75,000	0
Arapahoe County	4/28/2001	1	0	0	0
Arapahoe County	5/29/2001	0	0	$100,000	0
Arapahoe County	6/13/2001	0	0	0	0
Arapahoe County	8/16/2000	0	0	$250,000	0
Arapahoe County	8/8/2000	0	0	$47,000	0
Arapahoe County	7/19/1999	0	0	$30,000	0
Arapahoe County	July, 1999	0	0	0	0
Arapahoe County	August, 1999	0	0	0	0

JURISDICTION AFFECTED	DATE OF EVENTS	# OF INJURIES	# OF FATALITIES	RECORDED PROPERTY DAMAGES	RECORDED CROP DAMAGES
Arapahoe County	7/25/1998	1	0	0	0
Arapahoe County	July, 1998	0	0	0	0
Arapahoe County	July, 1998	0	0	0	0
Arapahoe County	7/30/1997	0	0	$75,000	0
Arapahoe County	6/24/1996	0	0	$1,000	0
Arapahoe County	3/5/1990	0	0	$166,666	0
Arapahoe County	7/7/1967	0	0	$125,000	0
TOTAL:		**12**	**0**	**$849,000**	**$1,000**

Source: NOAA, NCDC Storm Events Database; SHELDUS

For the period of 1996 to 2013, NOAA reported 12 injuries, 0 fatalities, and over eight hundred thousand dollars in damage in Arapahoe County. Reported lightning strikes over the past 53 years provide an acceptable framework for determining the future occurrence in terms of frequency for such events. The probability of the County and its municipalities experiencing a lightning strike associated with damages or injury can be difficult to quantify, but based on historical record of 27 reported lightning strikes since 1960 that have either caused damages to buildings and infrastructure or resulted in an injury or death, it can reasonably be assumed that this type of event has occurred once a year from 1996 through 2013.

[(Current Year) 2013] subtracted by [(Historical Year) 1960] = 53 Years on Record

[(Years on Record) 53] divided by [(Number of Historical Events) 27] = 1.9

Based on reported historic frequency there is a 50% chance of this type of event occurring each year in Arapahoe County.

HAZARD PROFILE: HAIL

Hailstorms form during thunderstorms, and Colorado has more thunderstorm days than any state other than Florida. Specifically, northeastern Colorado gets more hail each year than any other part of the county. Hail develops in thunderstorms between strong currents of rising air (aka updrafts) and currents of air descending toward the ground (aka downdrafts). When updrafts carry water droplets to a height where freezing occurs, the super cooled droplets collect layers of ice and continue to grow, sustained by the updraft. Once the hail stone cannot be held up any longer by the updraft, it falls to the ground. The following table provides a size reference chart for hail stones.

Table 80. Size Reference Chart for Hail

COMMON OBJECT	SIZE IN DIAMETER
Pea	0.25 Inch
Penny or Dime	0.75 Inch
Quarter	1.00 Inch
Half Dollar	1.25 Inch
Golf Ball	1.75 Inch
Tennis Ball	2.50 Inch
Baseball	2.75 Inch
Grapefruit	4.00 Inch

According to a June 25, 2013, report released by the National Insurance Crime Bureau, hail loss claims in the U.S. increased 84% from 2010 through 2012. During that time, multiple hailstorms have caused billions of dollars' worth of damage across the U.S. and peak losses coincide with the peak agricultural seasons. Severe hailstorms also cause considerable damage to buildings and automobiles, but rarely result in loss of life.

Colorado's hail season is considered to be from mid-April to mid-August. In the last 10 years, hailstorms have caused more than $3 billion in insured damage in Colorado. According to the Rocky Mountain Insurance Information Association, most Colorado residents can expect three to four "catastrophic" hailstorms every year ("catastrophic" storms are defined as causing at least $25 million in insured damages). As a result, up to one-half of local homeowners insurance premiums are going to hail and wind damage costs. The following table documents the most costly hail storms in the State on record.

Table 81. Colorado's Most Costly Hail Storms

Date	Location	Cost When Occurred (Millions)	2013 Dollars (Millions)*
July 20, 2009	Denver Metro	$767.6	$833.5
July 11, 1990	Denver Metro	$625.0	$1.1 Billion
June 6-15, 2009	Denver Metro	$353.3	$381.2
June 6-7, 2012	CO Front Range	$321.1	>$1 Billion
June 13-14, 1984	Denver Metro	$276.7	$620.3

July 29, 2009	Pueblo	$232.8	$252.7
October 1, 1994	Denver Metro	$225.0	$353.6
May 22, 2008	Windsor	$193.5	$209.3
July 13, 2011	CO Front Range	$164.8	$170.6
June 8-9, 2004	Denver Metro	$146.5	$180.6
August 11, 1997	Denver Metro	$128.0	$185.7
May 22, 1996	Denver Metro	$122.0	$181.1

*2013 estimated cost calculations based on the Consumer Price Index
Source: Rocky Mountain Insurance Information Association

In June 2012, the state of Colorado experienced over $1.0 billion in damages due to hail. Insurance claims were filed for roof, window, and vehicle damage. Large hail can damage structures, break windows, dent vehicles, ruin crops, and kill or injure people and livestock. Based on past occurrences, hail sizes greater than three inches in diameter are possible and should be accounted for in future planning activities.

The following map shows previous hail events in Arapahoe County from 1996 – 2013. Graduated symbols have been used to illustrate the relative size of the recorded hail events. Within the boundaries of Arapahoe County, the largest hail stones reported were 4.25 inches in diameter.

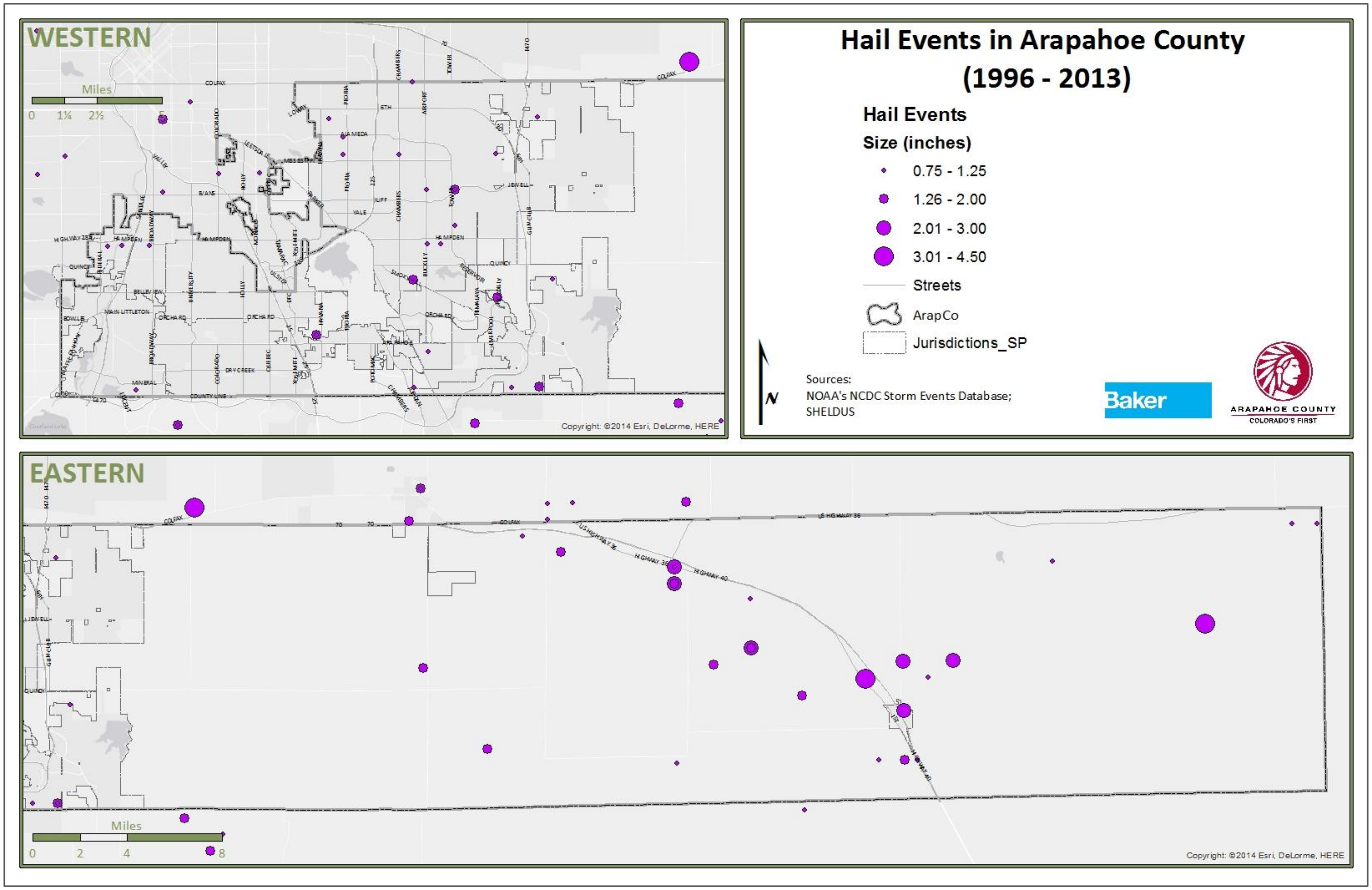


Figure 50. Historic Hail Events in Arapahoe County (1996 – 2013)

Data from NOAA's NCDC Storm Events Database was used to complete the historical mapping and hail risk assessment for Arapahoe County. Currently, the Storm Events Database does not include "non-severe" hail events, which includes measured hail diameters below ¾ of an inch that do not result in injuries, fatalities, or significant damage. Below is a list of the reported hail events for Arapahoe County since 1960. There have been 230 recorded hail events reported within Arapahoe County and its municipalities since 1990. Of those 230 hail events, 10 events were reported as causing property and/or crop damage (detailed in the following Table). None of the hail events reported in Arapahoe County resulted in death.

Table 82. Damaging Hail Events in Arapahoe County (1960 - 2014)

MONTH, YEAR	MAGNITUDE (INCHES)	DEATHS	INJURIES	PROPERTY DAMAGE	CROP DAMAGE
June, 2012	1.00	0	0	$160.0 million	-
June, 2012	2.50	0	0	$161.1 million	-
June, 2009	3.00	0	0	$161.0 million	-
August, 2009	1.25	0	0	-	$25,000
August, 2009	1.50	0	0	$15,000	-
July, 2008	1.75	0	0	$5,000	-
July, 2001	1.50	0	0	$606,000	$6,000
October, 1998	--	0	0	$87.8 million	-
May, 1991	--	0	0	$60.00 million	-
July, 1990	--	0	2	$69.4 million	-
August, 1985	--	0	1	$277,777	-
July, 1967	--	0	0	$125,000	-
July, 1960	--	0	1	$71,428	$714
	TOTAL:	**0**	**2**	**$699.6 million**	**$31,000**

*Source: SHELDUS; NOAA, NCDC Storm Events Database

Reported hail events over the past 24 years provide an acceptable framework for determining the future occurrence in terms of frequency for similar events. The probability of the County and its municipality experiencing a hail event associated with damages or injury can be difficult to quantify, but based on historical record of 10 hail events since 1990 that have either caused damages to buildings and infrastructure or resulted in an injury or death, it can reasonably be assumed that this type of event has occurred once every two and a half years from 1990 through 2014.

[(Current Year) 2013] subtracted by [(Historical Year) 1960] = 53 Years on Record

[(Years on Record) 53] divided by [(Number of Historical Events) 10] = 5.3

The historic frequency calculates that there is a 20% chance of a damaging hail event occurring each year.

HAZARD PROFILE: SNOW STORMS

The analysis of NCDC and SHELDUS records for heavy snow, winter storm, and winter weather events reveal that snow storms are frequent in the Arapahoe County region, with more than 71 reported events between 1983 and 2013. These 71 events were responsible for 6 deaths, 6 injuries, approximately $7.8 million in property damage, and $300,000 in crop damage over a thirty year period.

Snow storms occur frequently and can have a significant impact on Arapahoe County's vulnerable populations. All areas of Arapahoe County are assumed to have the same snow storm risk. Heavy snow can result in the closing of primary and secondary roads, particularly in rural locations, loss of utility services, and depletion of oil heating supplies. Environmental impacts often include damage to shrubbery and trees due to heavy snow loading, ice build-up, and/or high winds which can break limbs or even bring down large trees. Gradual melting of snow and ice provides excellent groundwater recharge; however, high temperatures following a heavy snowfall can cause rapid surface water runoff and severe flash flooding. Significant snow events that have affected the Denver Metro Area in the past include:

- November 1983 – Extreme cold temperatures as low as -21°F were accompanied by a prolonged snowstorm that dumped over 21 inches of snow on the regions.
- November 1991 – A large snowstorm dumped over 21 inches of snow.
- October 1997 – An October blizzard dumped over 31 inches of snow in the region, leaving 4,000 travelers stranded at the Denver International Airport. A state of emergency was declared for Colorado.
- December 1998 – Extreme cold temperatures across the region led to power outages, cracked water pipes, and a number of deaths and injuries. Temperatures dipped below 0°F, with a low of -19°F for six consecutive days.
- April 2001 – Severe spring snow, high winds and ice led to snapped power poles and downed power lines. Many residents and businesses were left without power. DIA lost power over two consecutive weekends.

- March 2003 – Largest snowstorm in the Denver Metro region since 1946. 31.8 inches of snow was reported.
- December 2006 – Extreme cold temperatures and multiple snow storms created ice build-up on local streets. Over 20 inches of snow accumulated and led to the closure of the airport, grocery stores, and the US mail service at the height of holiday travel. A state-wide disaster was declared.

Figure 51. Cherry Creek Dam Road, 1980s blizzard

The table below shows the history of significant winter storms and blizzards in Arapahoe County since 1960. “Significant” winter storm, winter weather, and blizzard events are included in the NCDC Storm Events Database if the event has more than one significant hazard (i.e., heavy snow and blowing snow; snow and ice; snow and sleet; sleet and ice; or snow, sleet, and ice) and meets or exceeds locally/regionally defined twelve or twenty-four hour warning criteria for at least one of the precipitation elements on a widespread or localized basis. According to data (provided by the National Climatic Data Center and SHELDUS) there are consistently two to three significant snow storm events recorded in Arapahoe County each year.

Table 83. Winter Storm Events in Arapahoe County (1960 - 2013)

EVENT TYPE	MONTH, YEAR	INJURIES	DEATHS	PROPERTY DAMAGE	CROP DAMAGE
Winter Storm	March, 2013	0	0	-	-
Blizzard	February, 2013	1	2	$6,200,000	-
Winter Weather	December, 2012	0	0	-	-
Winter Weather	November, 2012	0	0	-	-
Winter Storm	February, 2012	0	0	-	-
Winter Weather	December, 2011	0	0	-	-
Winter Storm	November, 2011	0	0	-	-
Winter Storm	October, 2011	0	0	-	-
Winter Weather	January, 2011	0	0	-	-
Winter Weather	December, 2010	0	0	-	-
Winter Weather	November, 2010	0	0	-	-
Winter Storm	March, 2010	0	0	-	-
Winter Weather	December, 2009	0	0	-	-
Winter Storm	November, 2009	0	0	-	-
Winter Storm	October, 2009	0	0	-	-
Blizzard	April, 2009	0	0	-	-
Winter Weather	March, 2009	2	2	-	-
Winter Storm	April, 2008	0	0	-	-
Winter Storm	December 2007	0	0	-	-
Blizzard	February, 2007	0	0	-	-

EVENT TYPE	MONTH, YEAR	INJURIES	DEATHS	PROPERTY DAMAGE	CROP DAMAGE
Blizzard	January, 2007	0	0	-	-
Blizzard	December, 2006	0	0	-	-
Winter Storm	October, 2005	0	0	-	-
Blizzard	April, 2005	0	0	-	-
Winter Storm	March, 2005	0	0	-	-
Blizzard	February, 2004	0	0	-	-
Winter Weather	March, 2003	1	2	$6,200,000	-
Heavy Snow	January, 2002	0	0	-	-
Heavy Snow	March, 2002	0	0	-	-
Heavy Snow	February, 2001	0	0	-	-
Heavy Snow	March, 2001	0	0	-	-
Heavy Snow	January, 2001	0	0	-	-
Heavy Snow	May, 2001	0	0	-	-
Winter Storm	April, 2001	0	0	-	-
Winter Weather	April, 2001	0	0	$344,444	-
Heavy Snow	March, 2000	0	0	-	-
Winter Weather	February, 1995	0	0	$40,697	-
Winter Weather	February, 1989	1	0	$79,365	$79,365
Winter Weather	December, 1987	0	0	$55,555	-
Winter Weather	April, 1986	1	0	$38,461	$38,461
Winter Weather	March, 1983	0	0	$26,315	-

EVENT TYPE	MONTH, YEAR	INJURIES	DEATHS	PROPERTY DAMAGE	CROP DAMAGE
Winter Weather	December, 1982	0	0	$793,651	$7,936
Winter Weather	March, 1977	1	0	$172,413	$172,413
Winter Weather	April, 1972	0	0	$33,333	-
	TOTALS:	**7**	**6**	**$13,984,234**	**$298,175**

Source: SHELDUS; NCDC

Severe winter storms can be predicted with a reasonable level of uncertainty. Through the identification of various indicators of weather systems, and by tracking these indicators, warning time for snow storms can be as much as a week in advance. Understanding the historical frequency, duration, and spatial extent of severe winter weather assists in determining the likelihood and potential severity of future occurrences. The characteristics of past severe winter events provide benchmarks for projecting similar conditions into the future. The probability that Arapahoe County will experience a severe winter storm event can be difficult to quantify, but based on historical record of forty-four events since 1960, this type of event has occurred once every year since data collection began.

[(Record Year) 2013] subtracted by [(Historical Year) 1960] = 53 Years on Record

[(Years on Record) 53] divided by [(Number of Historical Events) 44] = 1.2

Furthermore, the historic frequency calculates that there is an 85% chance of this type of event occurring each year.

CLIMATE CHANGE IMPACTS

As a result of global climate change, the United States is already experiencing more intense rain and snowstorms. The amount of snow falling in the heaviest one percent of storms has risen nearly 74%, averaged nationally, between 1958 and 2011.[26] As Arapahoe County prepares for regional changes in climate, it will be important to consider scenarios in which larger amounts of snow will fall over shorter periods of time. The impacts have the potential to affect infrastructure, public safety, and the local economy in a diversity of ways.

INVENTORY ASSETS EXPOSED

Inventory assets exposed to severe storms is dependent on the age of the building, type, construction material used, and condition of the structure. Probably the greatest issue for critical facilities during

[26] *Third U.S. National Climate Assessment*, 2014. U.S. Global Change Research Program.

significant Seasonal Weather Extremes is the inaccessibility of such facilities due to poor roadways and utility outages. Possible losses to critical infrastructure include:

- Electric power disruption
- Communication disruption
- Water and fuel shortages
- Road closures
- Damaged infrastructure components, such as sewer lift stations and treatment plants

Debris may also block roadways making transportation and commerce difficult if not impossible. Those facilities with back-up generators are better equipped to handle a severe weather situation should the power go out.

An extended power outage during winter may make many homes and offices unbearably cold. With poor road conditions, sheltering residents may present significant logistical challenges with getting people to heated facilities, feeding, and providing medical care. These situations, accompanied by stranded motorists that need to be rescued, represent significant threats to the population. Additional information on construction type and building codes enforced at time of construction would allow a more thorough assessment of the vulnerability of structures to severe storm impacts such as severe wind or snow loads.

All assets located in Arapahoe County can be considered at risk from severe storms. This includes 602,868 people, or 100% of the County's population and all buildings and infrastructure within the County. Damages primarily occur as a result of high winds, lightning strikes, hail, snow loading, and flooding. Most structures, including the county's critical facilities, should be able to provide adequate protection from hail but the structures could suffer broken windows and dented exteriors. Those facilities with back-up generators are better equipped to handle a severe weather situation should the power go out.

POTENTIAL LOSSES

Severe storms affect the entire planning area of Arapahoe County and its jurisdictions including all above-ground structures and infrastructure. Although losses to structures are typically minimal and covered by insurance, there can be impacts with lost time, maintenance costs, and contents within structures. A timely forecast may not be able to mitigate the property loss, but could reduce the casualties and associated injury.

It appears possible to forecast these extreme events with some skill, but further research needs to be done to test the existing hypothesis about the interaction between the convective storm and its environment that produces the extensive swath of high winds. Severe storms will remain a highly likely occurrence for Arapahoe County. It is likely that lightning and hail will also be experienced in the area due to such storms.

LAND USE & DEVELOPMENT TRENDS

All future structures built in Arapahoe County will likely be exposed to severe weather extremes and damage. Since the previous statement is assumed to be uniform countywide, the location of development does not increase or reduce the risk necessarily. Arapahoe County and its jurisdictions must adhere to building codes, and therefore, new development can be built to current standards to account for adverse weather. Additionally, as homes go up in more remote parts of the county, accessing those rural residents may become impossible should sheltering or emergency services be needed in an extreme event.

MULTI-JURISDICTIONAL DIFFERENCES

Each municipality in the County has an equal susceptibility to severe weather as profiled in this section. Forecasts are associated with varying degrees of uncertainty and it is a great challenge to pinpoint exactly where, when, and to what extent a thunderstorm or other severe weather event will cause damage. However, we know that thunderstorm events, with high wind and dangerous lightning, are highly possible throughout the county. These storms are prominent in the early spring and continue through late fall (as shown in the deadly November 2002 series of storms). If located in a densely populated area of the county, it is easy to estimate damages in the millions of dollars from these events.

HIRA SUMMARY

Arapahoe County is subject to severe storms ranging from thunderstorms to hail storms to blizzards. These hazards have the potential to trigger secondary hazards including flash flooding, downbursts, and debris flows and can disrupt commerce and transportation and often result in loss of life due to accidents or hypothermia. Mitigation measures may include enhanced building codes, planned deployment of resources, underground utility lines for critical facilities, and increased tree trimming along utilities.

Mitigation of building damage from severe storms has been most successful in places where strict building codes and designated special flood hazard areas have been adopted and enforced by local governments and complied with by builders. Pre-disaster mitigation efforts for the impacts of severe storms also include buyout programs, relocation efforts, structural elevations, improved open-space preservation, and holistic land use planning within high-risk areas. Due to the significant risk from severe storms, Arapahoe County will remain proactive in its mitigation efforts to help build resilience throughout the County.

SEVERE WIND/TORNADO

NATURAL HAZARDS	PROBABILITY	IMPACT	SPATIAL EXTENT	WARNING TIME	DURATION	RF RATING
Severe Wind/Tornado	3 (0.8)	2 (0.6)	2 (0.4)	4 (0.4)	1 (0.1)	**2.3**
MODERATE RISK HAZARD (2.0 – 2.5)						

HAZARD IDENTIFICATION

Tornadoes in Colorado are most often generated by thunderstorm activity when cool, dry air intersects and overrides a layer of warm, moist air forcing the warm air to rise rapidly. The damage caused by a tornado is a result of high wind velocities and wind-blown debris. According to the National Weather Service, tornado wind speeds can range between 30 to more than 300 miles per hour. They are more likely to occur during the spring and early summer months of March through June and are most likely to form in the late afternoon and early evening. Most tornadoes are a few dozen yards wide and touchdown briefly, but even small, short-lived tornadoes can inflict tremendous damage. Destruction ranges from minor to catastrophic depending on the intensity, size, and duration of the storm. Structures made of light materials such as mobile homes are most susceptible to damage. Each year, an average of over eight hundred tornadoes is reported nationwide, resulting in an average of eighty deaths and fifteen hundred injuries (NOAA, 2002). The majority of Colorado tornados occur in the eastern plains, including all areas of Arapahoe County.

Tornadoes were previously classified by their intensity using the Fujita (F) Scale, with FO being the least intense and F6 being the most intense. The Fujita Scale (seen in the table below) is used to rate the intensity of a tornado by examining the damage caused by the tornado after it has passed over a man-made structure.

Table 84. Fujita Tornado Damage Scale[27]

Fujita Scale			
F-Scale Number	**Intensity Phrase**	**Wind Speed**	**Type of Damage**
F0	Gale tornado	40-72 mph	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages signboards.

[27] Information provided by NOAA at http://www.spc.noaa.gov/faq/tornado/f-scale.html

Fujita Scale			
F-Scale Number	**Intensity Phrase**	**Wind Speed**	**Type of Damage**
F1	Moderate tornado	73-112 mph	The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
F2	Significant tornado	113-157 mph	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.
F3	Severe tornado	158-206 mph	Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted
F4	Devastating tornado	207-260 mph	Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.
F5	Incredible tornado	261-318 mph	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles fly through the air in excess of 100 meters; trees debarked; steel reinforced concrete structures badly damaged.
F6	Inconceivable tornado	319-379 mph	These winds are very unlikely. The small area of damage they might produce would probably not be recognizable along with the mess produced by F4 and F5 wind that would surround the F6 winds. Missiles, such as cars and refrigerators would do serious secondary damage that could not be directly identified as F6 damage. If this level is ever achieved, evidence for it might only be found in some manner of ground swirl pattern, for it may never be identifiable through engineering studies

On February 1, 2007, the Fujita scale was decommissioned in favor of the more accurate Enhanced Fujita Scale (aka the EF Scale). The EF-Scale measures tornado strength and associated damages and classifies tornadoes into six intensity categories, as shown in the following table. The scale was revised to reflect better examinations of tornado damage surveys, so as to align wind speeds more closely with associated storm damage. The new scale takes into account how most structures are designed, and is thought to be a much more accurate representation of the surface wind speeds in the most violent tornadoes.

Table 85. Enhanced Fujita (EF) Scale[28]

Enhanced Fujita (EF) Scale		
Enhanced Fujita Category	**Wind Speed (mph)**	**Potential Damage**
EF0	65-85	**Light damage**: Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over.
EF1	86-110	**Moderate damage**: Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	111-135	**Considerable damage**: Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	136-165	**Severe damage**: Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.
EF4	166-200	**Devastating damage**: Well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.
EF5	>200	**Incredible damage**: Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 m

[28] Source: http://www.spc.noaa.gov/faq/tornado/ef-scale.html

		(109 yds.); high-rise buildings have significant structural deformation; incredible phenomena will occur.

The Storm Prediction Center has developed damage indicators to be used with the Enhanced Fujita Scale for different types of buildings. These indicators can be also be used to classify any high wind event. Indicators for different building types are shown in the following tables.

Table 86. Institutional Buildings

DAMAGE DESCRIPTION	WIND SPEED RANGE (Expected in Parentheses)
Threshold of visible damage	59-88 MPH (72 MPH)
Loss of roof covering (<20%)	72-109 MPH (86 MPH)
Damage to penthouse roof & walls, loss of rooftop HVAC equipment	75-111 MPH (92 MPH)
Broken glass in windows or doors	78-115 MPH (95 MPH)
Uplift of lightweight roof deck & insulation, significant loss of roofing material (>20%)	95-136 MPH (114 MPH)
Façade components torn from structure	97-140 MPH (118 MPH)
Damage to curtain walls or other wall cladding	110-152 MPH (131 MPH)
Uplift of pre-cast concrete roof slabs	119-163 MPH (142 MPH)
Uplift of metal deck with concrete fill slab	118-170 MPH (146 MPH)
Collapse of some top building envelope	127-172 MPH (148 MPH)
Significant damage to building envelope	178-268 MPH (210 MPH)

Source: Storm Prediction Center, 2009

Table 87. Educational Institutions (Elementary Schools, High Schools)

DAMAGE DESCRIPTION	WIND SPEED RANGE (Expected in Parentheses)
Threshold of visible damage	55-83 MPH (68 MPH)
Loss of roof covering (<20%)	66-99 MPH (79 MPH)

Broken windows	71-106 MPH (87 MPH)
Exterior door failures	83-121 MPH (101 MPH)
Uplift of metal roof decking; significant loss of roofing material (>20%); loss of rooftop HVAC	85-119 MPH (101 MPH)
Damage to or loss of wall cladding	92-127 MPH (108 MPH)
Collapse of tall masonry walls at gym, cafeteria, or auditorium	94-136 MPH (114 MPH)
Uplift or collapse of light steel roof structure	108-148 MPH (125 MPH)
Collapse of exterior walls in top floor	121-153 MPH (139 MPH)
Most interior walls of top floor collapsed	133-186 MPH (158 MPH)
Total destruction of a large section of building envelope	163-224 MPH (192 MPH)

Source: Storm Prediction Center, 2009

Table 88. Metal Building Systems

DAMAGE DESCRIPTION	WIND SPEED RANGE (Expected in Parentheses)
Threshold of visible damage	54-83 MPH (67 MPH)
Inward or outward collapsed of overhead doors	75-108 MPH (89 MPH)
Metal roof or wall panels pulled from the building	78-120 MPH (95 MPH)
Column anchorage failed	96-135 MPH (117 MPH)
Buckling of roof purlins	95-138 MPH (118 MPH)
Failure of X-braces in the lateral load resisting system	118-158 MPH (138 MPH)
Progressive collapse of rigid frames	120-168 MPH (143 MPH)
Total destruction of building	132-178 MPH (155 MPH)

Source: Storm Prediction Center, 2009

Table 89. Electric Transmission Lines

DAMAGE DESCRIPTION	WIND SPEED RANGE (Expected in Parentheses)
Threshold of visible damage	70-98 MPH (83 MPH)
Broken wood cross member	80-114 MPH (99 MPH)
Wood poles leaning	85-130 MPH (108 MPH)
Broken wood poles	98-142 MPH (118 MPH)

Source: Storm Prediction Center, 2009

Severe wind can also occur outside of tornadoes, severe thunderstorms, and winter storms. These winds typically develop with strong pressure gradients and gusty frontal passages. The closer and stronger two systems (one high pressure, one low pressure) are, the stronger the pressure gradient, and therefore, the stronger the winds are.

Although severe wind events often garner less attention in the local media than tornados do, damaging straight line winds (or downbursts) can injure and kill animals and humans. **Downburst** winds, which can cause more widespread damage than a tornado, occur when air is carried into a storm's updraft, cools rapidly, and comes rushing to the ground. Cold air is denser than warm air, and therefore, wants to fall to the surface. On warm summer days, when the cold air can no longer be supported up by the storm's updraft, or when an exceptional downdraft develops, the air crashes to the ground in the form of strong winds. These winds are forced horizontally when they reach the ground and can cause significant damage. These types of strong winds can also be referred to as straight-line winds. Downbursts with a diameter of less than 2.5 miles are called microbursts and those with a diameter of 2.5 miles or greater are called macrobursts. A "derecho" is a series of downbursts associated with a line of thunderstorms. This type of phenomenon can extend for hundreds of miles and contain wind speeds in excess of 100 mph.

Figure 52. A tornado touches down in Arapahoe County

HAZARD PROFILE: TORNADO

Colorado, lying just west of "tornado alley," is fortunate to experience less frequent and intense tornadoes than its neighboring states to the east. However, tornadoes remain a significant hazard in the region. Tornadoes are the most intense storm on earth having been recorded at velocities exceeding 315 mph. The phenomena results in a destructive rotating column of air ranging in diameter from a few yards to greater than a mile, usually associated with a downward extension of cumulonimbus clouds.

All portions of Arapahoe County have the potential to be affected by tornadoes. Historically, tornadoes have been relatively small on the EF Scale but F1 tornadoes can still produce dangerous winds up to 112mph. High winds can cause damage to buildings (tearing shingles from roofs, tearing awnings, collapsing structures, etc.).

The following Table summarizes tornado history and damage data for Arapahoe County from 1964 – 2013 collected by the NOAA Storm Prediction Center. Over that time, NOAA's damage reporting methodologies have evolved. Prior to 1996, estimates of property damage from tornados were categorized within the NOAA database by ranges of dollar amounts (0 = unknown; 1< $50, 2 = $50 - $500; 3 = $500 - $5,000; 4 = $5,000 - $50,000; 5 = $50,000 - $500,000; 6 = $500,000 - $5,000,000; 7 = $5,000,000 - $50,000,000; 8 = $50,000,000 - $500,000,000; 9 = $5,000,000,000). From 1996 on, tornado damages were recorded in millions of dollars. A damage value of 0.0 meant damages were under $100,000. Starting in 2007, estimated crop damages were recorded in millions of dollars. In NOAA's database a damage value of 0.0 means that damages were under $100,000.

Table 90. Tornado History in Arapahoe County (1980 – 2012)

DATE	EF SCALE	INJURIES	DEATHS	ESTIMATED PROPERTY DAMAGE	ESTIMATED CROP DAMAGE
1964	1	0	0	$500 - $5,000	unknown
1965	0	0	0	unknown	unknown
1965	1	0	0	< $50	unknown
1965	0	0	0	unknown	unknown
1965	0	0	0	unknown	unknown
1966	0	0	0	unknown	unknown
1967	0	0	0	unknown	unknown
1967	1	0	0	$5,000 - $50,000	unknown
1967	0	0	0	unknown	unknown
1969	0	0	0	unknown	unknown
1969	0	0	0	unknown	unknown
1969	0	0	0	unknown	unknown
1971	0	0	0	unknown	unknown
1974	1	0	0	unknown	unknown
1974	0	0	0	unknown	unknown
1974	0	0	0	unknown	unknown

DATE	EF SCALE	INJURIES	DEATHS	ESTIMATED PROPERTY DAMAGE	ESTIMATED CROP DAMAGE
1975	0	0	0	unknown	unknown
1975	1	0	0	unknown	unknown
1977	0	0	0	unknown	unknown
1978	2	0	0	\$50,000 - \$500,000	unknown
1980	1	0	0	unknown	unknown
1980	1	0	0	unknown	unknown
1982	1	0	0	< \$50	unknown
1982	1	0	0	< \$50	unknown
1982	1	0	0	< \$50	unknown
1983	1	0	0	\$500 - \$5,000	unknown
1983	1	0	0	< \$50	unknown
1984	1	0	0	unknown	unknown
1984	1	0	0	unknown	unknown
1984	1	0	0	unknown	unknown
1984	1	0	0	\$5,000 - \$50,000	unknown
1985	1	0	0	unknown	unknown
1985	1	0	0	unknown	unknown
1985	1	0	0	unknown	unknown
1985	1	0	0	unknown	unknown
1986	2	6	0	\$500,000 - \$5,000,000	unknown
1987	1	0	0	unknown	unknown
1988	0	0	0	unknown	unknown
1988	1	0	0	unknown	unknown
1988	1	0	0	unknown	unknown
1988	1	0	0	unknown	unknown
1989	1	0	0	\$50,000 - \$500,000	unknown
1990	0	0	0	unknown	unknown
1991	0	0	0	unknown	unknown
1991	0	0	0	unknown	unknown
1991	0	0	0	unknown	unknown
1991	1	0	0	unknown	unknown
1991	0	0	0	unknown	unknown
1992	0	0	0	unknown	unknown
1992	0	0	0	unknown	unknown
1992	0	0	0	unknown	unknown
1992	0	0	0	unknown	unknown

DATE	EF SCALE	INJURIES	DEATHS	ESTIMATED PROPERTY DAMAGE	ESTIMATED CROP DAMAGE
1992	0	0	0	unknown	unknown
1992	0	0	0	unknown	unknown
1993	0	0	0	unknown	unknown
1994	0	0	0	unknown	unknown
1994	0	0	0	unknown	unknown
1995	0	0	0	unknown	unknown
1996	2	0	0	$220,000	<$100,000
1998	0	0	0	$100,000	<$100,000
2004	0	0	0	<$100,000	<$100,000
2008	0	0	0	<$100,000	<$100,000
2008	0	0	0	<$100,000	<$100,000
2009	1	2	0	$500,000	<$100,000
TOTALS:		**8**	**0**	--	--

*Source: NOAA; NCDC Storm Events Database

NCDC's Storm Events Database estimates that 64 tornadoes have touched down in, or moved through, Arapahoe County between 1964 and 2013. The following Figure depicts historical tornado tracks and events in and around Arapahoe County. The map illustrates where tornados have touched down (and traveled) between 1964 and 2013. It is important to note that all portions of the County are susceptible to tornado hazard, from the urban western portions to the rural eastern side.

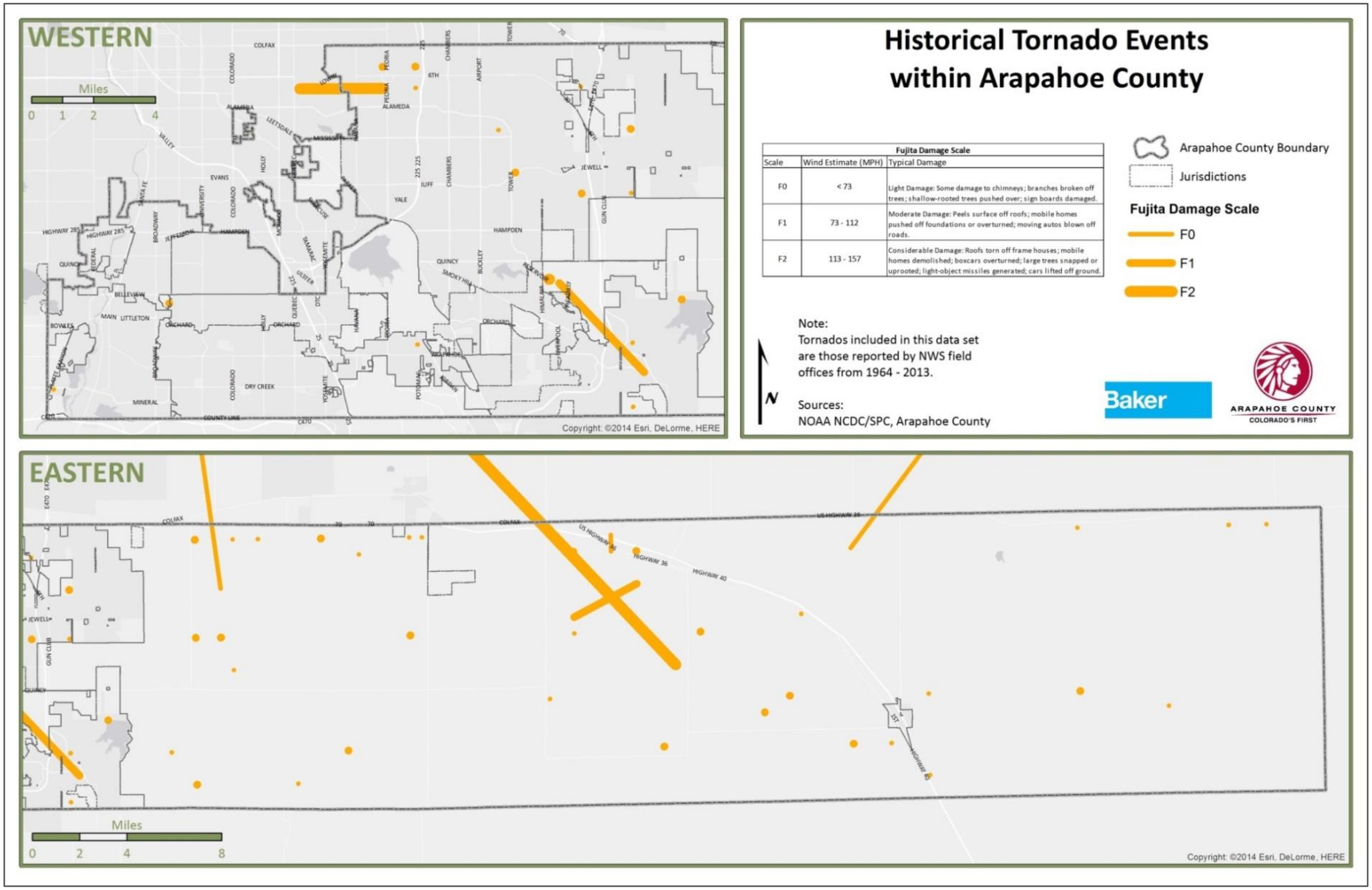


Figure 53. Map of Tornado Events in Arapahoe County (1950 – 2013)

Reported tornadoes over the past forty nine years provide an acceptable framework for determining the future occurrence in terms of frequency for such events. The probability of the County and its municipalities experiencing a tornado associated with damages or injuries can be difficult to quantify, but based on historical record of sixty four tornadoes since 1964 that have either caused damages to buildings and infrastructure or resulted in an injury or death, it can reasonably be assumed that this type of event has occurred once a year between 1964 and 2013.

[(Current Year) 2013] subtracted by [(Historical Year) 1964] = 49 Years on Record

[(Years on Record) 49] divided by [(Number of Historical Events) 64] = 0.77

Furthermore, the historic frequency calculates that there is a 100% chance of this type of event occurring each year.

HAZARD PROFILE: SEVERE WIND

Data from NOAA's NCDC Storm Events Database was used to complete the risk assessment for severe wind events Arapahoe County. Currently, the Storm Events Database only includes wind events that are classified as "Thunderstorm Winds" (including downbursts). These events are defined as winds with speeds of at least fifty knots (58 mph), or winds of any speed (non-severe winds under fifty knots) that result in a fatality, injury and/or damage. The following Table summarizes severe wind history and damage totals in Arapahoe County from 1964 to 2013.

Table 91. Severe Wind Event History in Arapahoe County (1964 – 2013)

DATE	MAGNITUDE (KNOTS)[29]	INJURIES	DEATHS	PROPERTY DAMAGE[30]	CROP DAMAGE[31]
1964-08-25	51	0	0	unknown	0.0
1968-06-23	59	0	0	unknown	0.0
1971-07-27	50	0	0	unknown	0.0
1972-06-23	51	0	0	unknown	0.0
1972-08-17	52	0	0	unknown	0.0
1973-08-14	74	0	0	unknown	0.0
1974-06-23	0	0	0	unknown	0.0
1974-06-23	0	0	0	unknown	0.0
1974-07-05	0	0	0	unknown	0.0
1975-06-27	50	0	0	unknown	0.0
1977-04-10	52	0	0	unknown	0.0

[29] 1 knot = 1.15 mph
[30] Damage numbers and their meaning are detailed in the paragraph following this Table.
[31] Damage numbers and their meaning are detailed in the paragraph following this Table.

DATE	MAGNITUDE (KNOTS)[29]	INJURIES	DEATHS	PROPERTY DAMAGE[30]	CROP DAMAGE[31]
1977-07-08	55	0	0	unknown	0.0
1979-08-30	50	0	0	unknown	0.0
1981-06-23	52	0	0	unknown	0.0
1982-06-24	61	0	0	unknown	0.0
1982-07-15	52	0	0	unknown	unknown
1982-08-16	53	0	0	unknown	unknown
1983-06-22	50	0	0	unknown	unknown
1983-07-10	50	0	0	unknown	unknown
1983-08-05	52	0	0	unknown	unknown
1983-08-05	52	0	0	unknown	unknown
1983-10-02	78	0	0	unknown	unknown
1984-05-24	56	0	0	unknown	unknown
1985-06-25	0	0	0	unknown	unknown
1985-08-16	0	0	0	unknown	unknown
1985-08-20	51	0	0	unknown	unknown
1985-08-31	52	0	0	unknown	unknown
1985-08-31	52	0	0	unknown	unknown
1985-09-01	56	0	0	unknown	unknown
1985-09-01	56	0	0	unknown	unknown
1986-06-08	0	0	0	unknown	unknown
1990-03-05	0	0	0	unknown	unknown
1990-05-30	0	0	0	$5,000 - $50,000	unknown
1990-07-14	50	0	0	unknown	unknown
1991-05-19	50	0	0	unknown	unknown
1991-05-19	52	0	0	unknown	unknown
1991-05-19	0	0	0	$50 - $500	unknown
1991-06-02	0	0	0	$500 - $5,000	unknown
1992-05-14	0	0	0	$50,000 - $500,000	unknown
1992-07-23	55	0	0	unknown	unknown
1992-07-23	52	0	0	unknown	unknown
1993-06-27	0	15	0	unknown	unknown
1993-07-08	77	0	0	unknown	unknown
1993-07-18	52	0	0	unknown	unknown
1993-09-18	62	0	0	$50 - $500	unknown
1994-05-19	56	0	0	unknown	unknown
1994-05-19	50	0	0	unknown	unknown

DATE	MAGNITUDE (KNOTS)[29]	INJURIES	DEATHS	PROPERTY DAMAGE[30]	CROP DAMAGE[31]
1994-05-19	54	0	0	unknown	unknown
1994-05-28	56	0	0	$5,000 - $50,000	unknown
1995-07-20	50	0	0	unknown	unknown
1996-07-13	0	0	0	0.0	0.0
1996-07-13	70	0	0	<$100,000	unknown
1998-07-09	62	0	0	<$100,000	unknown
1998-08-08	52	0	0	<$100,000	unknown
1999-07-29	52	0	0	<$100,000	unknown
1999-08-28	80	0	0	$20,000	unknown
2000-08-03	52	0	0	<$100,000	unknown
2001-04-20	58	0	0	<$100,000	unknown
2001-04-20	50	0	0	<$100,000	unknown
2001-07-08	54	0	0	<$100,000	unknown
2001-07-08	50	2	0	<$100,000	unknown
2006-05-22	57	0	0	<$100,000	unknown
2006-05-22	54	0	0	<$100,000	unknown
2006-07-04	60	0	0	<$100,000	unknown
2006-08-01	62	0	0	<$100,000	unknown
2007-05-14	70	0	0	<$100,000	<$100,000
	TOTALS:	**17**	**0**	**--**	**--**

*Source: NOAA; NCDC Storm Events Database

Based on data provided by NCDC's Storm Events Database, 66 severe wind events have occurred in Arapahoe County between 1964 and 2013. The following Figure provides a geospatial view of these historical severe wind events in Arapahoe County between 1964 and 2013. As with tornadoes, it should be noted that severe winds affect all portions of the County.

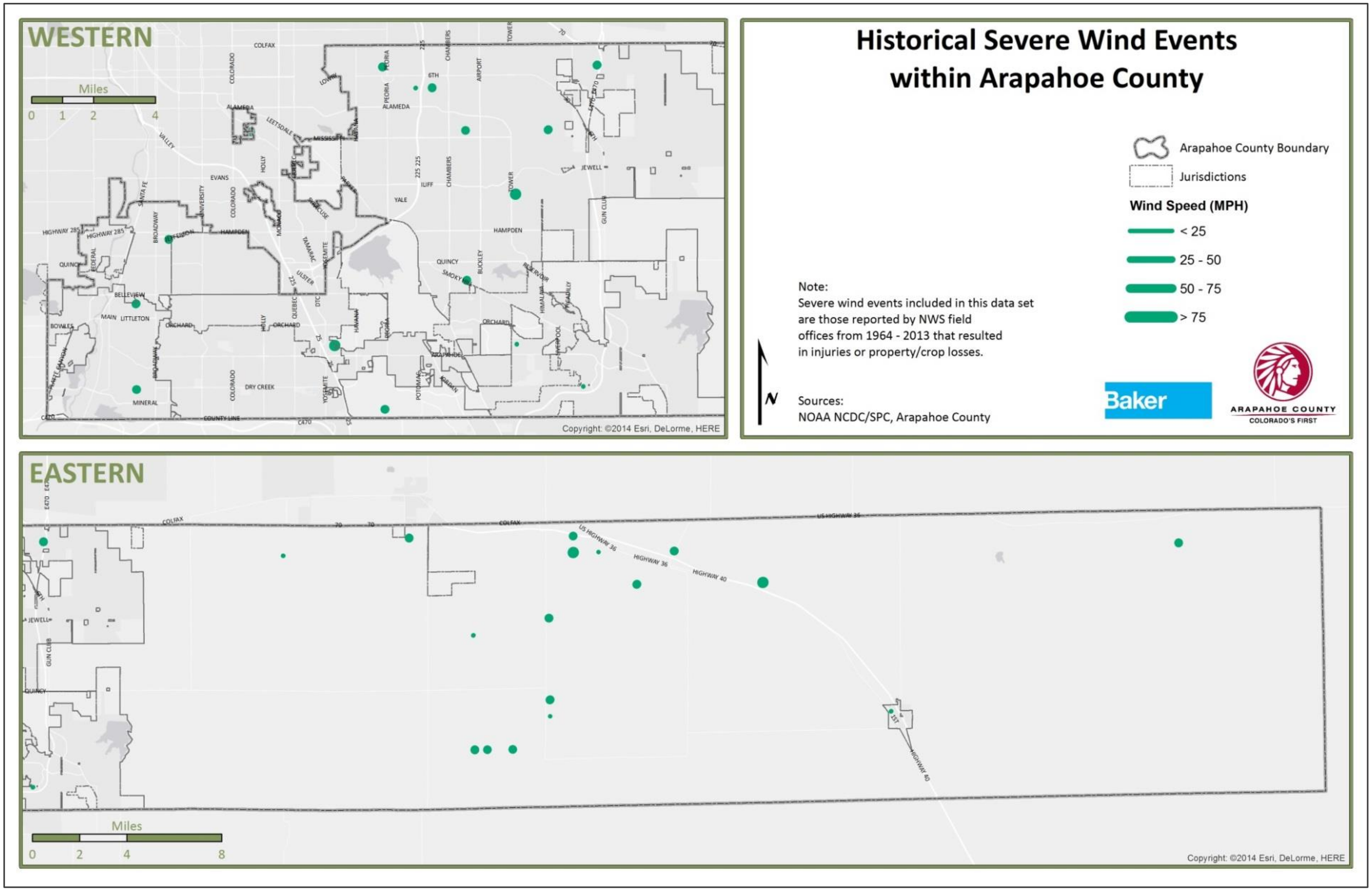


Figure 54. Map of Severe Wind Events in Arapahoe County (1950 – 2013)

Reported severe wind events over the past forty nine years provide an acceptable framework for determining the future occurrence in terms of event. The probability of Arapahoe County and its municipalities experiencing a severe wind event associated with damages or injuries can be difficult to quantify, but based on historical record of sixty-six severe wind events since 1964 that have either caused damages to buildings and infrastructure or resulted in an injury or death, it can reasonably be assumed that this type of event has occurred in Arapahoe County every year between 1964 and 2013.

[(Current Year) 2013] subtracted by [(Historical Year) 1964] = 49 Years on Record

[(Years on Record) 49] divided by [(Number of Historical Events) 66] = 0.74

Furthermore, the historic frequency calculation indicates that there is a 100% chance of this type of event occurring each year

INVENTORY ASSETS EXPOSED

Inventory assets exposed to severe wind is dependent on the age of the building, type, construction material used, and condition of the structure. Possible losses to critical infrastructure include:

- Electric power disruption
- Communication disruption
- Water and fuel shortages
- Road closures
- Damaged infrastructure components, such as sewer lift stations and treatment plants
- Damage to homes, structures, and shelters

Figure 55. Arapahoe County power lines damaged by severe wind

All assets located in Arapahoe County can be considered at risk from severe wind and tornados. This includes 602,868 people, or 100%of the County's population and all buildings and infrastructure within the County.[32] Most structures, including the county's critical facilities, should be able to withstand and provide adequate protection from severe wind and tornados. Those facilities with back-up generators should be fully equipped to handle a severe wind and tornado events should the power go out.

[32] Colorado State Demography Office, Department of Local Affairs

POTENTIAL LOSSES

Figure 56. Building damage from severe wind in Arapahoe County

Generally, severe wind events and tornados destroy private, commercial, and public property. Additional costs stem from debris removal, maintenance, repair, and response. Indirect costs include loss of industrial and commercial productivity as a result of damage to infrastructure, facilities, or interruption of services. Because no specific, countywide loss estimation exists for severe wind and tornado hazards, potential losses are related to historical property damage and injuries/deaths.

Over the last 49 years there have been no deaths reported in Arapahoe County due to severe wind or tornado events. During the same time period, there have been 8 reported injuries from tornados and 17 reported injuries from severe wind. Monetary losses to property and crops are largely unknown.

LAND USE & DEVELOPMENT TRENDS

All future structures built in Arapahoe County will likely be exposed to severe wind and tornado damage. As with other large extent hazards, increased development trends within Planning Reserve Areas and along the I-70 corridor will increase the vulnerability of these areas. Arapahoe County and its jurisdictions must continue to adhere to building codes and to facilitate new development that is built to the highest design standards to account for heavy winds.

MULTI-JURISDICTIONAL DIFFERENCES

Due to the nature of tornados and severe wind events, not all jurisdictions within Arapahoe County are expected to be impacted equally. For example, older homes, which are often subject to less advanced building codes, suffer increased vulnerability to wind and tornados over time. Mobile homes, which are most often occupied by low-income, socially vulnerable residents, are the most dangerous places during a windstorm or tornado. Studies indicate that 45% of all fatalities during tornados occur in mobile homes, compared to 26% in traditional site-built homes.[33] The Table below provides mobile home inventory data for jurisdictions within Arapahoe County.

Table 92. Mobile Homes in Arapahoe County

Area	Number of Mobile Homes	Percent of Total Housing Units
Aurora	2,028	1.5%
Bennett	112	13.4%
Bow Mar	0	0%
Centennial	103	0.3%
Cherry Hills Village	0	0%
Columbine Valley	0	0%
Deer Trail	65	32.5%
Englewood	208	1.4%
Foxfield	0	0%
Glendale	26	1%
Greenwood Village	8	0.1%
Littleton	437	2.2%
Sheridan	321	13.5%

Source: US Census Bureau, 2008 - 2012 American Community Survey

Census data indicates that there are high percentages of residential mobile homes located in Bennett, Deer Trail, and Sheridan. When discussing mitigation actions for severe wind and tornados in these communities, mobile homes deserve added attention.

HIRA SUMMARY

Mitigation of building damage from severe wind and tornados has been most successful in places where strict building codes for high-wind influence areas have been adopted and enforced by local governments and complied with by builders. The greatest protection from severe storms is afforded by quality construction and reinforcement of walls, floors, and ceilings. Proper anchoring of walls to foundations and roofs to walls is essential for a building to withstand certain wind speeds. County and

[33] Ashley, W.S., A.J. Krmenec, and R. Schwantes, 2008: Vulnerability due to nocturnal tornados. *Weather and Forecasting*, 23, 795 – 807.

municipal construction and zoning ordinances are often specific to a jurisdiction or municipality. Therefore, municipalities within Arapahoe County have the flexibility to select regulatory mitigation strategies that best fit the unique priorities and cultures of their communities.

Existing manufactured or mobile homes are most exposed to damage from severe wind and tornados. Even if anchored, mobile homes do not withstand high wind speeds as well as some permanent, site-built structures. Existing structures can be retrofitted to withstand higher winds and safe rooms may be constructed in existing buildings or as standalone facilities. Construction of safe rooms has shown great success in protecting life and reducing injuries during severe storm events. Walls and other structural components are heavily reinforced with concrete and rebar to provide an area designed to withstand high wind speeds and protect occupants from windborne debris. Safe rooms can be constructed not only in critical facilities such as police stations and hospitals but also in residential and commercial buildings. They can be built into any new structure during the construction phase, which is often the most cost-effective time to add a safe room. All projects should be designed to meet FEMA 320 standards or beyond.

WILDFIRE

NATURAL HAZARDS	PROBABILITY	IMPACT	SPATIAL EXTENT	WARNING TIME	DURATION	RF RATING
Wildfire	3 (0.8)	2 (0.5)	2 (0.4)	4 (0.4)	2 (0.2)	**2.3**
MODERATE RISK HAZARD (2.0 – 2.5)						

HAZARD IDENTIFICATION

Wildfires are defined as unwanted or unplanned wildland fires. They include unauthorized human caused fires, escaped prescribed burn projects, and all other wildland fires where the objective is to put the fire out.

Wildfires are fueled by natural ground cover, including native and non-native species of trees, brush and grasses, and crops along with weather conditions and topography. While available fuel, topography, and weather provide the conditions that allow wildfires to spread, most wildfires are caused by people through criminal or accidental misuse of fire.

Figure 57. Wildfire near Arapahoe County

Wildfires pose serious threats to human safety and property in Arapahoe County. They can destroy crops, timber resources, recreation areas, and critical wildlife habitat. Wildfires are commonly perceived as hazards in the western part of the state; however, wildfires are a growing problem in the wildland-urban interfaces of eastern Colorado, including communities within Arapahoe County.

Wildfire behavior is dictated in part by the quantity and quality of available fuels. Fuel quantity is the mass of material per unit area. Fuel quality is determined by a number of factors, including fuel density, chemistry, and arrangement. Arrangement influences the availability of oxygen surrounding the fuel source. Another important aspect of fuel quality is the total surface area of the material that is exposed to heat and air. Fuels with large area-to-volume ratios, such as grasses, leaves, bark and twigs, are easily ignited when dry.

Climatic and meteorological conditions that influence wildfires include solar insulation, atmospheric humidity, and precipitation, all of which determine the moisture content of wood and leaf litter. Dry spells, heat, low humidity, and wind increase the susceptibility of vegetation to fire. Additional natural agents can be responsible for igniting wildfires, including lightning, sparks generated by rocks rolling down a slope, friction produced by branches rubbing together in the wind, and spontaneous combustion.

Arson and accidents, including sparks from equipment and vehicles, can also cause wildfires. Human-caused wildfires are typically worse than those caused by natural agents. Arson and accidental fires usually start along roads, trails, streams, or at dwellings that are generally on lower slopes or bottoms of hills and valleys. Nurtured by updrafts, these fires can spread quickly uphill. Arson fires are often set deliberately at times when factors such as wind, temperature, and dryness contribute to the spread of flames.

HAZARD PROFILE

Local impacts from wildfire events include the following:

- Loss of life (human, livestock, wildlife)
- Damage to municipal watersheds
- Loss of property
- Evacuations
- Transportation interruption (closing highways)
- Reductions in air quality and human health
- Injuries – burns, smoke inhalation, etc.
- Coal seam or other energy facility ignitions
- Loss of vegetation (erosion, loss of forage and habitat for livestock and wildlife)
- Expense of responding (equipment, personnel, supplies, etc.)
- Loss of revenue from destroyed recreation and tourism areas

Predicting the intensity of a wildfire, its rate of spread, and its duration are important for wildfire mitigation activity, response, and firefighter safety. Three key factors affect wildfire behavior in the WUI:

1. *Fuels:* The type, density, and continuity of surrounding vegetation and, sometimes, flammable structures, that provide fuel to keep a wildfire burning. Fuels consist of combustible materials and vegetation (including grasses, leaves, ground litter, plants, shrubs, and trees) that feed a fire.

2. *Weather:* Relative humidity, wind, and temperatures all affect wildfire threat and behavior.

3. *Topography:* The steepness and aspect (direction) of slopes, as well as building-site locations, are features that affect fire behavior.

Very often the only factor that a community can have direct influence over is fuel.

Wildfires are often rated based on their ability of their fuels to ignite. Descriptions for the commonly used “Fire Danger Rating” system are listed below:

- **Low:** Fuels do not ignite readily from small firebrands. However, an intense heat source, such as lightning, may start fires in duff or rotted wood. Fires in open grasslands may burn freely for a few hours after rain, but wood fires spread slowly by creeping or smoldering, and burn in irregular fingers. There is little danger of spotting.
- **Moderate:** Fires can start from most accidental causes, with the exception of lightning. Fires in open grasslands will burn briskly and rapidly on windy days. Timber fires spread slowly to moderately fast. The average fire is of moderate intensity, although heavy concentrations of fuel may burn hot. Short-distance spotting may occur. Fires are not likely to become serious and control is relatively easy.
- **High:** All fine dead fuels ignite readily and fires start easily from most causes. Unattended brush and campfires are likely to escape. Fires spread rapidly and short-distance spotting is common. High-intensity burning may develop on slopes or in concentrations of fine fuels. Fires may become serious and their control difficult unless they are attacked successfully while small.
- **Extreme/Very High:** Fires start easily from all causes and immediately after ignition, spread rapidly and increase quickly in intensity. Spot fires are a constant danger. Fires burning in light fuels may quickly develop intensity characteristics such as long-distance spotting and fire whirlwinds when they burn into heavier fuels.

For the purpose of wildfire mitigation strategy development, this Plan divides the various land use types within Arapahoe County into four categories: *cultivated agricultural land*, *forested land*, *grazing land*, and *miscellaneous*. Cultivated agricultural lands include both irrigated and non-irrigated crop land. Typically, this category of land has very dynamic burning characteristics and seasons. Crops and dormant stands located on Arapahoe County’s cultivated agricultural land can both serve as fuel for wildfires. What makes agricultural land unique is the dynamic nature of the fuel locations and seasons of availability. These factors add to the challenge of wildfire suppression and mitigation.

In the context of the Arapahoe County landscape, forested land includes the riparian forest, windbreaks, shelterbelts, living snow fences, and urban forests. Much of the forested land in Arapahoe County occurs along rivers, seasonal water courses, lakes, and ponds. Other forested lands include farmsteads and urban areas. Here, trees are often planted near homes and outbuildings, which contribute to elevated wildfire risk. In addition to the trees, forested lands include a surface cover of dry brush and grasses, which are primary fuel sources for rapidly moving fires.

Grazing lands are primarily made up of sandhill steppe and prairie landscapes. Sandhill steppe is a combination of mixed grasses and sage, and is widely used for livestock grazing. Fuel loads on grazing lands are moderate to heavy and large fires have occurred with this fuel type during springtime wind events. In some areas within Arapahoe County livestock grazing maintains a rather sparse fuel load. Miscellaneous areas include transportation right of ways, fence lines, disturbed areas, and other locations that contain grasses, tumbleweeds, wild sunflowers, and other vegetation.

Long-term weather patterns in Arapahoe County have followed a cyclical pattern of wet years (characterized by average to high precipitation levels for the region), followed by a series of drought years (characterized by below average precipitation levels). During wet years, the typical fire season is from March through November. During drought years, the fire season in Colorado has been as long as a full year.

Regional precipitation patterns play a significant role in the availability of various fuel types. The following Table illustrates the seasons of availability for different fuel types in Arapahoe County based on average precipitation levels.[34] During drought years, the season of availability for all fuel types is extended, sometimes to the entire length of the year if drought conditions are severe enough.

[34] 2012 Eastern Arapahoe County CWPP

Wildfire Fuels: Average Season of Availability in Arapahoe County												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Fuel Type												
Prairie												
Sandhill Steppe												
Dormant Winter Wheat												
Wheat Stubble												
Mature Corn												
Corn Stubble												
Mature Millets & Sorghum												
Forest												
Misc. Areas												

Table 93. Seasonal Wildfire Fuel

In 2012, partners and stakeholders within Arapahoe County collaborated to create the Eastern Arapahoe County Community Wildfire Protection Plan (CWPP). The CWPP provides detailed information about risk and response capabilities and identifies goals and projects to address wildfire risks in Eastern Arapahoe County. Located in the Division of Fire Protection and Control's (DFPC) North Central Plains Fire Management Region, Arapahoe County has actively pursued interagency coordination to manage and mitigate wildfires within the county. Although different reports, assessments, plans, and programs have been developed by different organizations at all levels of government, interagency coordination has been proven to be more effective. Today Colorado wildfires are managed at varying extents through cooperative efforts by the following stakeholders:

- Arapahoe County Sheriff's Office (OEM)
- Colorado State Land Board
- Colorado Department of Transportation
- Colorado Division of Wildlife
- Colorado State Forest Service
- Arapahoe County Homeowner Associations
- Arapahoe County Fire Protection Districts
- Buckley Air Force Base Fire Department
- Arapahoe County Local Jurisdiction Fire Departments

Before discussing wildland fire risk in Arapahoe County, a key wildfire management term must first be defined. The term ''wildland-urban interface", or WUI, is widely used within the wildland fire management community to describe any area where manmade buildings are constructed close to or within a boundary of natural terrain and fuel, where high potential for wildland fires exist. Communities are able to establish the definition and boundary of their local WUI, and the boundaries often help in meeting local management needs. WUIs can include both public and private land, and can help improve local access to funding sources.

In the 2012 Eastern Arapahoe County CWPP, the WUI boundary was drawn "around those areas within unincorporated portions of eastern Arapahoe County where hazard conditions exist."[35] The western portion of the County was not included in the CWPP WUI boundary because of the highly urbanized nature of the environment. Here, there is very little vegetation available to carry fire. For the purpose of the 2015 Arapahoe County Multi-Hazard Mitigation Plan, the planning area for wildfire risk analysis has been expanded to include the entire western portion of the County.

Historical wildfire occurrence data included in this Plan was collected in part from the Colorado Division of Fire Prevention and Control's Fire Incident Reporting System (NFIRS). The NFIRS data includes wildfire incident types related to natural vegetation fires and cultivated vegetation fires and is currently

[35] 2012 Arapahoe County Community Wildfire Protection Plan

available for events that occurred from 2003-2013. It is important to note that NFIRS wildfire data is only available when it is voluntarily submitted by participating local fire departments.

Based on the NFIRS Colorado Fire Data Summary, there have been 83,083 wildfires reported in Colorado between January 1, 2007 and December 31, 2013. The Table below summarizes wildfire occurrences located in Arapahoe County between 2003 and 2013. The Colorado NFIRS data shows that there have been 2,445 wildfire events reported in Arapahoe County since 2003. Losses associated with the 2,445 events include over 15,900 acres of land and over $491,000 dollars.

Table 94. Summary of Arapahoe County Wildfire Events (2003 – 2013)

Fire Department	**Summary of Arapahoe County Wildfire Events, 2003 – 2013**		
	Count	*Total Acres Burned*	*Total Losses*
Aurora FD	847	404.9	$140,320
Byers FD	112	4803.46	$42,550
Cunningham FPD	179	91.9	$21,315
Deer Trail FPD	15	391	$20
Englewood FD	123	<1	$10,825
Littleton FR	528	9779	$200,949
Sheridan FD	36	<1	$ -
Skyline FPD	2	1.1	$ -
South Metro FRA	603	429.8	$75,120
Total:	2,445	15,901.16	$491,099

The following Table summarizes the incidence and loss information for those wildfires within Arapahoe County reported to the Colorado Division of Fire Prevention and Control between 2003 and 2013.

Table 95. Wildfire Events in Arapahoe County by Year (2003 - 2013)

Year	**Count**	**Total Acres**	**Total Losses**
2003	197	1,364.9	$13,302
2004	144	38.2	$14,506
2005	168	431	$16,011
2006	248	286	$25,670
2007	220	320	$80,360
2008	310	2,411	$82,945
2009	129	1,026	$9,445
2010	330	1,145	$52,260
2011	288	598	$144,840
2012	248	8,255	$32,500
2013	163	28.6	$19,260
Total:	2,445	15,901.16	$491,099

Based on the NFIRS data, 2011 was the worst year for wildfires in Arapahoe County in terms of monetary losses, 2012 was the worst year for wildfires in the county in terms of total acres burned (8,255), and 2010 was the worst year for wildfires in the county in terms of the total number of events.

In order to facilitate continued wildfire mitigation activity and planning at the local jurisdiction levels, the following nine tables summarize the NFIRS data for each participating local fire department. Not only do the tables summarize wildfire losses and historical occurrences at fine scale, they also highlight areas of need for data collection and record keeping for future events.

Table 96. Summary of Wildfire Events Reported by Aurora FD (2003 – 2013)

Aurora Fire Department			
Year	**Count**	**Total Acres**	**Total Losses**
2003	80	28.1	$100
2004	81	26.3	$7,000
2005	43	4.5	$3,000
2006	71	10	$1025
2007	96	64	$56,135
2008	97	210	$21,760
2009	14	3	$500
2010	111	<1	$27,620
2011	86	16	$1,160
2012	107	43	$21,400
2013	61	<1	$620
Total:	847	404.9	$140,320

Table 97. Summary of Wildfire Events Reported by Byers FD (2003 – 2013)

Byers Fire Department			
Year	**Count**	**Total Acres**	**Total Losses**
2003	-	-	$ -
2004	-	-	$ -
2005	-	-	$ -
2006	14	80	$ -
2007	15	224	$ -
2008	29	2,063	$32,400
2009	6	1,012	$ -
2010	15	812	$ -
2011	22	444	$10,150
2012	10	168	$ -
2013	1	1	$ -
Total:	**112**	**4,803.46**	**$42,550**

Table 98. Summary of Wildfire Events Reported by Cunningham FPD (2003 – 2013)

Cunningham Fire Protection District			
Year	**Count**	**Total Acres**	**Total Losses**
2003	13	14	$ -
2004	12	4	$ -
2005	10	1.9	$130
2006	24	10.7	$5,550
2007	14	7.3	$ -
2008	31	44	$5,725
2009	13	5	$1,000
2010	20	1	$7,600
2011	20	1	$1,100
2012	8	0	$200
2013	14	3	$10
Total:	**179**	**91.9**	**$21,315**

Table 99. Summary of Wildfire Events Reported by Deer Trail FPD (2003 – 2013)

Deer Trail Fire Protection District			
Year	**Count**	**Total Acres**	**Total Losses**
2003	-	-	$ -
2004	-	-	$ -
2005	13	391	$20
2006	2	0	$ -
2007	-	-	$ -
2008	-	-	$ -
2009	-	-	$ -
2010	-	-	$ -
2011	-	-	$ -
2012	-	-	$ -
2013	-	-	$ -
Total:	**15**	**391**	**$20**

Table 100. Summary of Wildfire Events Reported by Englewood FD (2003 – 2013)

Englewood Fire Department			
Year	**Count**	**Total Acres**	**Total Losses**
2003	8	0	$100
2004	10	0	$ -
2005	19	0	$700
2006	12	0	$1,400

Englewood Fire Department			
Year	**Count**	**Total Acres**	**Total Losses**
2007	6	0	$2,840
2008	13	0	$1,650
2009	12	0	$2,810
2010	13	0	$500
2011	14	0	$100
2012	10	0	$75
2013	6	0	$650
Total:	**123**	**0**	**$10,825**

Table 101. Summary of Wildfire Events Reported by Littleton FR (2003 – 2013)

Littleton Fire Rescue			
Year	**Count**	**Total Acres**	**Total Losses**
2003	58	1,313	$10,652
2004	15	7.9	$456
2005	45	15.3	$501
2006	57	54	$ 1,435
2007	50	20.3	$16,200
2008	75	45.7	$14,000
2009	34	0	$2,985
2010	49	304	$2,725
2011	64	3	$127,525
2012	50	8,010	$ 8,370
2013	31	6	$16,100
Total:	**528**	**9,779**	**$200,949**

Table 102. Summary of Wildfire Events Reported by Sheridan FD (2003 – 2013)

Sheridan Fire Department			
Year	**Count**	**Total Acres**	**Total Losses**
2003	7	0	$ -
2004	4	0	$ -
2005	6	0	$ -
2006	10	0	$ -
2007	2	0	$ -
2008	7	0	$ -
2009	-	-	$ -
2010	-	-	$ -
2011	-	-	$ -
2012	-	-	$ -

Sheridan Fire Department			
Year	**Count**	**Total Acres**	**Total Losses**
2013	-	-	$ -
Total:	**36**	**0**	**$ -**

Table 103. Summary of Wildfire Events Reported by Skyline FPD (2003 – 2013)

Skyline Fire Protection District			
Year	**Count**	**Total Acres**	**Total Losses**
2003	-	-	$ -
2004	-	-	$ -
2005	-	-	$ -
2006	1	1	$ -
2007	1	0.1	$ -
2008	-	-	$ -
2009	-	-	$ -
2010	-	-	$ -
2011	-	-	$ -
2012	-	-	$ -
2013	-	-	$ -
Total:	**2**	**1.1**	**$ -**

Table 104. Summary of Wildfire Events Reported by South Metro FRA (2003 – 2013)

South Metro Fire Rescue Authority			
Year	**Count**	**Total Acres**	**Total Losses**
2003	31	10	$2,450
2004	22	<1	$7,050
2005	32	18	$11,660
2006	57	130	$16,260
2007	36	4	$5,185
2008	58	48	$7,410
2009	50	6	$2,150
2010	122	27.5	$13,815
2011	82	134	$4,805
2012	63	34.1	$2,455
2013	50	18.6	$1,880
Total:	603	429.8	$75,120

Fire occurrence is a key input into the calculation of Wildfire Threat. Wildfire threat is the likelihood of a wildfire occurring or burning into an area and represents the likelihood of an acre burning. Wildfire threat analysis incorporates probability of fire occurrence, information about fire behavior and rate of spread (including surface fuels, canopy closure, canopy characteristics, and topography), and the effectiveness of previous fire suppression activities. The inputs were combined using analysis techniques based on established fire science and data provided by the Colorado Wildfire Risk Assessment Project.[36]

Figure 58. Wildfire in Centennial, CO, open space (2009)

Figure 55 on the following page shows wildfire threat levels across Arapahoe County. The measure of wildfire threat used in in the Plan is called the Fire Threat Index (FTI).[37] The FTI combines the fire occurrence values and the expected final fire size based on rate of spread in four weather percentile categories. FTI was calculated the same way for the 2013 Colorado State Hazard Mitigation Plan, which allows for the comparison of areas within Arapahoe County to others across the entire state. For example, high threat areas in western Arapahoe County are equivalent to high threat areas in southwestern Colorado.

Similar to the threat data depicted in Figure 55, Figure 56 shows wildfire threat across the county using parcel centroids. This map allows us to identify individual parcels or group of parcels that have particularly high threat levels. Together, the two Arapahoe County wildfire threat maps show a number of moderate to high threat areas scattered across the planning area. The threat assessment indicates that the land areas with the highest likelihood of an acre burning are located in the eastern part of Arapahoe County, along the I-70 corridor and to the south east of C-470 near the Aurora Reservoir.

[36] Colorado State Forest Service, Colorado Wildfire Risk Assessment Portal (2013)
[37] Colorado State Forest Service, Colorado Wildfire Risk Assessment Portal (2013)

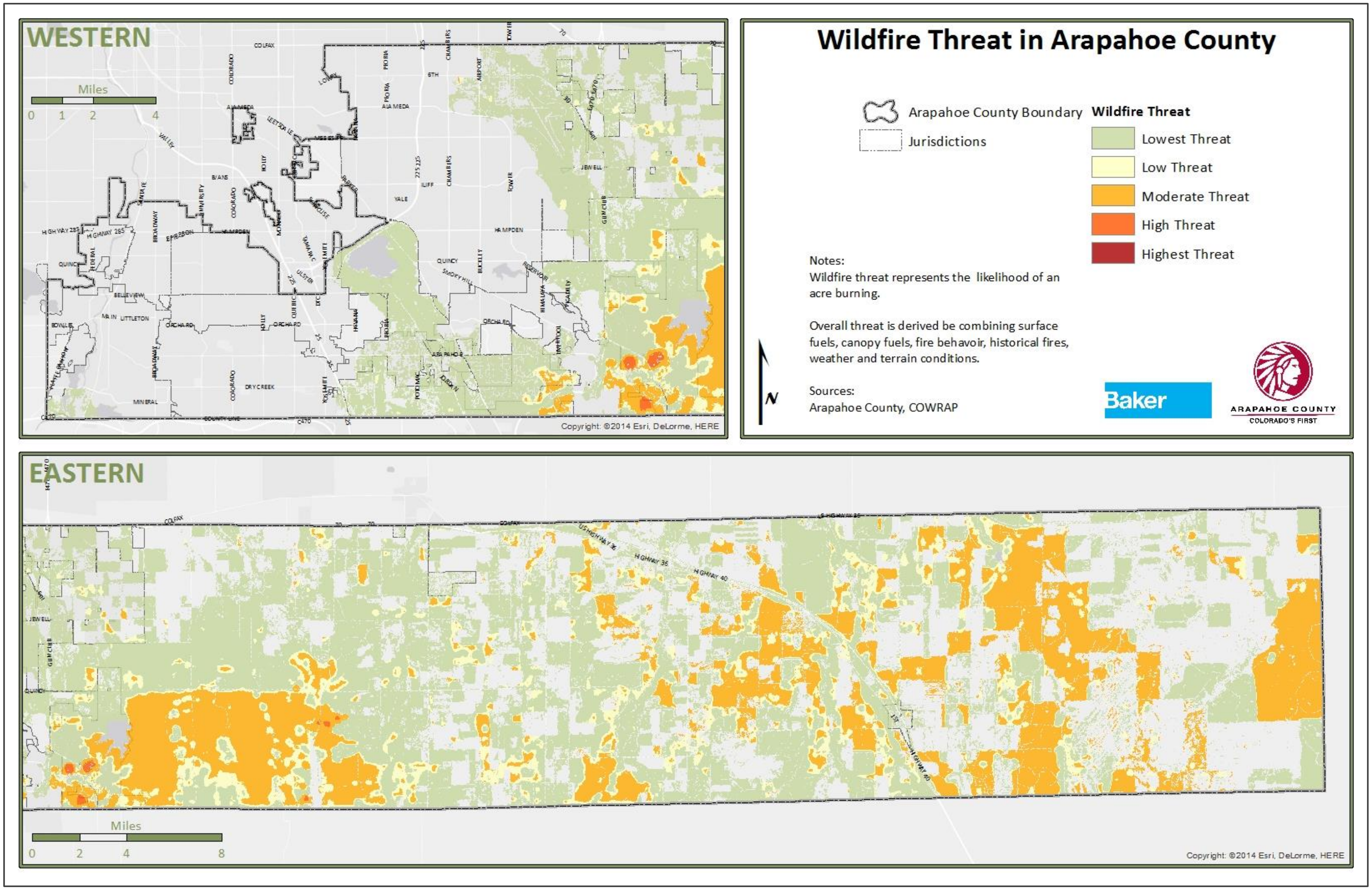


Figure 59. Map of Wildfire Threat

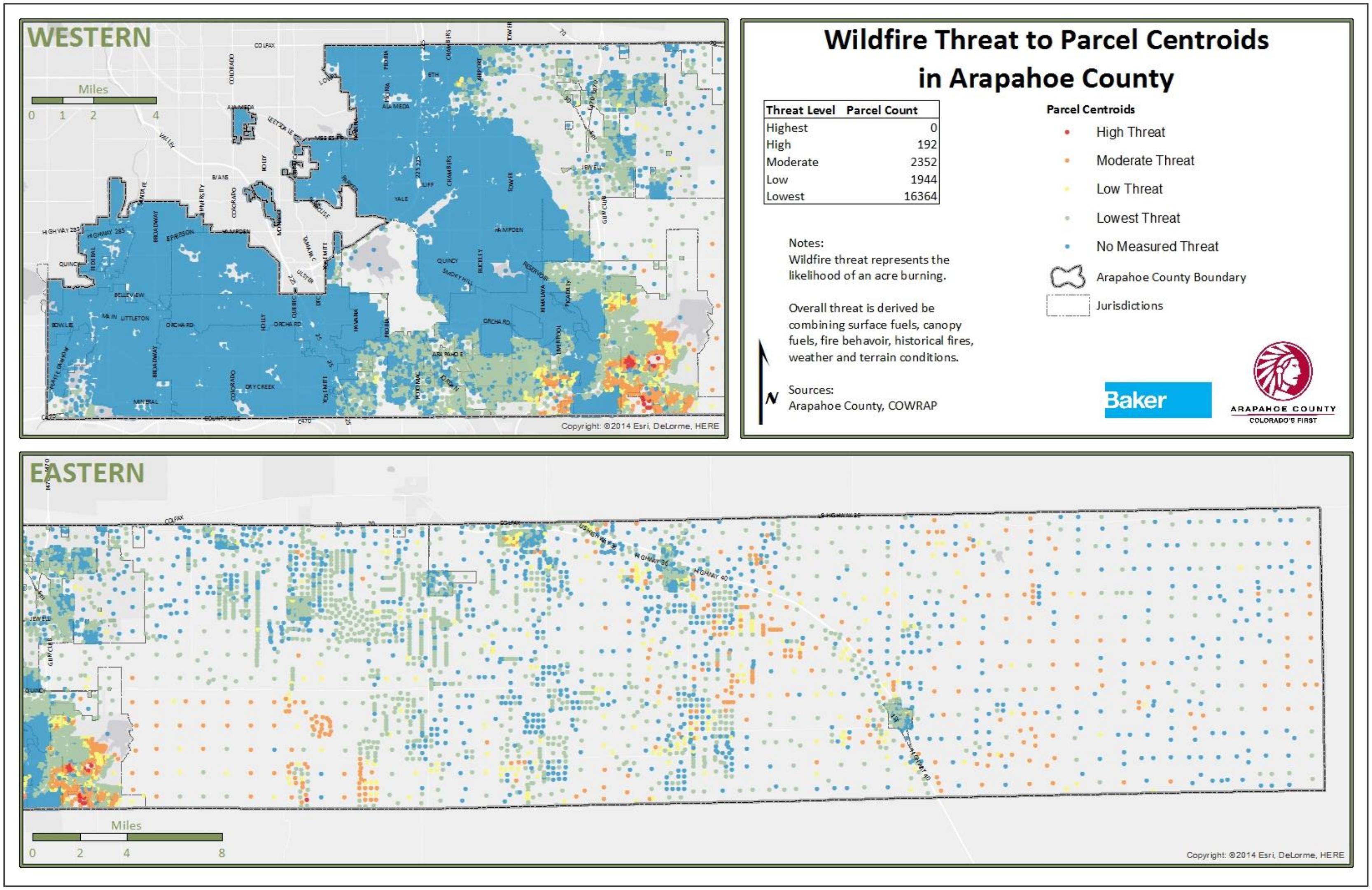


Figure 60. Map of Wildfire Threat by Parcel

"Wildfire Risk" represents the possibility of loss or harm occurring from a wildfire. For the purpose of this Plan, risk has been derived by combining "Wildfire Threat" and "Fire Effects." Fire Effects is comprised of several inputs that identify damaged assets. These inputs include the following: information on where people live (derived from 2012 LandScan data from Colorado), Colorado forest assets, riparian assets, and drinking water assets. The following Wildfire Risk map (Figure 57) identifies areas with the greatest potential impacts from a wildfire, in other words, those areas most at risk. The highest wildfire risk areas in the county are located in the west, in areas where there are higher population densities.

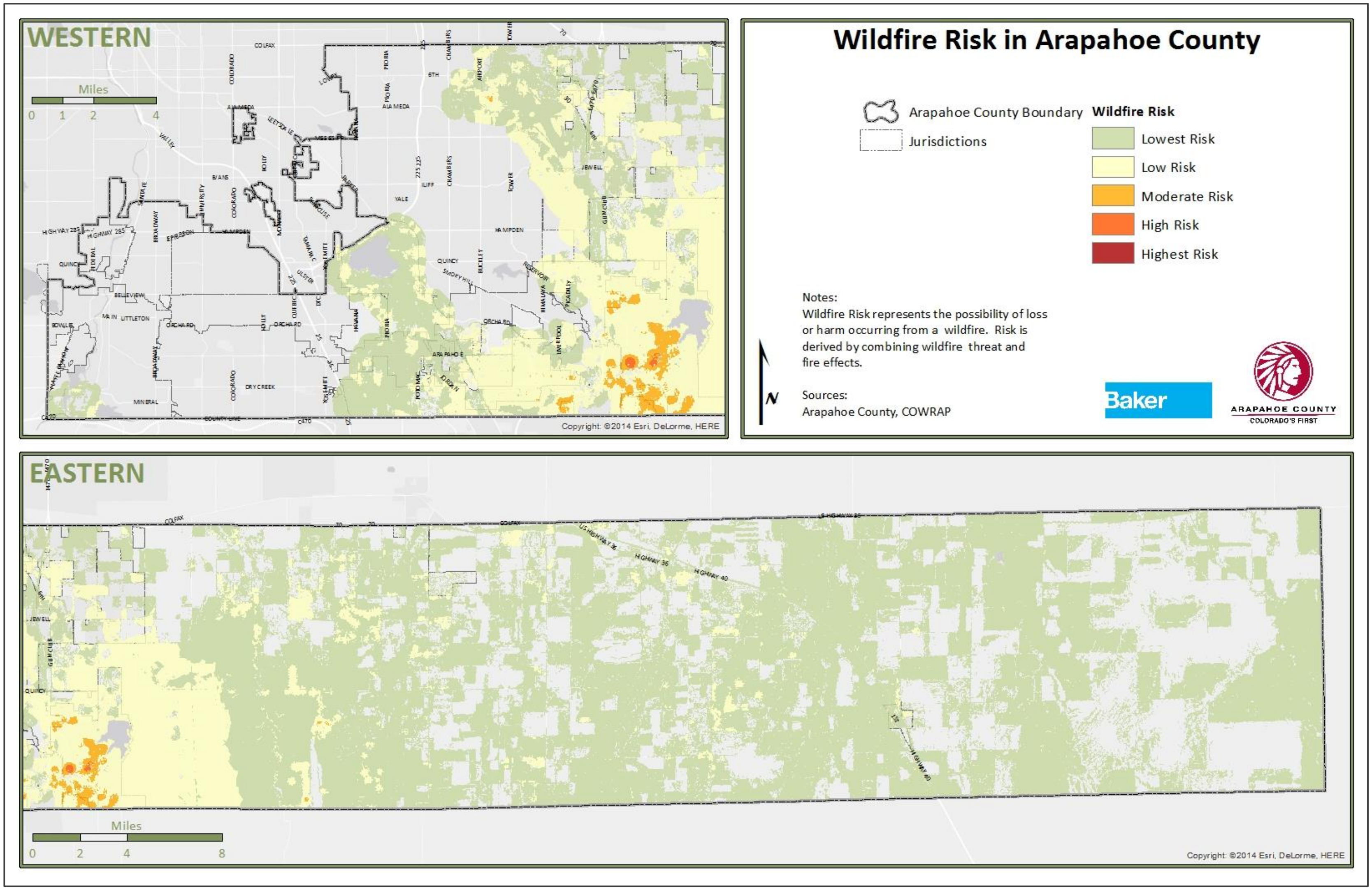


Figure 61. Map of Wildfire Risk

Michael Baker
INTERNATIONAL

ARAPAHOE COUNTY
COLORADO'S FIRST

As was discussed previously, understanding the location of people living in the wildland-urban interface is essential for defining potential wildfire impacts to people and homes. The WUI Risk analysis provides a rating of the potential impact of a wildfire on people and their homes. The key input, the wildland-urban interface, reflects housing density (houses per acre).

To calculate WUI risk, WUI housing density data was combined with response function data. Response functions are a method of assigning a net change in the value of a resource or asset based on its susceptibility to fire at various intensity levels (such as flame length). The response functions were defined by a team of experts led by Colorado State Forest Service mitigation planning staff. By combining these data sets it is possible to determine where the greatest potential impact to homes and people are likely to occur in Arapahoe County.

Figure 62. Wildfire near Byers, CO (Summer 2010)

The following Figure shows the various levels of WUI Risk within Arapahoe County. The range of values is from -1 to -9, with -1 representing the least negative impacts and -9 representing the most negative impact. For example, areas with high housing density and high flame lengths are rated -9, while areas with low housing density and low flame lengths are rated -1. Understandably so, the Map of WUI Risk shows a number of high risk areas concentrated around densely populated parts of the county. Like the Wildfire Risk and Threat analyses, Wildland-Urban Interface Risk was calculated in the 2013 Colorado State Hazard Mitigation Plan using the same methodology. This allows for comparison and ordination to be made across the state.

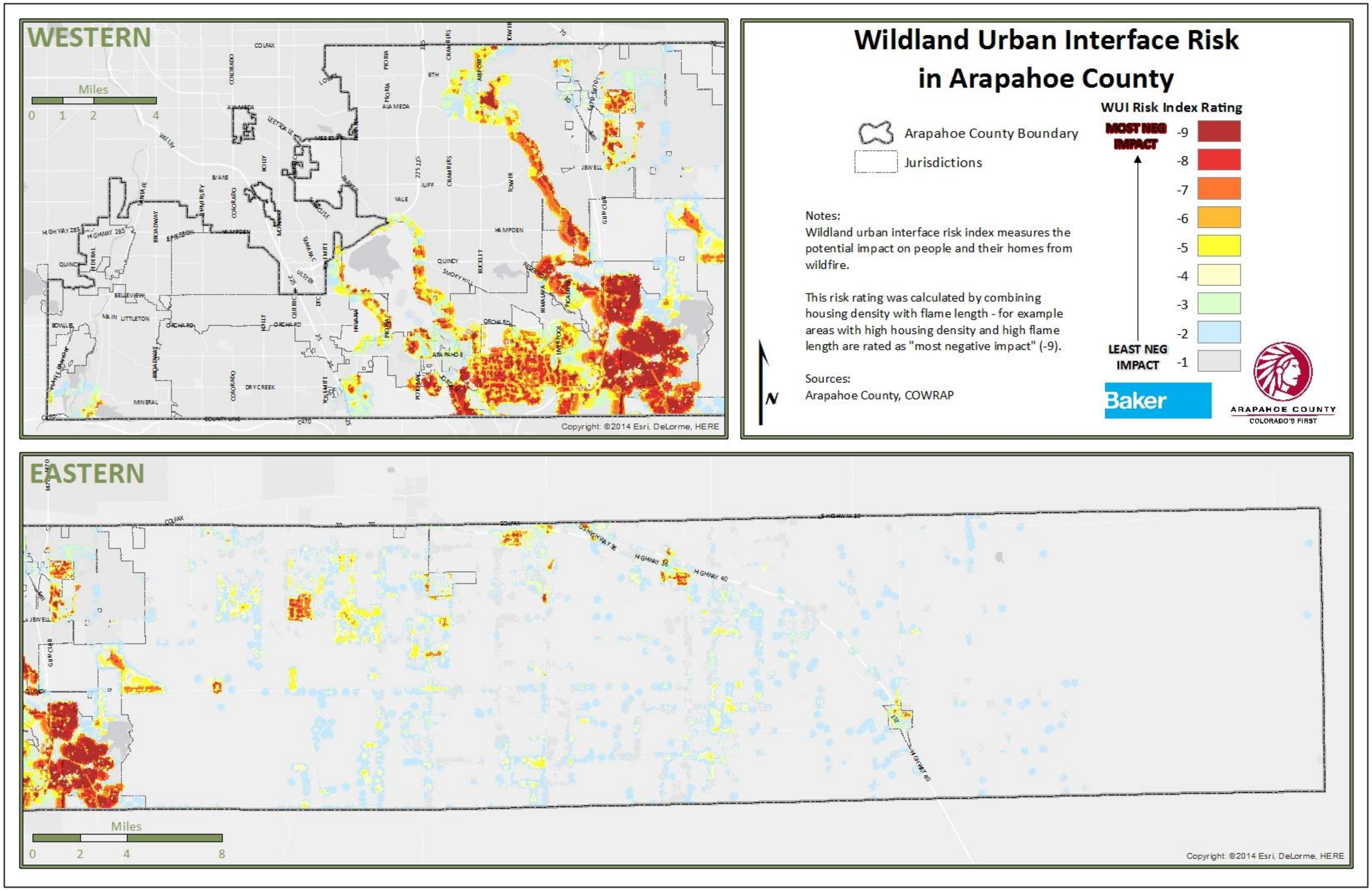


Figure 63. Map of Wildland-Urban Interface Risk

Reported wildfires in Arapahoe County over the past ten years provide an acceptable framework for determining the future occurrence in terms of frequency for such events. The probability of the County and its municipalities experiencing a wildfire associated with damages or loss can be difficult to quantify, but based on historical record of 2,445 wildfires since 2003 that have either caused damages to buildings and infrastructure or resulted in burned acreage, it can reasonably be assumed that a wildfire event has occurred in Arapahoe County more than 240 times a year between 2003 and 2013.

[(Current Year) 2013] subtracted by [(Historical Year) 2003] = 10 Years on Record

[(Years on Record) 10] divided by [(Number of Historical Events) 2,445] = 0.0004

Furthermore, the historic frequency calculates that there is a 100% chance of this type of event occurring each year.

CLIMATE CHANGE IMPACTS

Wildfires can occur at any time of day and during any month of the year. The length of the wildfire season and peak months may vary considerably from year to year. Land use, vegetation, available fuels, and weather conditions (including wind, low humidity, and lack of precipitation) are chief factors in determining the number of fires and acreage burned in Colorado each year. Generally, fires are more likely when vegetation is dry from a winter with little snow and/or a spring and summer with sparse rainfall. For these reasons, climate change in Colorado (specifically, a pattern of extended drought conditions) had contributed to increased concern about wildfire in Arapahoe County.

The frequency, intensity, and duration of wildfires have increased across the Western United States since the 1980s. A 2012 federal report released by the U.S. Department of Agriculture found that the Colorado region, among others, will face an even greater fire risk over time. The report expects Colorado to experience up to a five-fold increase in acres burned by 2050.[38] The report's findings are consistent with previous studies on the relationship between climate change and fire risk. Colorado landscapes, including those that characterize Arapahoe County, are expected to become hotter and drier as the planet warms, which will in turn increase regional wildfire risk.

INVENTORY ASSETS EXPOSED

Fires can extensively impact the economy of an affected area, including the agricultural, recreation and tourism industries, water resources, and the critical facilities upon which Arapahoe County depends. The following Figure shows identified critical facilities within the county in relation to areas with identified wildfire threat (i.e. the likelihood of an acre burning).

[38] US Department of Agriculture. Effects of Climate Variability and Change on Forest Ecosystems. General Technical Report, December 2012

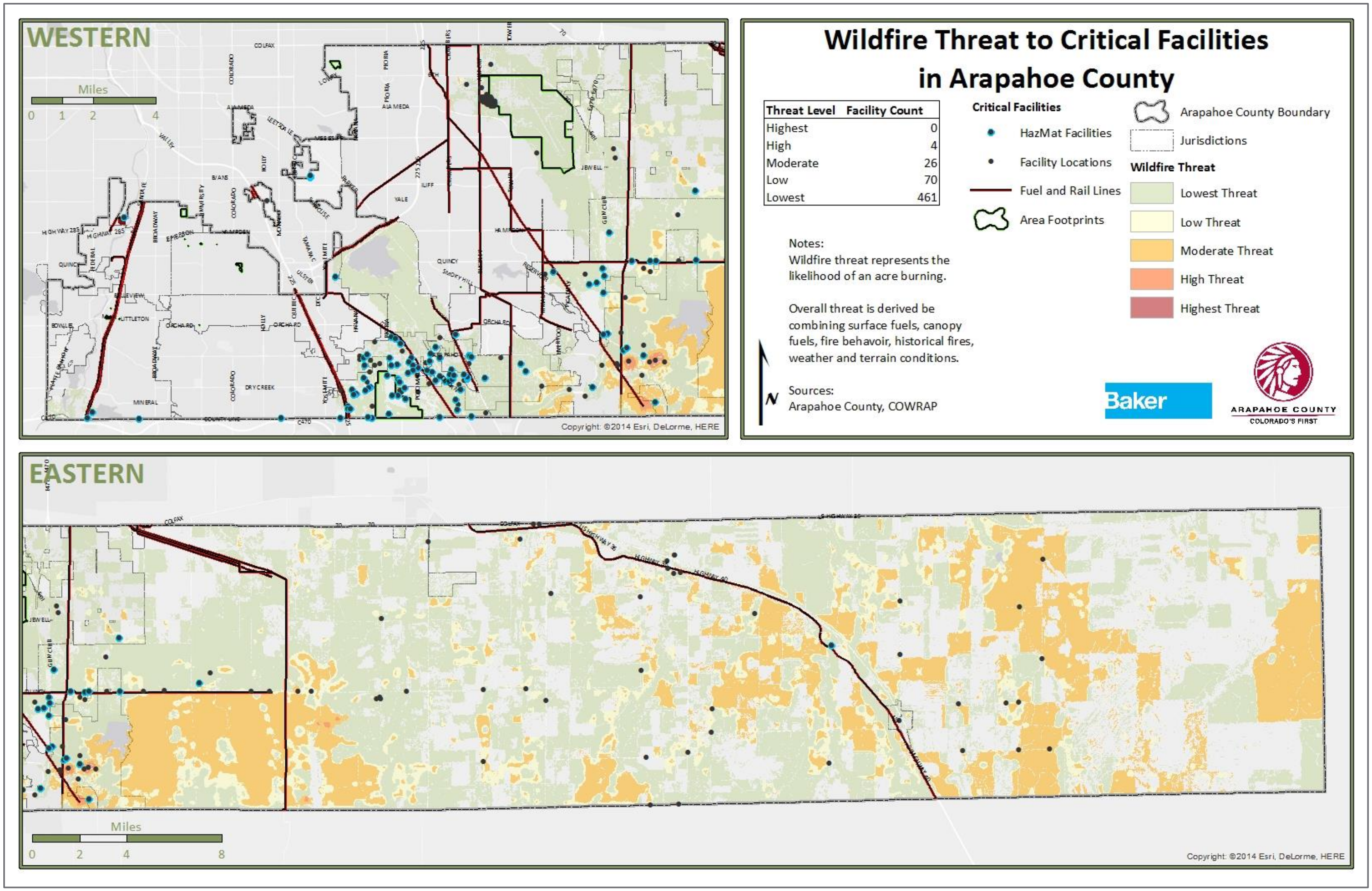


Figure 64. Map of Wildfire Threat to Critical Facilities

Tables 104 through 108 summarize the exposure data shown in the Map of Wildfire Threat to Critical Facilities by showing the number of critical facilities located within areas of each wildfire threat level. The critical facilities have been organized into the following five categories:

- Emergency Services
- Community Services
- Infrastructure and Transportation
- Fuel and Rail Lines
- Hazardous Materials Storage

There are no identified county assets located in areas with the highest wildfire threat total. There are, however, 4 county assets located in areas categorized as having high wildfire threat. The appraisal value of the assets within these high threat areas is approximately $79,120,500. When considering assets located in areas of *moderate* wildfire threat there are 26 assets identified. The appraised value of these assets is approximately $128,720,700. The majority of critical facilities are located in the *low* to *lowest* threat areas, with a total of 70 assets in the low threat areas and 461 assets in the lowest threat areas of the county.

Figure 65. Wildfire near Byers, CO, Summer 2010

Critical Facilities: Emergency Services						
	Fire Stations		Police/Sheriff		Military	
Wildfire Threat Level	*Count*	*Appraisal Value*	*Count*	*Appraisal Value*	*Count*	*Appraisal Value*
No measured threat	0	-	0	-	120	-
Lowest	3	$7,419,123	3	$16,225,107	28	-
Low	0	-	1	$4,950,540	0	-
Moderate	1	$8,019,332	0	-	0	-
High	0	-	0	-	0	-
Highest	0	-	0	-	0	-
TOTAL:	4	$15,438,455	4	$21,175,647	148	-

Table 105. Wildfire Exposure Table – Emergency Services

Critical Facilities: Community Services										
	Schools		Libraries		Churches		County Facility		Historic Areas
Wildfire Threat Level	*Count*	*Appraisal Value*	*Count*	*Appraisal Value*	*Count*	*Appraisal Value*	*Count*	*Appraisal Value*	*Count*
No measured threat	1	$644,406	0	-	0	-	0	-	16
Lowest	11	$125,125,607	2	$12,679,601	11	$20,304,309	7	$25,491,991	2
Low	0	-	0	-	0	-	1	$4,950,540	0
Moderate	2	$56,341,030	0	-	0	-	0	-	0
High	2	$64,542,817	0	-	1	$14,577,641	0	-	0
Highest	0	-	0	-	0	-	0	-	0
TOTAL:	16	$246,653,860	2	$12,679,601	12	$34,881,950	8	$30,442,531	18

Table 106. Wildfire Exposure Table – Community Services

Critical Facilities: Infrastructure and Transportation							
	Bridge		Water Facility		Light Rail Station		Airports
Wildfire Threat Level	*Count*	*Appraisal Value*	*Count*	*Appraisal Value*	*Count*	*Appraisal Value*	*Count*
No measured threat	1	-	0	-	0	-	0
Lowest	38	-	7	$240,257	1	-	0
Low	7	-	0	-	0	-	2
Moderate	6	-	0	-	0	-	0
High	0	-	0	-	0	-	0
Highest	0	-	0	-	0	-	0
TOTAL:	52	-	7	$240,257	1	-	0

Table 107. Wildfire Exposure Table – Infrastructure and Transportation

Critical Facilities – Fuel and Rail Lines						
	Fuel Line		Light Rail		Railroad	
Wildfire Threat Level	*Count*	*Miles*	*Count*	*Miles*	*Count*	*Miles*
No measured threat	113	68.5672	26	35.9171	86	57.1646
Lowest	54	32.4001	20	1.7908	86	19.7893
Low	16	5.2521	0	0.0000	12	0.9089
Moderate	8	6.7930	0	0.0000	9	0.6290
High	1	0.1738	0	0.0000	0	0.0000
Highest	0	0.0000	0	0.0000	0	0.0000
TOTAL:	79	113.1862	20	37.7080	107	78.4918

Table 108. Wildfire Exposure Table – Fuel and Light Rail Lines

Table 109. Wildfire Exposure Table – Hazardous Materials Storage

Critical Facilities – Hazardous Materials Storage			
	Hazmat Locations	Fuel Depots	
Wildfire Threat Level	*Count*	*Count*	*Appraisal Value*
No measured threat	7	0	-
Lowest	94	2	$455,000
Low	3	0	-
Moderate	0	0	-
High	0	0	-
Highest	0	0	-

The 2015 Plan integrates social vulnerability into its hazard risk analysis in order to more effectively identify hazard risk experienced by the most vulnerable residents and communities within the county. The following social vulnerability map integrates the physical and human elements of wildfire hazards by combining physical and social vulnerability models. On its own, the social vulnerability map can inform communities about disparate social conditions across the county. When combined with physical hazard analyses, the new map illustrates where human hardships may occur in a disaster situation. These hardships may results in citizens that are less likely to prepare, respond, withstand, or recover from a wildfire due to their elevated levels of social vulnerability.   This information is valuable for both mitigation and disaster response activity.

The Map of Social Vulnerability to Wildfires shows wildfire threat areas across the county and the relative levels of social vulnerability in those areas. The wildfire threat layer includes areas in the County that are classified only in the moderate to highest threat categories. Although the majority of areas within the moderate to high wildfire threat boundary have medium-low to low social vulnerability, it does not mean that there are no socially vulnerable people living in these areas.

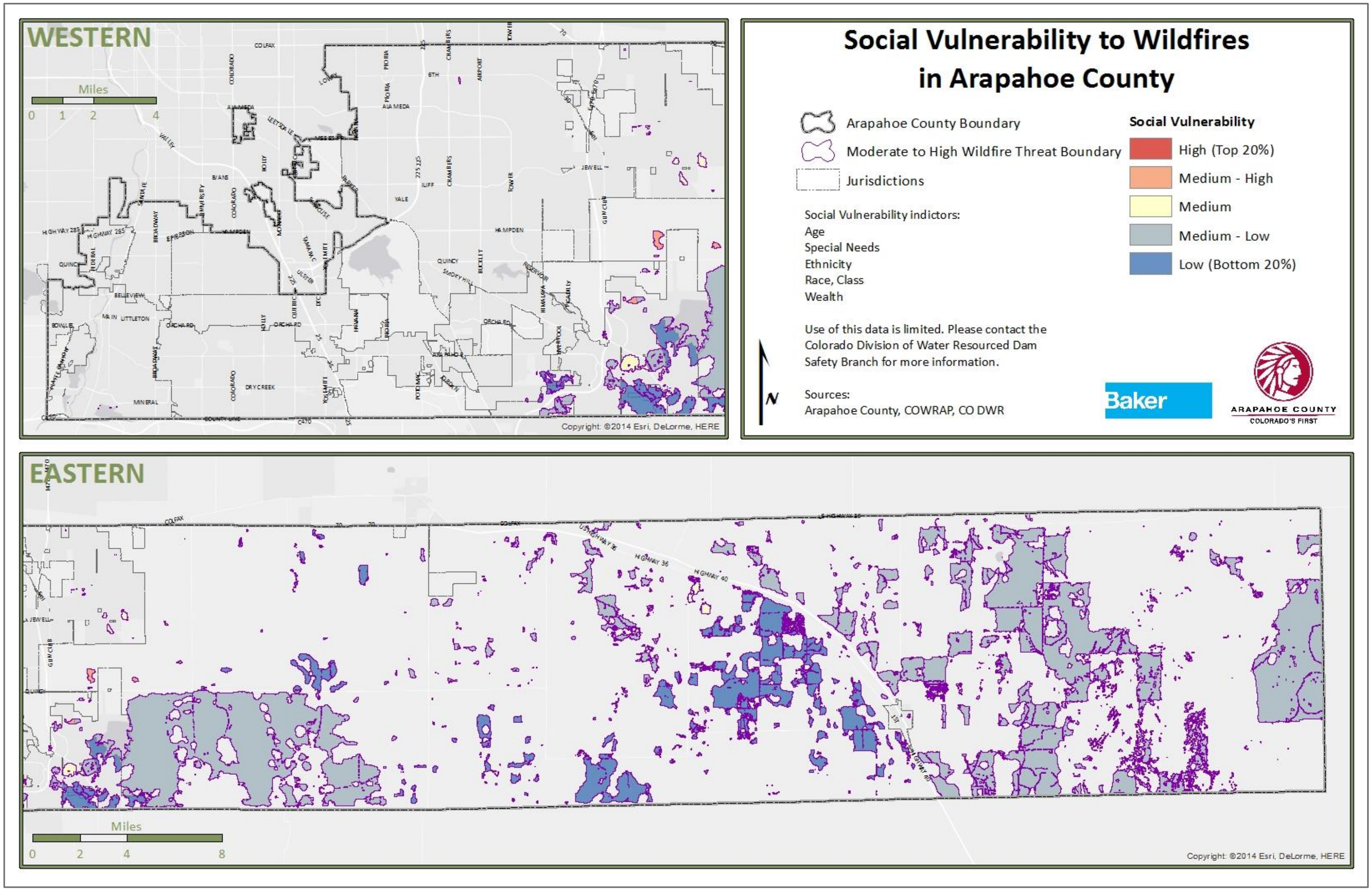


Figure 66. Map of Social Vulnerability to Wildfires

POTENTIAL LOSSES

Currently, there is no method for estimating wildfire loss. In most cases, the emergency management community equates potential losses to assets exposed to wildfire as a method of quantifying and comparing potential losses across communities. The exposure data provided in the previous section (Inventory Assets Exposed) provides the clearest picture of potential losses to wildfire in Arapahoe County.

LAND USE & DEVELOPMENT TRENDS

Future development is an important factor to consider in the context of wildfire mitigation because development and population growth can contribute to increased exposure of people and property to wildfire. During the past few decades, population growth in the Arapahoe County WUI has increased greatly. Subdivisions and other high-density developments have created a situation where wildland fires can involve more buildings than any amount of fire equipment can possibly protect.

By identifying areas with significant potential for population growth and/or future development in high-risk areas, communities can identify areas of mitigation interest and reduce hazard risks associated with increased exposure.

The following map depicts current Planning Reserve areas within Arapahoe County and areas of wildfire risk within the WUI. The Planning Reserve areas represent designated areas of future growth identified by the Arapahoe County Comprehensive Plan. When wildfire risk and areas of future development are overlaid on the map, we see a pattern of development in a number of high-risk areas, particularly along the I-70 corridor. In the future, when discussing wildfire mitigation actions in these areas, building codes related to new development deserve special consideration.

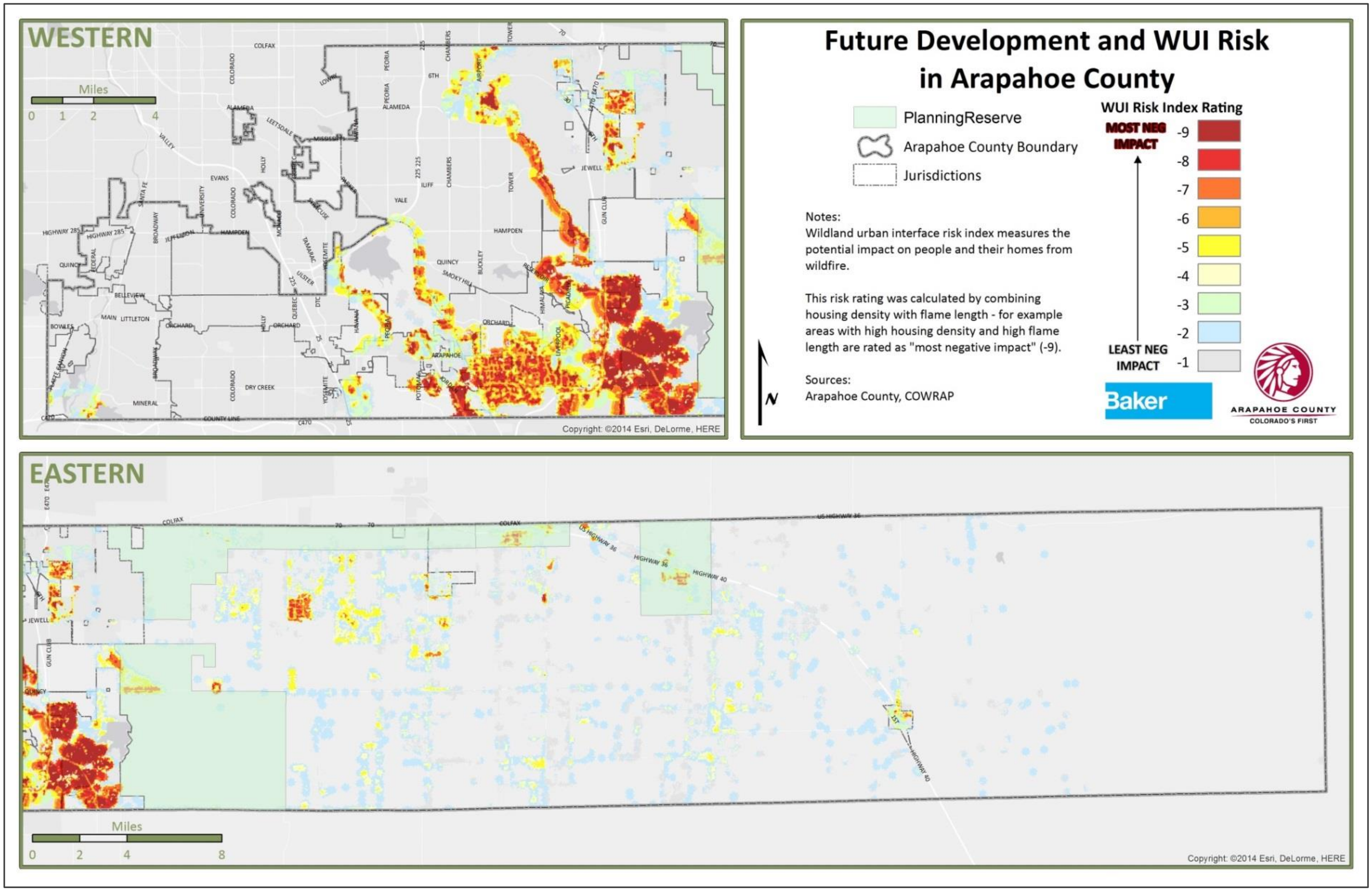


Figure 67. Map of Wildfire Risk and Future Development

MULTI-JURISDICTIONAL DIFFERENCES

Wildfires can occur at any time of day and during any month of the year. Moreover, the length of a wildfire season and/or peak months may vary appreciably from year to year. As evidenced by the wildfire risk assessment, areas within Arapahoe County that are characterized by dense development and single family homes along the wildland-urban interface are most vulnerable to wildfire. The map of Wildland-Urban Interface Risk illustrates the difference in wildfire risk between jurisdictions within the County. The jurisdictions with the highest WUI Risk Index rating include areas of Centennial, Aurora, Greenwood Village and portions of unincorporated Arapahoe County located along the I-70 corridor.

The following table shows the number and length of critical facilities and fuel lines that are exposed to Moderate – High wildfire threat throughout the County. Although the majority of jurisdictions within Arapahoe County do not have any exposed facilities, both Aurora and Areas of Unincorporated Arapahoe County have critical assets located in Moderate – High threat areas.

Table 110. Number of Critical Facilities Located in Moderate – High Wildfire Threat Areas

Jurisdiction	Critical Facilities (Count)	Lines (Count and Miles)
Aurora	6 (critical facilities within Arapahoe County)	4 fuel lines (1.2 total miles exposed)
Bennett	0	0
Bow Mar	0	0
Centennial	0	0
Cherry Hills Village	0	0
Columbine Valley	0	0
Deer Trail	0	0
Englewood	0	0

Jurisdiction	Critical Facilities (Count)	Lines (Count and Miles)
Foxfield	0	0
Glendale	0	0
Greenwood Village	0	0
Littleton	0	0
Sheridan	0	0
Unincorporated Arapahoe County	6	7 fuel lines 9 railroad segments (6.2 total miles exposed)

HIRA SUMMARY

Figure 68. Wildfire mitigation activity in Arapahoe County

Recent wildfires and brush fires across Colorado have forced school closures, disrupted telephone services by burning fiber optic cables, damaged railroads and other infrastructure, and adversely affected tourism, outdoor recreation, and hunting. The likelihood of one of those fires attaining significant size and intensity is unpredictable and highly dependent on environmental conditions and firefighting response. Weather conditions, particularly drought events, increase the likelihood of wildfires occurring. That said, it is important to note that 98% of wildfires are human-caused. Ultimately, the occurrence of future wildfire events will strongly depend on patterns of human activity and events are more likely to occur in wildfire-prone areas experiencing new or additional development.

As development expands into wildland areas, people and property are increasingly at risk from wildfire. Wildfire mitigation in the wildland-urban interface has primarily been the responsibility of property owners who choose to build and live in vulnerable zones. In practice, successful wildfire mitigation strategies can be quite involved. The most important aspect of successful suppression is disruption of the continuity of fuels, achieved by creating breaks or defensible areas. For interface fires, where homes and other structures fill the space, fuel reduction is best accomplished before the fires begin.

Safety zones can be created around structures by reducing or eliminating brush, trees, and vegetation around a home or facility. FEMA recommends using a 30-foot safety zone; including keeping grass below 2 feet tall and clearing all fallen leaves and branches promptly. Additionally, only fire-resistant or non-combustible materials should be used on roofs and exterior surfaces. Firebreaks -- areas of inflammable materials that create a fuel break and reduce the ability for fires to spread and roads and pathways -- can be planned and designed to serve as wildfire mitigation.

2015 - 2020 HIRA SUMMARY

Over time, accepted risk assessment methodologies evolve, develop, and grow. Data availability also tends to change as funding shifts and technological improvements emerge. For this reason, it is important to incorporate best available data and analysis strategies when formulating a comprehensive mitigation plan. The table below summarizes the vulnerability and loss estimation methodologies used in the 2010 DRCOG Denver Regional Natural Hazard Mitigation Plan and presents the updated methodologies used for the 2015 Arapahoe County Multi-Hazard Mitigation Plan. This table highlights the progress of Arapahoe County's Hazard Mitigation Planning efforts over time and will provide a record of planning activity for future mitigation planning projects in the County.

Table 111. Summary of Vulnerability Analysis and Loss Estimation Methodologies

	2010 DRCOG Denver Regional Natural Hazard Mitigation Plan	**2015 Arapahoe County Multi-Hazard Mitigation Plan**
Atmospheric Hazards		
Extreme Temperatures	*Vulnerability Analysis* (Heat and Cold): Data tables of historically affected counties (Source: NOAA NCDC) *Loss Estimation* (Heat and Cold): Narrative	*Vulnerability Analysis* (Heat and Cold): Assessment of historical extreme heat events based on data supplied by the National Weather Service and the USDA NRCS. *Loss Estimation* (Heat and Cold): Narrative.
Severe Storm: Hail/Lightning/ Snow	Hail *Vulnerability Analysis*: Obtained point locations for large hailstorms (with an average hail stone size of 1 inch) in the region using Severe Plot 2.0 (Source: NOAA). *Loss Estimation*: Assessment of historical hail losses based on data supplied by SHELDUS Lightning *Vulnerability Analysis:* Assessment of historical injuries and fatalities	Hail *Vulnerability Analysis:* Assessment of historical hail events based on data supplied by the Storm Prediction Center. *Loss Estimation:* Narrative, including projections for future losses based on historical data supplied by the Storm Prediction Center. Lightning

	2010 DRCOG Denver Regional Natural Hazard Mitigation Plan	2015 Arapahoe County Multi-Hazard Mitigation Plan
	based on data supplied by NWS CO Lightning Resource Center *Loss Estimation:* Narrative based on data supplied by NOAA Snow *Vulnerability Analysis:* Assessment of historical events based on data supplied by SHELDUS *Loss Estimation:* Assessment of historical losses from snow storms based on data supplied by SHELDUS	*Vulnerability Analysis*: Assessment of historical lightning events based on data supplied by the Storm Prediction Center. *Loss Estimation:* Narrative including projections for future losses based on historical data supplied by the Storm Prediction Center. Winter Storm *Vulnerability Analysis:* Assessment of historical winter storm events based on data supplied by Storm Prediction Center. *Loss Estimation:* Narrative including projections for future losses based on historical data supplied by the Storm Prediction Center.
Severe Wind/Tornado	Severe Wind/Tornado *Vulnerability Analysis:* Obtained point locations for tornados and high wind events in the region using Severe Plot 2.0 (NOAA). *Loss Estimation:* Assessment of historical losses from severe wind and tornadoes based on data supplied by SHELDUS	Severe Wind *Vulnerability Analysis:* Assessment of historical severe wind events based on data supplied by the Storm Prediction Center. *Loss Estimation*: Narrative including projections for future losses based on historical data supplied by the Storm Prediction Center. Tornado

	2010 DRCOG Denver Regional Natural Hazard Mitigation Plan	2015 Arapahoe County Multi-Hazard Mitigation Plan
		Vulnerability Analysis: Assessment of historical tornado events based on data supplied by the Storm Prediction Center. *Loss Estimation*: Narrative including projections for future losses based on historical data supplied by the Storm Prediction Center.
Drought	*Vulnerability Analysis:* Cited various drought indices including Palmer Drought Index, Standardized Precipitation Index, and the Surface Water Supply Index, as well as the CSU Technical Report, Historical Dry and Wed Periods in Colorado, 1999 (data provided by NOAA, NCDC) Loss Estimation: Narrative	*Vulnerability Analysis:* Assessment of historical drought events based on data supplied by CO Drought Mitigation and Response Plan (2010), NCDC, and the Colorado Climate Center. *Loss Estimation:* Narrative, references drought impact analysis contained in Annex B of the Colorado Drought Mitigation Response Plan.
Flood	*Vulnerability Analysis:* GIS analysis using 100-yr flood areas taken from DFIRMs. An updated DFIRM was unavailable for Arapahoe County and digital Q3 data of FEMA FIRMs was used instead. *Loss Estimation*: A HAZUS Flood Model was used to estimate flood depths. Where DFIRMS and FEMA Q3 was not available, DRCOG staff created flood hazard areas using the USGS National Hydrography Dataset (NHD).	*Vulnerability Analysis*: Hazus Level 2 analysis using: flooding depth grids produced from FEMA defined 100-yr floodplains supplemented by available FHADs and Hazus 100-yr floodplains, best available LiDAR and DEMs terrain coverages, FEMA Region VIII updated site-specific building inventory derived from local, state, and federal data sources. User defined Hazus Level 2 analysis for critical facilities. Analysis of social vulnerability present in high hazard areas for flooding. *Loss Estimation:* Hazus Level 2 analysis using: FEMA defined 100-yr floodplains

	2010 DRCOG Denver Regional Natural Hazard Mitigation Plan	2015 Arapahoe County Multi-Hazard Mitigation Plan
		supplemented by available FHADs and Hazus 100-yr floodplains, best available LiDAR and DEMs terrain coverages, FEMA Region VIII updated building inventory derived from local, state, and federal data sources. User defined Hazus Level 2 analysis for critical facilities.
Geologic Hazards		
Earthquake	*Vulnerability Analysis*: An earthquake event was modeled using HAZUS 99 *Loss Estimation:* Utilized HAZUS scenarios to estimate the number and type of buildings damaged and estimated number of people injured or killed by an earthquake in a likely "worst case scenario". A magnitude 6.2 earthquake was modeled and located at the site where several other regional earthquakes have occurred in the past on and near the Rocky Mountain Arsenal in Adams County.	*Vulnerability Analysis:* Hazus Level 2 analysis using: CGS fault, soil, and landslide inputs and FEMA Region VIII updated site-specific building inventory derived from local, state, and federal data sources. User defined Hazus Level 2 analysis for critical facilities. Analysis of social vulnerability present in high hazard areas for earthquake. *Loss Estimation:* Hazus Level 2 analysis using: CGS fault, soil, and landslide inputs and FEMA Region VIII updated building inventory derived from local, state, and federal data sources. User defined Hazus Level 2 analysis for critical facilities.
Erosion / Land Subsidence	*Vulnerability Analysis:* Narrative (CGS and County Land Use Departments)	*Vulnerability Analysis:* Narrative (CGS and County Land Use Departments)

	2010 DRCOG Denver Regional Natural Hazard Mitigation Plan	2015 Arapahoe County Multi-Hazard Mitigation Plan
	Loss Estimation: Narrative	*Loss Estimation:* Narrative.
Other Hazards		
Wildfire	*Vulnerability Analysis:* GIS analysis of Colorado land cover layer (USGS: 2001) to identify vulnerable areas; a review of previous occurrences identified in the 2007 CO wildfire hazard mitigation plan and 2009 CSFS Fire Report; 1999 CO OEM data on "percentage of acres at risk for wildfire by county"; GIS analysis of Colorado wildfire urban interface assessment; 2008 Colorado Wildfire Risk Assessment. *Loss Estimation:* Analysis of data on building content and value exposed to high risk wildfire zones by county (CSFS WUI Hazard Assessment).	*Vulnerability Analysis:* Utilizing data supplied by the Colorado State Forest Service, assessment of historical wildfire events and analysis of those areas vulnerable to wildfire threat and risk, and also specifically the WUI. Analysis of social vulnerability present in high hazard areas. References analysis included in the Eastern Arapahoe County CWPP (December 2012). *Loss Estimation:* Analysis of counts and associated replacement costs of county and public assets, including critical facilities that are exposed to wildfire vulnerability as defined by the Colorado State Forest Service.
Public Health Hazards	*Vulnerability Analysis:* Narrative based on historical data (Colorado CDPHE; US CDC; USGS) *Loss Estimation:* Narrative	*Vulnerability Analysis:* Social vulnerability analysis, estimated # of episodes of illness, healthcare utilization, and death associated with moderate and severe pandemic influenza scenarios in Colorado (Source: CO-specific Census data in the CDC's FluAid program) *Loss Estimation:* Assessment of loss using CDC's FluWorkLoss 1.0 tool. The tool estimates the potential number of days lost from work due to a pandemic

The following table displays summary data for each of the nine hazards profiled in Chapter 2 of the Plan. The table facilitates comparison between hazards in terms of their historic recurrence intervals and anticipated historic frequencies.

Table 112. Hazard Frequency Analysis

HAZARD	# EVENTS ON HISTORIC RECORD	# YEARS ON HISTORIC RECORD	HISTORIC RECURRENCE INTERVAL (YEARS)	HISTORIC FREQUENCY % (CHANCE PER YEAR)
Drought	7	121	17.30	6%
Earthquake	0	53	NA	-
Erosion/Land Subsidence	0	53	NA	-
Extreme Temperatures				
Cold	20	17	0.85	100%
Heat	720	53	0.07	100%
Flooding	14	63	4.50	25%
Public Health Hazards	5329	5	0.01	100%
Severe Storm				
Hail	10	53	5.30	20%
Lightning	27	53	1.90	50%
Snow	44	53	1.20	85%
Severe Wind	66	49	0.74	100%
Tornado	64	49	0.77	100%
Wildfire	2,455	10	0.0004	100%

After review of the available local, state, and national risk datasets, it can be reasonably assumed that extreme temperatures, public health hazards, severe storms, and severe wind events can be expected on an annual basis throughout Arapahoe County. The individual hazard risk assessments illustrate a clear pattern in which damages and losses are clustered around the most populated areas of the county (primarily the jurisdictions in the western region of the County). At the County level, the areas of elevated hazard risk are those places where resources and people are concentrated. Because these areas have high potential for loss, mitigation resources must be strategically allocated in order to sufficiently serve the most at-risk communities while simultaneously mitigating risk in rural, sparsely populated communities.

CHAPTER 3: HAZARD MITIGATION GOALS, OBJECTIVES AND ACTIONS

This section of the Plan provides the blueprint for Arapahoe County and participating municipalities to become less vulnerable to natural hazards. It is based on the general consensus of the Arapahoe County MPWG and local stakeholder feedback along with the findings of the Hazard Identification and Risk Assessment. This section consists of the following subsections:

- INTRODUCTION
- GOALS AND OBJECTIVES SUMMARY
- COMMUNITY VALUES, HISTORIC AND SPECIAL CONSIDERATIONS
- 2010 ARAPAHOE COUNTY HAZARD MITIGATION ACTION REPORT
- 2015 - 2020 ARAPAHOE COUNTY HAZARD MITIGATION ACTIONS

INTRODUCTION

The intent of the Mitigation Strategy is to provide Arapahoe County and participating municipalities with the goals that will serve as the guiding principles for future mitigation policy and project administration, along with a list of proposed actions deemed necessary to meet those goals and reduce the impact of natural hazards. It is designed to be comprehensive and strategic in nature. The development of the strategy included a thorough review of natural hazards and identified policies and projects intended to not only reduce the future impacts of hazards, but also to help Arapahoe County and participating municipalities achieve compatible economic, environmental, and social goals. The development of this section is also intended to be strategic, in that all policies and projects are linked to establish priorities assigned to specific departments or individuals responsible for their implementation. Potential funding sources are identified when possible and identified projects were assumed to be realistically achievable over the coming five years.

- *Mitigation goals* are general guidelines that explain what the county wants to achieve. Goals are usually expressed as broad policy statements representing desired long-term results.
- *Mitigation objectives* describe strategies or implementation steps to attain the identified goals. Objectives are more specific statements than goals; the described steps are usually measurable and can have a defined completion date.
- *Mitigation Actions* provide more detailed descriptions of specific work tasks to help the county and its municipalities achieve prescribed goals and objectives.

Based on participation from the Arapahoe County MPWG, the mitigation strategy from the 2010 DRCOG Plan was modified and updated. Objectives were clarified to better document roles and responsibilities. Completed actions were noted and deleted. New actions have been added to address particular hazards facing Arapahoe County and the consensus achieved in how to address those actions.

Prioritizing mitigation actions for each jurisdiction was completed using FEMA's STAPLEE methodology. The STAPLEE approach allows for a careful review of the feasibility of mitigation actions by using seven criteria. The criteria are described below:

- *S - Social*
- *T - Technical*
- *A - Administrative*
- *P - Political*
- *L - Legal*
- *E - Economic*
- *E - Environmental*

FEMA mitigation planning requirements indicate that any prioritization system used shall include a special emphasis on the extent to which benefits are maximized according to a cost-benefit review of the proposed projects. To do this in an efficient manner that is consistent with FEMA's guidance on using cost-benefit review in mitigation planning, the STAPLEE method was adapted to include a higher weighting (x1.5) for the economic feasibility factor – Cost Effective. This method incorporates concepts similar to those described in Method C of FEMA 386-5: Using Benefit Cost Review in Mitigation Planning (FEMA, 2007).

For the individual actions, a STAPLEE score was calculated based on the number of favorable (+1), un-favorable (-1), or neutral (0) considerations that can be found on the STAPLEE document. Twelve considerations were used to prioritize each action using this evaluation methodology, which included:

- Social
    - Community Acceptance
    - Effect on Segment of Population
- Technical
    - Technically Feasible
    - Long-Term Solution
- Administrative
    - Staffing Capability (included maintenance)
- Political
    - Political Support
- Legal
    - Local Authority
- Economic
    - Cost Effective
    - Contributes to Economic Goals
- Environmental
    - Effect of Environment and Species

- Consistent with Community Environmental Goals
- Other
    - Advances Other Community Objectives

In order to ensure that a broad range of mitigation actions were considered, the Arapahoe County MPWG analyzed a comprehensive range of specific mitigation actions for each hazard after it had completed the risk assessment. This helped to ensure that there was sufficient span and creativity in the mitigation actions considered.

There are six categories of mitigation actions which Arapahoe County considered in developing its mitigation action plan. Those categories include:

- **Prevention**: Government administrative or regulatory actions or processes that influence the way land and buildings are developed and built. These actions also include public activities to reduce hazard losses. Examples include planning, zoning, building codes, subdivision regulations, hazard specific regulations (such as floodplain regulations), capital improvement programs, and open-space preservation and stormwater regulations.
    - *Planning and zoning*
    - *Building codes*
    - *Open space preservation*
    - *Floodplain regulations*
    - *Stormwater management regulations*
    - *Drainage system maintenance*
    - *Capital improvement programming*
    - *Riverine setbacks*

- **Property Protection**: Actions that involve modifying or removing existing buildings or infrastructure to protect them from a hazard. Examples include the acquisition, elevation and relocation of structures, structural retrofits, flood-proofing, storm shutters, and shatter resistant glass. This category also includes insurance.
    - *Acquisition*
    - *Relocation*
    - *Building elevation*
    - *Critical facilities protection*
    - *Retrofitting (i.e. wind-proofing, flood-proofing, etc.)*
    - *Safe rooms, shutters, shatter-resistant glass*
    - *Insurance*

- **Public Education and Awareness:** Actions to inform and educate citizens, elected officials, and property owners about potential risks from hazards and potential ways to mitigate them. Such actions include hazard mapping, outreach projects, library materials dissemination, real estate disclosures, the creation of hazard information centers, and school age / adult education programs.

- *Outreach projects*
- *Speaker series/demonstration events*
- *Hazard mapping*
- *Real estate disclosure*
- *Library materials*
- *School children educational programs*
- *Hazard expositions*
- *Inter-governmental coordination*

- **Natural Resource Protection**: Actions that in addition to minimizing hazard losses also preserve or restore the functions of natural systems. These actions include sediment and erosion control, stream corridor restoration, forest and vegetation management, wetlands restoration or preservation, slope stabilization, and historic property and archeological site preservation.
  - *Land acquisition*
  - *Floodplain protection*
  - *Watershed management*
  - *Riparian buffers*
  - *Forest and vegetative management*
  - *Erosion and sediment control*
  - *Wetland preservation and restoration*
  - *Habitat preservation*
  - *Slope stabilization*
  - *Historic properties and archaeological site preservation*

- **Structural Project Implementation**: Mitigation projects intended to lessen the impact of a hazard by using structures to modify the environment. Structures include stormwater controls (culverts); dams, dikes, and levees; and safe rooms.
  - *Reservoirs*
  - *Dams/levees/dikes/floodwalls*
  - *Diversions/detention/retention*
  - *Channel modification*
  - *Storm Sewers*

- **Emergency Services**: Actions that typically are not considered mitigation techniques but reduce the impacts of a hazard event on people and property. These actions are often taken prior to, during, or in response to an emergency or disaster. Examples include warning systems, evacuation planning and management, emergency response training and exercises, and emergency flood protection procedures.

- *Warning systems*
- *Evacuation planning and management*
- *Emergency response training and exercises*
- *Sandbagging for flood protection*
- *Installing temporary shutters for wind protection*

GOALS AND OBJECTIVES SUMMARY

The following Table provides an update summary of the goals identified within the 2010 Denver Regional Hazard Mitigation Plan and of how they were incorporated into the 2015 Arapahoe County Hazard Mitigation Plan. Mitigation objectives were not clearly defined in the 2010 Plan, however, the updated 2015 Arapahoe County Multi-Hazard Mitigation Plan includes clear planning objectives laid out by the MPWG.

Table 113. Goals – 2010 Denver Regional Hazard Mitigation Plan

Goal	Goal	Continue	Change	Delete
1	Protect people, property, and natural resources.		X	
2	To increase public awareness of natural hazards and their mitigation.	X		
3	Strengthen communication and coordination among public agencies, non-governmental organizations (NGOs), businesses, and private citizens.	X		
4	Coordinate and integrate natural hazard mitigation activities with local land development planning activities and emergency operations planning.		X	

Mitigation Goals are general guidelines that explain what a community wants to achieve with their local hazard mitigation plan. Goals are overarching targets and describe the ideal long-term outcomes envisioned by the community. In 2014, Arapahoe County identified the following five mitigation goals as the foundation of their local mitigation strategy:

- **GOAL 1:** To prevent the loss of lives and injuries from hazards
- **GOAL 2:** To prevent or reduce damages to public and private property from hazards
- **GOAL 3:** To strengthen communication and coordination among public agencies, non-governmental organizations (NGOs), businesses, and private citizens

- **GOAL 4:** To reduce the adverse economic and natural resource impacts of hazards
- **GOAL 5:** To improve local resiliency to hazard events

More specific than Goals, Mitigation Objectives are the fundamental strategies prescribed by the Plan to achieve the identified Goals. In other words, Objectives are the "how" of the mitigation strategy.

- **OBJECTIVE 1:** Reduce public exposure to hazards
- **OBJECTIVE 2:** Increase knowledge of hazard mitigation options
- **OBJECTIVE 3:** Increase awareness of hazards and their impacts
- **OBJECTIVE 4:** Adopt a coordinated alert system for jurisdictions within the County
- **OBJECTIVE 5:** Build redundancy into communication systems

In order to maintain continuity within the local mitigation strategy, each mitigation objective is associated with one or more mitigation goals (as is shown in the following Table). This helps communities stay on track during the development of the mitigation strategy and focus their planning efforts around clear priorities. Together, the goals and objectives identified during the Arapahoe County mitigation strategy meeting and refined over the course of the planning process established the scope and focus of the proposed mitigation actions outlined in this Plan.

The next Table provides a summary of the updated and/or revised mitigation goals for the 2015 Plan. It also outlines the planning objectives identified by the MPWG for each goal and identifies whether the Goal is new to Arapahoe County or is instead derived from the 2010 DRCOG Regional Hazard Mitigation Plan.

Table 114. 2015 Arapahoe County Mitigation Strategy – Updated Goals and Objectives

Goal	Objective	New
GOAL 1: Prevent the loss of lives and injuries from hazards.	1. Reduce public exposure to hazards	
	2. Increase knowledge of hazard mitigation options	
	3. Increase awareness of hazards and their impacts	
	4. Adopt a coordinated alert system for jurisdictions within the County	
	5. Build redundancy into communication systems	
GOAL 2: Prevent and/or reduce damages to public and private property from hazards.	1. Reduce public exposure to hazards	
	2. Increase knowledge of hazard mitigation options	

Goal	Objective	New
	3. Increase awareness of hazards and their impacts	
	4. Adopt a coordinated alert system for jurisdictions within the County	
	5. Build redundancy into communication systems	
GOAL 3: Strengthen communication and coordination among public agencies, non-governmental organizations (NGOs), businesses, and private citizens.	4. Adopt a coordinated alert system for jurisdictions within the County	
	5. Build redundancy into communication systems	
GOAL 4: Reduce the adverse economic and natural resource impacts of hazards.	1. Reduce public exposure to hazards	X
	2. Increase knowledge of hazard mitigation options	
	3. Increase awareness of hazards and their impacts	
GOAL 5: Improve local resiliency to hazard events.	1. Reduce public exposure to hazards	X
	2. Increase knowledge of hazard mitigation options	
	3. Increase awareness of hazards and their impacts	
	4. Adopt a coordinated alert system for jurisdictions within the County	
	5. Build redundancy into communication systems	

COMMUNITY VALUES, HISTORIC AND SPECIAL CONSIDERATIONS

Historic resources include landmarks buildings, historic structures and sites, commercial and residential districts, historic rural resources, archaeological and cultural sites, and the historic environment in which they exist. Historic resources serve as visual reminders of a community's past, providing a link to its development. Preservation of these important resources makes it possible for them to continue to play an integral, vital role in the community. Currently, Arapahoe County has twenty properties listed on the National Register of Historic Places and four Historic Districts.

Depending on the number of historic resources within a community, it can be unrealistic to assume that all of the necessary mitigation activities can be taken to protect these resources. Historic preservation and protection work must be done in a manner that retains the character-defining features of a historic property. Because this work can be costly, it is important to set priorities in terms of which resources and mitigation projects should become the point of focus. Arapahoe County realizes that the preservation and maintenance historic sites and structures contributes to the cultural heritage of Colorado's first county and is in the long-term best interest of the community.

2010 ARAPAHOE COUNTY HAZARD MITIGATION ACTION REPORT

The MPWG reviewed those actions in the 2010 DRCOG Plan that were specific to Arapahoe County and its municipalities. The following Table presents those actions and reports on the status of each. Of the eight (8) overall actions specific to participants of the 2015 Arapahoe County Plan, 50% were noted as being complete. Four actions are currently in-progress/on-going and one was noted as no longer being applicable.

Table 115. 2010 Hazard Mitigation Strategy Actions

Number	Action	Project Need and Location	Responsible Agencies L- Lead Agency S – Support Agency	Status & Notes
2010-01	Incorporate planning and zoning land development regulations (NFIP Action)	Update land development code re: stormwater drainage and floods; Riparian areas of Arapahoe County	Planning Division (L) Engineering Services Division (S)	Completed - identified in 2004 Plan and reported completed in the 2010 Plan.
2010-02	2015 Hazard Mitigation Plan Update	Funding to conduct the creation of a stand-alone HMP for Arapahoe County (not a regional plan), while updating and incorporating the information already present in the regional plan and ensuring continuity of mitigation projects and procedures from earlier efforts	Arapahoe County Office of Emergency Management (L)	Completed - as part of the 2015 Plan Update

Number	Action	Project Need and Location	Responsible Agencies L- Lead Agency S – Support Agency	Status & Notes
2010-03	Update EOC Backup Power Systems	Run power supplies from the EOC to the generator to ensure full backup power for all equipment (including: lights, computers printers, phones, charging stations, televisions, radios, projectors, and other equipment activated as needed) to increase the resilience of the facility -- Arapahoe County Sheriff's Office Connect generator to the City of Englewood's Emergency Operation Center	Arapahoe County Office of Emergency Management (L) City of Englewood (S)	In Progress / Ongoing - Arapahoe County project scope has expanded to include the entire building (estimated completion 2015) Complete - Englewood EOC is now connected to a generator
2010-04	Produce/acquire hazards-related data sets in GIS format	Hire a consultant to work with GIS department to obtain new hazard data for identified hazards and integrate the information into a GIS format for use in future hazard mitigation projects and planning efforts. The lack of this data was identified as a significant barrier in the 2010 mitigation update process -- County wide	Arapahoe County Office of Emergency Management (L) Arapahoe County GIS(S)	Completed - as part of the 2015 Plan Update
2010-05	Continued National Flood Insurance Program (NFIP) Participation	**Multi-Jurisdiction Action** In coordination with the UDFCD, continue to participate in the NFIP by implementing and improving upon effective floodplain and stormwater management practices.	Project Lead not identified	In Progress / Ongoing - majority of jurisdictions continue to participate in the NFIP, discussions regarding additional jurisdictional participation ongoing.

Number	Action	Project Need and Location	Responsible Agencies L- Lead Agency S – Support Agency	Status & Notes
2010-06	Coordinate with local water providers to continually identify and promote water conservation measures, including but not limited to, incentive programs, water efficient appliances, xeriscaping and the use of recycled water where feasible.	**Multi-Jurisdiction Action**	Project Lead not identified	No Longer Applicable / Remove - It was determined that this action is being addressed by various water districts serving the County.
2010-07	Monitor proceedings of the Colorado Water Availability Task Force. When necessary, support water providers in the implementation of conservation measures	**Multi-Jurisdiction Action**	Project Lead not identified	In Progress / Ongoing - OEM will continue to monitor and support as necessary.
2010-08	Provide the DRCOG HMP to other departments for possible integration into various planning efforts	**Multi-Jurisdiction Action**	Emergency Manager	In Progress / Ongoing - OEM will continue to involve the Public Works and Planning Departments in all future Hazard Mitigation Planning activities.

2015 - 2020 ARAPAHOE COUNTY HAZARD MITIGATION ACTIONS

The last step in updating the Mitigation Strategy is the creation of jurisdictionally specific Mitigation Actions. In preparing their Mitigation Action, each jurisdiction considered their overall hazard risk and capability to mitigate identified hazards, in addition to meeting the adopted countywide mitigation goals. These actions represent the key outcome of the mitigation planning process. As detailed above, all actions were prioritized utilizing a modified STAPLEE ranking. All actions are tied to specific goals and objectives to ensure alignment with the Plan's overall mitigation strategy. In addition to the current status of each action, the responsible jurisdiction and entities are identified allowing for improved reporting and accountability. Actions from the 2010 Plan that are currently in-progress/on-going are also included below.

The following Tables each list the 2015 Hazard Mitigation Strategy Actions. The first table presents an overview of each action, followed by: additional notes, relationship to the overall mitigation strategy, and the STAPLEE score. The second table below includes information relating to the responsible party for each action and the current status of each mitigation effort.

Table 116. 2015 Hazard Mitigation Strategy Action Summary

Number	Action	Notes	Goal(s) Address	Objective(s) Addressed	STAPLEE SCORE
2010-03	Update EOC Backup Power Systems	Ongoing project scope has been expanded to include the entire building (estimated completion 2015).	3,5	4,5	5.5
2010-05	Continued National Flood Insurance Program (NFIP) Participation	Majority of jurisdictions continue to participate in the NFIP, additional jurisdictional participation added as new Plan Action in 2015.	1,2,3,4,5	1,3	12.5
2010-07	Monitor proceedings of the Colorado Water Availability Task Force.	When necessary, support water providers in the implementation of conservation measures.	2,3,4	3	9.5

Number	Action	Notes	Goal(s) Address	Objective(s) Addressed	STAPLEE SCORE
2010-08	Provide the DRCOG HMP to other departments for possible integration into various planning efforts	OEM will continue to involve the Public Works and Planning Departments in all future Hazard Mitigation Planning activities. Planning to incorporate HMP into upcoming Comprehensive Plan update.	3	2,3	9.5
2015-01	Improvements and updates to the County emergency notification system		1,2,3,4,5	1,3	10.5
2015-02	Improvements to Computer Aided Dispatch systems to ensure interoperability		1,2,3,4,5	1,3,4	5
2015-03	Ready, Set, Go Program		1,2,3,4,5	1,2,3,4	11.5
2015-04	Increase awareness and use of First Watch within Arapahoe County and support implementation in neighboring counties.	First Watch is a web based system that can aggregate and report out local agency dispatches.	1,2,3,4	1,2,3,4	6

Number	Action	Notes	Goal(s) Address	Objective(s) Addressed	STAPLEE SCORE
2015-05	Centralize the storage and dissemination of FOUO GIS data sets	To ensure the availability and improve the accuracy of data used across the County for numerous efforts.	1,2,3,4	2,3	7.5
2015-06	Develop, maintain, centralize, and store CIKR GIS data sets	To ensure the availability and improve the accuracy of data used across the County for numerous efforts.	1,2,3,4	2,3	7.5
2015-07	Continue coordination efforts pertaining to the upcoming Integrated Emergency Management Conference		3	2,3,5	9.5
2015-08	Town of Bennett to join the NFIP		1,2,3,4,5	1,3	8.5
2015-09	Continued utilization of the UDFCD alert system	Real-time alert system provides precipitation and flooding related notifications.	1,2,3,4,5	1,3,4	8.5

Number	Action	Notes	Goal(s) Address	Objective(s) Addressed	STAPLEE SCORE
2015-10	Involvement in the UDFCD Emergency Action Plans for the Holly & Englewood Dams	Participate in the roll-out of these newly produced EAPs.	1,2,3,4,5	1,2,3	8.5
2015-11	Participation and adoption of the UDFCD master plans affecting the County	Part of the master planning efforts involves identification of capital improvement projects and are based on future conditions hydrology (watershed level).	2,3,4,5	2,3	8.5
2015-12	Continued development of the Cherry Creek School District's collaboration meetings with first responders	Meetings are quarterly and currently involve 9 agencies across the District.	1,2,3,5	3,4	9.5
2015-13	Increase public awareness by utilizing the City's various social media and public events and trainings	Utilize the city's various social media and listservs to educate citizens on hazards and the recommended protective actions; host preparedness trainings and safety fairs for citizens. Possible funding: NCR Citizen Corps Grants, department budgets.	2,3,4	3	9.5

Number	Action	Notes	Goal(s) Address	Objective(s) Addressed	STAPLEE SCORE
2015-14	Implement Water Conservation Plan	Ensure Water Conservation Plan is implemented and citizens are educated on conservation measures.	4,5	1,2,3	7.5
2015-15	Create and consolidate a GIS vulnerability dataset	Consolidate various hazard maps to create one overall city-wide hazard vulnerability map. Possible funding: HMEP and department budgets.	3,5	3	9.5
2015-16	Conduct a risk assessment focused on the distribution of city resources	Complete a "Standards of Cover" study to ensure resources are distributed in the most efficient manner. Possible funding: EMPG.	1,2,3,4,5	1	9.5
2015-17	Implement continuity of data system for emergency management-related GIS databases and software	Currently negotiating remote backup data partnership agreement with State OIT.	3	3,5	8.5
2015-18	Update citywide addressing system	Enhancements to citywide addressing based on the City's two fire department dispatches.	1,2,3	1	9.5

Number	Action	Notes	Goal(s) Address	Objective(s) Addressed	STAPLEE SCORE
2015-19	Update contacts for Special Districts	Updating to ensure improved communication to stakeholders.	3	2,3,5	9.5
2015-20	Updating data sets relating to hazardous material locations, various community assets, and hydrology	Updated data to allow for improved future risk assessments and planning.	2,4	3	9.5
2015-21	Monitor Hazardous Materials commodity flow by rail through the BNSF and UP rail lines	Obtain and monitor commodity flow from the Burlington Northern Santa Fe and Union Pacific Railroads. Share that information with the Arapahoe County LEPC as appropriate	1,2,3,4,5	1,2,3	9.5
2015-22	Involvement in the Denver Water Emergency Action Plans for the Marston & Harriman Dams	Participate in the update and orientation of the Dam EAPs.	1,2,3,4,5	1,2,3	9.5
2015-23	Participation and adoption of the UDFCD Flood Hazard Area Delineation (FHAD) Studies affecting the County	New or updated flood risk areas are identified, providing communities with best available flood risk data for permitting and land development decisions.	1,2,3,4,5	1,3	9.5

Number	Action	Notes	Goal(s) Address	Objective(s) Addressed	STAPLEE SCORE
2015-24	Continue participation in the NFIP Community Rating System (CRS) Program	Flood Insurance premiums are reduced to reflect the reduced flood risk based on the community's floodplain management programs and activities	1,2,3,4,5	1,2,3,4,5	11.5
2015-25	Continued mowing/ maintenance of the WPA ditch and roadway for wildfire mitigation.	Preventative maintenance will assist with wildfire mitigation efforts.	1,2,3	1	9.5
2015-26	Participate in the UDFCD Program for Public Information (PPI) Committee	Project/Action already underway	1,2,3	2,3	8.5
2015-27	Improve County's Community Rating System Score (CRS)	May require Involvement of BoCC	1,2,4,5	1-5	11.5
2015-28	Wildfire Mitigation Planning	Mitigation Plans will be incorporated into Code by adoption of specific ordinance by the Town of Bennett.	1,2,3,4,5	1-5	9.5

Number	Action	Notes	Goal(s) Address	Objective(s) Addressed	STAPLEE SCORE
2015-29	Stormwater Drainage Master Plan	Town of Bennett	1-5	1-5	9.5
2015-30	Develop Engineering guidelines for drainage from new development	Town of Bow Mar	1,2,4,5	1,2,3	9.5
2015-31	Complete a drainage study for the Town of Bow Mar	Town of Bow Mar	1,2,3,4,5	1,2,3	9.5
2015-32	Enforcement of Floodplain Regulations to limit development in floodplain areas	Cherry Hills Village; Codes already adopted, will continue to enforce.	1,2,4,5	1	7
2015-33	Adopt and Enforce 2012 International Building Codes	Cherry Hills Village; Codes already adopted, will continue to enforce.	1,2,4,5	1	6.5

Number	Action	Notes	Goal(s) Address	Objective(s) Addressed	STAPLEE SCORE
2015-34	Conduct winter weather risk awareness activities through a three-phased approach using the town newsletter, website, and community/HOA meetings.	Town of Columbine Valley	1,2,3,4,5	2,3,5	9.5
2015-35	Increase severe wind risk awareness through a three phased approach utilizing the newsletter, website, and community/HOA meetings.	Town of Columbine Valley	1,2,3,4,5	2,3,5	9.5
2015-36	Conduct lightning awareness programs through a three phased approach utilizing the newsletter, website, and community/HOA meetings.	Town of Columbine Valley	1,2,3,4,5	2,3,5	9.5
2015-37	Public information/awareness programs	City of Englewood	1,2,3,4,5	2,3,5	9.5
2015-38	Evacuation and shelter plan	City of Englewood	1,2,3,4,5	2,3,5	8.5

Number	Action	Notes	Goal(s) Address	Objective(s) Addressed	STAPLEE SCORE
2015-39	Working with our local fire district, publicizing fire bans and warnings, especially related to fireworks	Town of Foxfield	1,2,3,4,5	1,2,3	6.5
2015-40	Provide information to residents, perhaps by using Facebook and Twitter	Town of Foxfield	1,2,3,4,5	1,2,3,4,5	8.5
2015-41	Publicize sheriff's department Twitter account. Monitor snow removal practices and procedures to ensure adequacy. Serve as a clearinghouse for emergency announcements; making sure these are communicated to residents.	Town of Foxfield	1,2,3,4,5	1,2,3,4,5	8.5
2015-42	Continue/expand community-wide "Run-Hide-Fight-Treat" training	City of Glendale	1,2,3,4,5	1,2,3,4,5	8.5
2015-43	Increase participation in "reverse 911" opt-in	City of Glendale	1,2,3,4,5	1-5	8.5

Number	Action	Notes	Goal(s) Address	Objective(s) Addressed	STAPLEE SCORE
2015-44	Increase participation in "Ready Colorado"	City of Glendale	1,2,3,4,5	1-5	8.5
2015-45	Increase Severe Weather Risk Awareness - A multi-pronged approach to increase citizen awareness through a combination of the city newsletter, web site, social media and community/HOA/School presentations.	City of Greenwood Village	1,2,3,4,5	1,2,3,4,5	8.5
2015-46	Improve Citizen Knowledge and Understanding of Severe Weather Warning Systems in Place - Utilizing the city newsletter, web site, social media, community/HOA/school presentations and park signs, educate public on severe weather warning systems in place at city parks.	City of Greenwood Village	1,2,3,4,5	1,2,3,4,5	8.5
2015-47	Locate and identify tornado shelter areas in City of Littleton public buildings	City of Littleton	1,5	1,2	8.5

Number	Action	Notes	Goal(s) Address	Objective(s) Addressed	STAPLEE SCORE
2015-48	Work with railroads (BNSF and UP) to identify and then monitor hazardous commodity flows and hazards.	City of Littleton	1,2,3,4,5	1,2,3,4,5	6.5
2015-49	Identify evacuation shelters and evacuation routes.	City of Littleton	1,5	1,2	8.5
2015-50	River Run Park/ Rehab river banks and chutes	City of Sheridan	1,2,4,5	1	9
2015-51	Storm Water Evaluation/ Proposed new storm sewers and drainage in nine key areas	Sheridan	1,2,4,5	1	7
2015-52	Tri County Health Department Health Impact Assessment	Sheridan	1,3,5	2,3	7.5

Table 117. 2015 Hazard Mitigation Strategy Action Owners

Number	Action	Responsible Jurisdiction(s)	Responsible Entities L – Lead S - Support	Estimated Budget Category A - No cost B - $0-$10K C - $10K-$100K D - $100K+	Status -New -Deferred -In Progress/ Ongoing -Completed -Revised -No Longer Applicable/ Removed
2010-03	Update EOC Backup Power Systems	Arapahoe County	OEM	n/a	In Progress / Ongoing
2010-05	Continued National Flood Insurance Program (NFIP) Participation	City of Centennial, City of Cherry Hills Village, Town of Columbine Valley, Town of Deer Train, City of Englewood, City of Glendale, City of Greenwood Village, City of Littleton, City of Sheridan	Local Jurisdictions / Floodplain Administrators (L) OEM (S)	A	In Progress / Ongoing
2010-07	Monitor proceedings of the Colorado Water Availability Task Force.	Arapahoe County	OEM	A	In Progress / Ongoing

Number	Action	Responsible Jurisdiction(s)	Responsible Entities L – Lead S - Support	Estimated Budget Category A - No cost B - $0-$10K C - $10K-$100K D - $100K+	Status -New -Deferred -In Progress/ Ongoing -Completed -Revised -No Longer Applicable/ Removed
2010-08	Provide the DRCOG HMP to other departments for possible integration into various planning efforts	Arapahoe County	OEM	A	In Progress / Ongoing
2015-01	Improvements and updates to the County emergency notification system	Arapahoe County	OEM	B	New -In Progress / Ongoing
2015-02	Improvements to Computer Aided Dispatch systems to ensure interoperability	Arapahoe County	Local Fire Agencies	D	New -In Progress / Ongoing
2015-03	Ready, Set, Go Program	Arapahoe County	OEM (L) Local Fire Agencies (S)	B	New -In Progress / Ongoing
2015-04	Increase awareness and use of First Watch within Arapahoe County and support implementation in neighboring counties.	Arapahoe County	E911 Board	A	New -In Progress / Ongoing

Number	Action	Responsible Jurisdiction(s)	Responsible Entities L – Lead S - Support	Estimated Budget Category A - No cost B - $0-$10K C - $10K-$100K D - $100K+	Status -New -Deferred -In Progress/ Ongoing -Completed -Revised -No Longer Applicable/ Removed
2015-05	Centralize the storage and dissemination of FOUO GIS data sets	Arapahoe County	Arapahoe County GIS Department (L) OEM (S)	B	New
2015-06	Develop, maintain, centralize, and store CIKR GIS data sets	Arapahoe County	Arapahoe County GIS Department, OEM	B	New
2015-07	Continue coordination efforts pertaining to the upcoming Integrated Emergency Management Conference	Arapahoe County	OEM	B	New -In Progress / Ongoing
2015-26	Participate in the UDFCD Program for Public Information (PPI)Committee	Arapahoe County	Arapahoe County Public Works, SEMSWA and UDFCD	A	New
2015-27	Improve County's Community Rating System (CRS)	Arapahoe County	Arapahoe County Public Works, SEMSWA and UDFCD	B	New

Number	Action	Responsible Jurisdiction(s)	Responsible Entities L – Lead S - Support	Estimated Budget Category A - No cost B - $0-$10K C - $10K-$100K D - $100K+	Status -New -Deferred -In Progress/ Ongoing -Completed -Revised -No Longer Applicable/ Removed
2015-08	Town of Bennett to join the NFIP	Town of Bennett	Town of Bennett (L) Arapahoe County Floodplain Administrator (S)	A	New
2015-28	Wildfire Mitigation Planning	Town of Bennett	Chief Earl Cumley - Bennett Fire Protection District	C	New
2015-29	Stormwater Drainage Master Plan	Town of Bennett	Daymon Johnson - Town Public Works Director	C	New
2015-09	Continued utilization of the UDFCD alert system	Arapahoe County	OEM	A	New -In Progress / Ongoing
2015-10	Involvement in the UDFCD Emergency Action Plans for the Holly & Englewood Dams	Arapahoe County	OEM	A	New

Number	Action	Responsible Jurisdiction(s)	Responsible Entities L – Lead S - Support	Estimated Budget Category A - No cost B - $0-$10K C - $10K-$100K D - $100K+	Status -New -Deferred -In Progress/ Ongoing -Completed -Revised -No Longer Applicable/ Removed
2015-11	Participation and adoption of the UDFCD master plans affecting the County and its jurisdictions	Town of Bennett, Town of Bow Mar, City of Centennial, City of Cherry Hills Village, Town of Columbine Valley, City of Englewood, Town of Foxfield, City of Sheridan, City of Glendale, City of Greenwood Village, City of Littleton, Arapahoe County	Town of Bennett, Town of Bow Mar, City of Centennial, City of Cherry Hills Village, Town of Columbine Valley, Town of Foxfield, City of Sheridan, City of Glendale, City of Greenwood Village, City of Littleton, City of Englewood, Arapahoe County (L) OEM (S)	A	New
2015-12	Continued development of the Cherry Creek School District's collaboration meetings with first responders	Arapahoe County, Cherry Creek School District	Cherry Creek School District	A	New -In Progress / Ongoing
2015-30	Develop engineering guidelines for drainage from new development	Town of Bow Mar	Our town Mayor or Public Works Commissioner	C	New

Number	Action	Responsible Jurisdiction(s)	Responsible Entities L – Lead S - Support	Estimated Budget Category A - No cost B - $0-$10K C - $10K-$100K D - $100K+	Status -New -Deferred -In Progress/ Ongoing -Completed -Revised -No Longer Applicable/ Removed
2015-31	Complete a drainage study for our town	Town of Bow Mar	Town Mayor or Public Works Commissioner	C	New
2015-32	Implement continuity data system for EM related GIS databases and software	The City of Centennial	The City of Centennial	C	New
2015-33	Update City addressing system	The City of Centennial	The City of Centennial	B	New
2015-34	Update contacts for special districts, update data sets relating to hazardous material locations, various community assets, and hydrology	The City of Centennial	The City of Centennial	B	New
2015-35	Enforcement of Floodplain Regulations to limit development in floodplain areas	Cherry Hills Village	Community Development Department - Robert Zuccaro	C	New

Number	Action	Responsible Jurisdiction(s)	Responsible Entities L – Lead S - Support	Estimated Budget Category A - No cost B - $0-$10K C - $10K-$100K D - $100K+	Status -New -Deferred -In Progress/ Ongoing -Completed -Revised -No Longer Applicable/ Removed
2015-36	Adopt and Enforce 2012 International Building Codes	Cherry Hills Village	Community Development Department - Robert Zuccaro	C	New
2015-37	Conduct winter weather risk awareness activities through a three-phased approach using the town newsletter, website, and community/HOA meetings.	Town of Columbine Valley	Town staff and consultants	B	New
2015-38	Increase severe wind risk awareness through a three phased approach utilizing the newsletter, website, and community/HOA meetings.	Town of Columbine Valley	Town staff and consultants	B	New
2015-39	Conduct lightning awareness programs through a three phased approach utilizing the newsletter, website, and community/HOA meetings.	Town of Columbine Valley	Town staff and consultants	B	New
2015-13	Increase public awareness by utilizing the City's various social media and public events and trainings	City of Englewood	Englewood OEM (S) Englewood Public Relations (L)	A	New

Number	Action	Responsible Jurisdiction(s)	Responsible Entities L – Lead S - Support	Estimated Budget Category A - No cost B - $0-$10K C - $10K-$100K D - $100K+	Status -New -Deferred -In Progress/ Ongoing -Completed -Revised -No Longer Applicable/ Removed
2015-14	Implement Water Conservation Plan	City of Englewood	Englewood Utilities	B	New
2015-15	Create and consolidate a GIS vulnerability dataset	City of Englewood	Englewood OEM (L) GIS Department (S)	B	New
2015-16	Conduct a risk assessment focused on the distribution of city resources	City of Englewood	Englewood Fire (L) Community Development (S)	B	New
2015-40	Develop a Public information/awarenes s program	City of Englewood	Commander Tim Englert	B	New
2015-41	Develop an evacuation and shelter plan	City of Englewood	Commander Tim Englert	C	New

Number	Action	Responsible Jurisdiction(s)	Responsible Entities L – Lead S - Support	Estimated Budget Category A - No cost B - $0-$10K C - $10K-$100K D - $100K+	Status -New -Deferred -In Progress/ Ongoing -Completed -Revised -No Longer Applicable/ Removed
2015-17	Implement continuity of data system for emergency management-related GIS databases and software	City of Centennial	City of Centennial	B	New / Ongoing
2015-18	Update citywide addressing system	City of Centennial	City of Centennial	B	New
2015-19	Update contacts for Special Districts	City of Centennial	City of Centennial	A	New
2015-20	Updating data sets relating to hazardous material locations, various community assets, and hydrology	City of Centennial	City of Centennial	A	New
2015-21	Monitor Hazardous Materials commodity flow by rail through the BNSF and UP rail lines	Littleton, Arapahoe County	Arapahoe LEPC, Littleton	A	New -In Progress / Ongoing

Number	Action	Responsible Jurisdiction(s)	Responsible Entities L – Lead S - Support	Estimated Budget Category A - No cost B - $0-$10K C - $10K-$100K D - $100K+	Status -New -Deferred -In Progress/ Ongoing -Completed -Revised -No Longer Applicable/ Removed
2015-22	Involvement in the Denver Water Emergency Action Plans for the Marston & Harriman Dams	Littleton, Arapahoe County	Littleton, OEM	A	In Progress / Ongoing
2015-23	Participation and adoption of the UDFCD Flood Hazard Area Delineation (FHAD) Studies affecting the County	Local Jurisdictions, Arapahoe County	Local Jurisdictions (L) OEM (S)	A	In Progress / Ongoing
2015-24	Continue participation in the NFIP Community Rating System (CRS) Program	Arapahoe County, City of Centennial, City of Cherry Hills Village, City of Englewood and City of Littleton	Local Jurisdictions	A	In Progress / Ongoing
2015-25	Continued mowing/ maintenance of the WPA ditch and roadway for wildfire mitigation.	Town of Deer Trail	Town of Deer Trail - Kent Vashus	B	In Progress / Ongoing
2015-37	Public information/awareness programs	City of Englewood	Commander Tim Englert	B	New

Number	Action	Responsible Jurisdiction(s)	Responsible Entities L – Lead S - Support	Estimated Budget Category A - No cost B - $0-$10K C - $10K-$100K D - $100K+	Status -New -Deferred -In Progress/ Ongoing -Completed -Revised -No Longer Applicable/ Removed
2015-38	Evacuation and shelter plan	City of Englewood	Commander Tim Englert	B	New
2015-39	Working with our local fire district, publicizing fire bans and warnings, especially related to fireworks	Town of Foxfield	The Town Clerk (L) Sheriff's Department (S) The Fire District (S)	B	New
2015-40	Provide information to residents, perhaps by using Facebook and Twitter	Town of Foxfield	The Town Clerk (L) Sheriff's Department (S) The Fire District (S)	B	New
2015-41	Publicize sheriff's department Twitter account. Monitor snow removal practices and procedures to ensure adequacy. Serve as a clearinghouse for emergency announcements; making sure these are communicated to residents.	Town of Foxfield	The Town Clerk (L) Sheriff's Department (S) The Fire District (S)	B	New

Number	Action	Responsible Jurisdiction(s)	Responsible Entities L – Lead S - Support	Estimated Budget Category A - No cost B - $0-$10K C - $10K-$100K D - $100K+	Status -New -Deferred -In Progress/ Ongoing -Completed -Revised -No Longer Applicable/ Removed
2015-42	Continue/expand community-wide "Run-Hide-Fight-Treat" training	City of Glendale	Capt. Mike Gross	B	In Process/Ongoing
2015-43	Increase participation in "reverse 911" opt-in	City of Glendale	Lt. Jamie Dillon	B	In Process/Ongoing
2015-44	Increase participation in "Ready Colorado"	City of Glendale	Capt. Mike Gross	B	New
2015-45	Increase Severe Weather Risk Awareness - A multi-pronged approach to increase citizen awareness through a combination of the city newsletter, web site, social media and community/HOA/School presentations.	City of Greenwood Village	Commander Eric Schmitt	B	New

Number	Action	Responsible Jurisdiction(s)	Responsible Entities L – Lead S - Support	Estimated Budget Category A - No cost B - $0-$10K C - $10K-$100K D - $100K+	Status -New -Deferred -In Progress/ Ongoing -Completed -Revised -No Longer Applicable/ Removed
2015-46	Improve Citizen Knowledge and Understanding of Severe Weather Warning Systems in Place - Utilizing the city newsletter, web site, social media, community/HOA/school presentations and park signs, educate public on severe weather warning systems in place at city parks.	City of Greenwood Village	Commander Eric Schmitt	B	New
2015-47	Locate and identify tornado shelter areas in city of Littleton public buildings	City of Littleton	Captain Jim Olsen - Littleton Emergency Manager	B	New
2015-48	Work with railroads (BNSF and UP) to identify and then monitor hazardous commodity flows and hazards.	City of Littleton	Captain Jim Olsen - Littleton Emergency Manager	B	New
2015-49	Identify evacuation shelters and evacuation routes.	City of Littleton	Captain Jim Olsen - Littleton Emergency Manager	B	New

Number	Action	Responsible Jurisdiction(s)	Responsible Entities L – Lead S - Support	Estimated Budget Category A - No cost B - $0-$10K C - $10K-$100K D - $100K+	Status -New -Deferred -In Progress/ Ongoing -Completed -Revised -No Longer Applicable/ Removed
2015-50	River Run Park/ Rehab river banks and chutes	City of Sheridan	Army Corp of Engineers (S) Urban Drainage and Flood Control District (L)	C	New
2015-51	Storm Water Evaluation/ Proposed new storm sewers and drainage in nine key areas	City of Sheridan	Sheridan Public Works	C	New
2015-52	Tri County Health Department Health Impact Assessment	City of Sheridan	Tri County Health Department	B	New

CHAPTER 4: PLAN IMPLEMENTATION, CAPABILITIES, AND MAINTENANCE

This Chapter discusses how the Arapahoe County Mitigation Strategy will be implemented by participating jurisdictions and how the overall Hazard Mitigation Plan will be evaluated and enhanced over time. This section also discusses how the public and participating stakeholders will continue to be involved in the hazard mitigation planning process. Chapter 4 consists of the following three subsections:

- IMPLEMENTATION ACTION PLAN
- CAPABILITIES AND RESOURCES
- EVALUATION, MONITORING, UPDATING
- PLAN UPDATE PROCESS PRIOR TO 5-YEAR UPDATE

IMPLEMENTATION ACTION PLAN

The 2015 planning process was overseen by the Arapahoe County Sheriff's Office: Office of Emergency Management and the Colorado Office of Emergency Management.

The Arapahoe County Board of Commissioners has authorized the submission of this Plan to both the Colorado Division of Homeland Security and Emergency Management (DHSEM) and the Federal Emergency Management Agency (FEMA) for their respective reviews and subsequent approvals. Upon state and federal approval, the Arapahoe County Board of Commissioners will act to formally adopt this Plan.

CAPABILITIES AND RESOURCES

The capability and resource assessment examines the ability of Arapahoe County to implement and manage the comprehensive mitigation strategy laid out in this Plan. The strengths, weaknesses, and resources of the County, its partner agencies, and local jurisdictions are identified here as a means for evaluating and maintaining effective and appropriate management of the County's hazard mitigation program.

The information included in the capability assessment was gathered from members of the MPWG, the Colorado State Hazard Mitigation Plan (2013), and from the Colorado Department of Local Affairs (DOLA) 2010 County Land Use Survey. DOLA conducted the Land Use Survey in partnership with Colorado Counties Inc. (CCI), the Colorado Chapter of the American Planning Association (APA CO), and the Colorado State University Extension Office. The Land Use Survey provides a snapshot of the current planning practices of Colorado local governments. Similar surveys were conducted in 1983, 1992 and 2004 and efforts were made to keep the survey questions consistent from one survey to the next to aid in a longitudinal analysis. The survey was distributed electronically to county planning directors and the results were reviewed in 2014 by the Arapahoe County MPWG for accuracy and updates. The following capability sections represent capabilities and resources in Arapahoe County at the time that this plan was written (2014).

Local Personnel

The ability of a community to implement a comprehensive mitigation strategy depends, in part, on available resources, including people and staff. The table below outlines County capabilities as they relate to key personnel.

Table 118. Local Personnel

County	Emergency Manager	Floodplain Administrator	Community Planner	GIS Specialist	Grant Writer
Arapahoe	FT	NA	NA	FT	NA

* Full Time (FT), Part Time (PT), None (NA)
** Data received from Local Plans, MPWG members, and DOLA and Use Survey (2010)

A common challenge related to plan implementation is the reality of limited time and resources. Despite monetary and staff limitations, there are ample opportunities to establish and strengthen relationships between emergency managers and their counterparts at public works, floodplain management agencies, and planning departments, and with other stakeholders who contribute to risk reduction efforts. One such opportunity for collaboration comes from the long-term maintenance of local hazard mitigation plans.

NFIP and CRS Participation

The NFIP and the CRS are highly effective in reducing flood risk (and insurance premium rates) for participating communities. The table below highlights the NFIP and CRS participation status for Arapahoe County and its local jurisdictions. Additional information on the NFIP and CRS can be found in the flood hazard profile section of this Plan.

Table 119. Participation in the NFIP and CRS Programs

Community	County	NFIP Participating	Current Effective Map Date	CRS Status	CRS Class	% Discount SFHA	% Discount Non-SFHA
Arapahoe County	Arapahoe	Y	12/17/2010	Current	8	10%	5%
Centennial, City of	Arapahoe	Y	12/17/2010	Current	8	10%	5%
Cherry Hills Village, City of	Arapahoe	Y	12/17/2010	Current	8	10%	5%
Columbine Valley, Town of	Arapahoe	Y	12/17/2010	N/A	--	--	--
Deer Trail, City of	Arapahoe	Y	(NSFHA)	N/A	--	--	--
Englewood, City of	Arapahoe	Y	12/17/2010	Current	7	15%	5%
Glendale, City of	Arapahoe	Y	12/17/2010	N/A	--	--	--
Greenwood Village, City of	Arapahoe	Y	12/17/2010	N/A	--	--	--

Community	County	NFIP Participating	Current Effective Map Date	CRS Status	CRS Class	% Discount SFHA	% Discount Non-SFHA
Bow Mar, Town of	Arapahoe/ Jefferson	N	06/17/2003	N/A	--	--	--
Foxfield, Town of	Arapahoe/ Adams	N	Not Mapped	N/A	--	--	--
Bennett, Town of	Arapahoe/ Adams	N	03/05/07	N/A	--	--	--
Littleton, City of	Arapahoe	Y	12/17/2010	Current	7	15%	5%
Sheridan, City of	Arapahoe	Y	12/17/2010	Rescinded	10	0%	0%

Sometimes, smaller communities with limited staff have greater difficulty implementing new flood risk reduction activities and maintaining the required documentation for the CRS than communities with more resources. This presents an opportunity for collaboration and support from larger jurisdictions that can assist smaller communities and contribute to increased disaster resilience of the region.

Land Use Planning and Codes

Local land use plans and building codes are tremendous tools for evaluating local policies related to hazard mitigation and risk reduction. Additionally, comprehensive master plans, capital improvement plans, stormwater plans and zoning ordinances all present opportunities for enhanced local capabilities.

In Colorado, land use regulations and building codes are typically implemented at the local level. Even without a statewide mandate, most counties and many municipalities have enacted regulations and codes. Of jurisdictions responding to a DOLA survey on local regulations, 96.8 percent have a local zoning ordinance in effect. Of these, 71.6 percent of jurisdictions in Colorado report having adopted a hazard-specific zoning ordinance. The table below shows the results of the DOLA survey for those jurisdictions located within Arapahoe County.

Table 120. Local Land Use Planning Capability

Community	Zoning Ordinance?	Hazard-Specific Zoning Ordinance?	Building Codes?	Comprehensive / Master Plan?	Capital Improvements Plan?	Storm water Plan?	Long Term Recovery Plan?
Arapahoe County	Y	Y	Y	Y	Y	Y	N
Bennett, Town of	Y	N	Y	Y	--	N	--
Bow Mar, Town of	Y	N	Y	--	--	--	--
Centennial, City of	Y	N	Y	Y	Y	N	--
Cherry Hills Village, City of	Y	Y	Y	Y	N	N	--
Columbine Valley, Town of	Y	N	Y	Y	N	Y	--

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ARAPAHOE COUNTY COLORADO'S FIRST

Community	Zoning Ordinance?	Hazard-Specific Zoning Ordinance?	Building Codes?	Comprehensive / Master Plan?	Capital Improvements Plan?	Storm water Plan?	Long Term Recovery Plan?
Deer Trail, Town of	Y	--	Y	Y	--	--	--
Englewood, City of	Y	--	Y	Y	Y	N	--
Foxfield, Town of	Y	N	Y	Y	N	N	--
Glendale, Town of	Y	--	Y	--	--	--	--
Greenwood Village, City of	Y	--	Y	Y	Y	N	--
Littleton, City of	Y	N	Y	Y	N	N	--
Sheridan, City of	Y	--	Y	Y	--	--	--

*Blank entries indicate no survey data

Building codes are one tool that communities use to enhance public safety. For example, they can increase structural integrity, mitigate structure fires, and provide benefits in relation to natural hazard avoidance. The *Local Jurisdiction Building Code Adoption* table (below) provides a summary of local municipal code adoptions within Arapahoe County. All local jurisdictions have adopted some type of code requirement, demonstrating the widespread understanding of the benefits codes provide, including reduced exposure to hazards.

Table 121. Local Jurisdiction Building Code Adoption

Jurisdiction	Has Code (Y / N)	Current Code as of August 2014: International Building Code (IBC) Uniform Building Code (UBC)
Arapahoe County	Y	2009 IBC
Bennett, Town of	Y	2006 IBC
Bow Mar, Town of	Y	2000 IBC
Centennial, City of	Y	2009 IBC
Cherry Hills Village, City of	Y	2012 IBC
Columbine Valley, Town of	Y	2012 IBC
Deer Trail, Town of	Y	1997 UBC

Jurisdiction	Has Code (Y / N)	Current Code as of August 2014: International Building Code (IBC) Uniform Building Code (UBC)
Englewood, City of	Y	2012 IBC
Foxfield, Town of	Y	2006 IBC
Glendale, Town of	Y	1997 UBC
Greenwood Village, City of	Y	2012 IBC
Littleton, City of	Y	2012 IBC
Sheridan, City of	Y	2009 IBC

Other Local Capabilities

The state of Colorado Division of Emergency Management has prepared a *State Emergency Operations Plan (SEOP)* to provide emergency response direction to state, local, tribal, and volunteer agencies and well as to the private sector. The SEOP is a comprehensive all-hazards plan that outlines emergency response procedures, responsibilities, lines of authority and continuities of government. The format of the SEOP aligns with the National Response Plan (NRP) by incorporating National Incident Management System (NIMS). The SEOP is a statewide capability that applies to communities within Arapahoe County.

As mandated by C.R.S. 24-32-2107, each local jurisdiction and disaster agency within Colorado must prepare (and keep current) a local or interjurisdictional disaster emergency plan for its area. These Local Emergency Operations Plans, which are based upon valid hazard and risk analyses, are an important local capability to consider during the implementation of the Arapahoe County hazard mitigation strategy.

In addition to existing emergency response plans there are numerous outreach programs and voluntary community initiatives adopted throughout Arapahoe County that play a role in reducing both local and regional disaster risk. A list is provided below:

- *Community Wildfire Protection Plan (CWPP), Eastern Arapahoe County* – In December 2012, partners and stakeholders within Arapahoe County collaborated to create the Eastern Arapahoe County Community Wildfire Protection Plan (CWPP). The CWPP provides detailed information about risk and response capabilities and identifies goals and projects to address wildfire risks in Eastern Arapahoe County.
- The *StormReady* Program – The City of Englewood was designated as a National Weather Service *StormReady Community* in 2013 (http://www.stormready.noaa.gov/).

- The *Ready, Set, Go*! Program – The Ready, Set, Go! Program is a three step process encouraging homeowners to create their own Action Plans in order to prepare their property for wildfire long before an emergency occurs. Arapahoe County OEM and local fire agencies have rolled-out the program in the County and intend to continue their efforts as an action item on the mitigation strategy described in this Plan (www.wildlandfirersg.org).
- *Firewise Communities/USA®*– Roxborough Park, located in Littleton, CO, has been a recognized Firewise Communities/USA® site since September 16, 2007.
- *Continuity of Operations Plan / Continuity of Government Plan (COOP/COG)* – Arapahoe County is currently in the process of updating their COOP/COG Plan.

Together, the capabilities outlined in this plan highlight both strengths and areas of improvement that the County and its local jurisdictions should consider as they work to mitigate hazard impacts, reduce risk to life and property, and build a disaster resilient community.

Integrating Hazard Mitigation into Local Planning

Unfortunately, DRCOG's 2010 Denver Regional Hazard Mitigation Plan was not incorporated into other local planning mechanisms beyond the Eastern Arapahoe CWPP. The scope of the 2010 Plan was so broad and general that it did not prove to be a useful hazard mitigation guidance document for Arapahoe County or its local jurisdictions.

Despite previous challenges related to plan integration, Arapahoe County sees great potential for integrating the 2015-2020 Hazard Mitigation Plan into local planning mechanisms over the next five years. The County and local communities understand that local land use planning plays an integral role in shaping our ability to avoid, mitigate, respond, and recover from a hazard event. During the development of the 2015 Arapahoe County Multi-Hazard Mitigation Plan, the planning team worked closely with the Arapahoe County Planning Department to identify areas within the county that are designated for a greater mix of uses and higher density development over time. This land use information was used to inform the Risk/ Vulnerability Assessment and the Mitigation Strategy. Moreover, the data collection and analysis process helped strengthen the relationship between Arapahoe County Sheriff's Office and the Planning and Land Development Department. This has led to a mutual understanding of the many connections between hazard mitigation and local land use planning.

Currently, the Arapahoe County Planning and Land Development Department is in the process of updating their Comprehensive Plan. Under the direction of the County's Long Range Planning Program Manager the updated Comprehensive Plan will identify long range (20-year) development frameworks for the County. It will identify parts of the County that will and will not undergo urban development (at least within the Plan's 20-year time horizon) in addition to places where land is intended for agricultural purposes, open lands, low density rural development, and sensitive development/conservation areas. The Comprehensive Plan update presents a great opportunity for Arapahoe County Sheriff's Office and the Planning Department to integrate hazard mitigation and land use planning and to start a discussion about incorporating hazards through some of the following planning pathways:

- Zoning ordinances and municipal codes
- Building codes and standards
- Subdivision regulations
- Capital improvement programs and other funding mechanisms
- Economic development strategies
- Functional plans (such as parks and recreation or water quality plans)
- Environmental resource management plans
- Site review plans (including permitting)
- Safe Growth evaluation or assessment

Moving forward, the Sheriff's Office will encourage the Planning Department to consider including hazard identification, risk assessment information, and/or hazard mitigation goals in the Comprehensive Plan. This may include adding a public safety/hazard element to the comprehensive plan. The Sheriff's Office will also collaborate with the Planning Department to leverage FEMA's *Safe Growth Integration Tool* during all phases of the Comprehensive Plan Update.

Ultimately, the goal of integrating the hazard mitigation strategy with local planning frameworks is to encourage development patterns that do not increase hazard risks or leads to redevelopment that reduces risks from known hazards. Additionally, integration will increase public participation in the mitigation plan maintenance process. Moving forward, we will apply the tools outlined in the FEMA guidance document *Integrating Hazard Mitigation into Local Planning: Case Studies and Tools for Local Officials* as a framework for achieving plan integration goals. Included in Appendix B is FEMA's Safe Growth Integration Tool and a How to Guide for implementing the tool.

Through discussions at planning meetings and the use of an online survey, individual outreach and phone calls, each participating jurisdiction brainstormed with the planning team to identify processes for integrating hazard mitigation into their local planning mechanisms and policies. The table below lists the specific integration strategies identified by each community based on the mitigation actions listed in this plan.

Table 122. Processes for Integrating Hazard Mitigation into Other Planning Mechanisms

Jurisdiction	Strategy
Arapahoe County	The Arapahoe County Sheriff's office will utilize the risk assessment data from this plan during the next update of the County EOP. Additionally, the County is the in process of refining and rolling out a county-specific Training and Exercise Program for local emergency management staff. In designing the program, Arapahoe County will utilize the results and risk assessment data from this plan to tailor activities and training to mitigate and prepare for hazards that are higher on the list for Arapahoe County. This will create a specialized and more valuable training regimen for county staff.
Town of Bennett	"Mitigation Plans will be incorporated into Code by adoption of specific ordinance by the Town of Bennett."
Town of Bow Mar	"In order to amend our building code requirements, our community will bring an ordinance before our Town Trustees for approval. Also, we will complete a drainage study for our town."

City of Centennial	"Utilizing the mitigation strategy defined in the Arapahoe County Hazard Mitigation Plan, the City of Centennial will integrate our proposed mitigation actions into existing City Communications Plan and GIS policies and procedures."
City of Cherry Hills Village	"The Community Development Director's office plans to review the updated hazard mitigation plan and risk assessment results to identify areas within the current building codes and zoning requirements that need to be updated to curtail unsafe development in hazard prone areas."
Columbine Valley	"Allocated time on meeting agendas, HOA outreach through newsletters, and special funding allotment for any paid consultant time."
Town of Deer Trail	"The Town hired a code enforcement officer. This should help with keeping the fire hazards at individual properties down."
City of Englewood	"Using the Hazard Mitigation Plan results, the City of Englewood will incorporate public information procedures and evacuation plans into the City Emergency Operations Plan update."
Town of Foxfield	"The Town Clerk will need to incorporate our mitigation actions into the written Policies and Procedures."
City of Glendale	"The City of Glendale is initiating a program called, "Ready Glendale," to integrate the "Ready Colorado" concepts on a municipal level. We will be coordinating monthly trainings for the community, some taught by our in-house instructors, some using outside resources. The City will leverage both the risk assessment results and mitigation strategy developed as part of the Arapahoe County Hazard Mitigation Plan for portions of this effort."
City of Greenwood Village	"Using the Hazard Mitigation Plan results, the City of Greenwood Village will incorporate training and education actions into the existing City of Greenwood Village Communications Plan. Examples of existing Communication Plan resources and outlets include, but are not limited to: GVTV Channel 8 - Public Access TV Station; City Newsletter; Local News Media (ex. The Villager Newspaper); Social Media (ex. City Facebook Account); Community Liaison Officer (access to business publications, HOA newsletters, etc.); School Resource Officers (access to school papers, handouts and newsletters); Education booths at city functions."
City of Littleton	"Utilizing the Arapahoe County Hazard Mitigation Plan, the City of Littleton will incorporate those mitigation actions into City of Littleton policies and procedures for all areas of the City of Littleton within Arapahoe County. Areas that are in or under contract to the City of Littleton that are in Douglas or Jefferson Counties will utilize the respective plans of those counties for areas within those counties."
City of Sheridan	"The City of Sheridan and Englewood are working with UDFCD as well as the Colorado Water Conservation Board and Army Corp of Engineers to establish the best mitigation plans for River Run Park. As well, the City reviews all development and requires developers to use drainage criteria from UDFCD as well as Arapahoe drainage Criteria Manual. The City of Sheridan is also re-evaluating its City wide infrastructure and has developed a Capital Improvement Plan to address both infrastructure of streets, water conveyance systems, and the storm drainage systems or lack of within the City."

GOVERNMENT

Mayor Ron reports

continued from page 3

follow the Village leash law requiring all dogs to be secured with a pet leash in public areas of Greenwood Village.

Dog Feces

It is illegal for pet owners to leave their pet waste on public property in Greenwood Village. Leaving your pet's waste in the grass or on the trail is not only discourteous to others, but is very harmful to public health and the environment. Dog feces are not fertilizer, not biodegradable, and cannot be flushed down the drain. Trash receptacles are provided at all Village parks and along trails. If there is no trash receptacle nearby, keep a bag with you and dispose of it when you get home.

VISIT WITH TAIPEI ECONOMIC AND CULTURE OFFICE

Having a presence in the International Business Community is a foundation for further economic development. Several months ago I was contacted by the Director General Jack Yang of the Taipei Economic and Culture Office which then represented Taiwan's interests in Kansas City. The Taiwan Ministry of Foreign Affairs made the decision to close the Kansas City office and move it to Denver. I had the opportunity to host Director General Yang and his assistant Amber Wang to explain the dynamic aspects of Greenwood Village that would be beneficial to Taiwanese business interests. Subsequently on May 2 the Taiwanese-American Community feted the Director General and his wife Rita at a unique Greenwood Village eatery — Minj Asian Cuisine. The capacity crowd included myself, Congressman Mike Coffman and present and past members of the Colorado General Assembly.

Mayor Ron Rakowsky with Director General Jack Yang and Amber Wang from the Cultural and Economic Office of Taipei, Taiwan.

RAMBLE WITH RON IN JULY

Have some ideas or suggestions to share about living or working in Greenwood Village? Walk and talk with Mayor Ron Rakowsky from 7:30-8:30 a.m. (weather permitting) on **Monday, July 13** at Westlands Park, 5701 S. Quebec Street, and **Thursday, July 16** at Tommy Davis Park, Swim Club Lot, 9200 E. Orchard Road. Registration is not required. For more information, please call the Mayor's Office at 303-486-5745. Check for updates of the monthly schedule for *Ramble with Ron* at www.greenwoodvillage.com.

KNOW THE SOUNDS OF THE LIGHTNING DEVICES AT MAJOR VILLAGE PARKS

During the summer storm season, Village park users and visitors may be exposed to potential dangers of a lightning storm while being outside. In efforts to provide a safer environment while attending events at Village Greens Park, Curtis Park, Westlands Park, Silo Park, and Tommy Davis Park, the Village has installed lightning prediction and warning systems to alert park users of the potential for lightning before it strikes.

The lightning systems in designated Village parks are prediction systems not detector systems. These systems measure the shift of the positive and negative ions in the atmosphere and in the ground that could create an energy flow that may result in a lightning strike once a conductive cloud to ground path is available. The lightning prediction and warning system senses and evaluates these shifts and changes in the electrostatic field that precede the occurrence of an actual lightning strike and activates an audible as well as visual warning alerting of the dangerous conditions.

The systems are set to monitor a 2.5 mile radius from its location. When the conditions are ripe for lightning at the parks or within the 2.5 mile radius, a continuous audible horn is activated for a period of 15 seconds alerting users of the potential for lightning and activating yellow strobes on the roofs of the structures located within the parks. These strobes will stay activated throughout the period of potential lightning activity and will shut off only after an all clear signal consisting of three five second audible horn blasts. The systems are operational between the hours of 7 a.m. and 9 p.m., seven days a week through the spring and summer months.

For more information, please call Laird Thornton, Public Works Manager, at 303-708-6155.

PG. 4 GV NEWSLETTER | JULY 2015

Figure 69. Greenwood Village Newsletter

Above, a July 2015 story from the Greenwood Village Newsletter describes the City's new lightning prediction and warning system. This is an example of the successful implementation of local mitigation actions, and is also an illustration of Greenwood Village's Communications Plan in action.

EVALUATION, MONITORING, UPDATING

Monitoring, evaluating, and updating this Plan is critical to maintaining its value and success in Arapahoe County's hazard mitigation efforts. Ensuring effective implementation of mitigation activities paves the way for continued momentum in the planning process and gives direction for the future. This section explains who will be responsible for maintenance activities and what those responsibilities entail. It also provides a methodology and schedule of maintenance activities including a description of how the public will be involved on a continual basis.

The Arapahoe County MPWG established for this Plan is designated to lead the Plan maintenance processes of monitoring, evaluation and updating with support and representation from all participating municipalities. The MPWG will coordinate maintenance efforts, but the input needed for effective periodic evaluations will come from community representatives, local emergency management coordinators and planners, the general public, and other community stakeholders.

Each municipality will designate a community representative to monitor implementation of mitigation activities and hazard events within their respective communities. This individual will be asked to work with the Arapahoe County MPWG to provide updates on applicable mitigation actions and feedback on changing hazard vulnerabilities within their community. Representatives will also be asked to monitor other local planning mechanisms to identify potential opportunities for incorporating appropriate elements of the Hazard Mitigation Plan. Bi-annual mitigation-specific public outreach and engagement activities (e.g. town hall meetings, information booths at community events, social media campaigns, etc.) will be encouraged by both community representatives and the Arapahoe County MPWG to drive continued public participation in the plan maintenance process over time.

The MPWG will oversee the progress made on the implementation of action items identified and modify actions, as needed, to reflect changing conditions. The Arapahoe County MPWG will meet annually to evaluate the Plan and discuss specific coordination efforts that may be needed with participating jurisdictions and other stakeholders. The annual evaluation may include the participation of individual municipal monitors, or at least will include reports prepared by them.

The annual evaluation of the 2015 Hazard Mitigation Plan will not only include an investigation of whether mitigation actions were completed, but also an assessment of how effective those actions were in mitigating losses. A review of the qualitative and quantitative benefits (or avoided losses) of mitigation activities will support this assessment. Results of the evaluation will then be compared to the goals and objectives established in the plan and decisions will be made regarding whether actions should be discontinued, or modified in any way in light of new developments in the community. Progress will be documented by the MPWG for use in the next Hazard Mitigation Plan update. Finally, the MPWG will monitor and incorporate elements of this Plan into other planning mechanisms. The annual reviews will be led by the Emergency Management coordinator or their designee.

This Plan will be updated by the FEMA approved five year anniversary date, as required by the Disaster Mitigation Act of 2000, or following a disaster event. Future Plan updates will account for any new hazard vulnerabilities, special circumstances, or new information that becomes available. During the five-year review process, the following questions will be considered as criteria for assessing the effectiveness of the Arapahoe County Hazard Mitigation Plan.

- Has the nature or magnitude of hazards affecting the County changed?
- Are there new hazards that have the potential to impact the County?
- Do the identified goals and actions address current and expected conditions?
- Have mitigation actions been implemented or completed?
- Has the implementation of identified mitigation actions resulted in expected outcomes?
- Are current resources adequate to implement the plan?
- Should additional local resources be committed to address identified hazards?

Issues that arise during monitoring and evaluation which require changes to the local hazard, risk and vulnerability summary, mitigation strategy, and other components of the Plan will be incorporated during future updates.

PLAN UPDATE PROCESS PRIOR TO 5-YEAR UPDATE

Any interested party wishing for an update of this Plan sooner than the 5-year update will submit such a request to the Arapahoe County Emergency Management Agency for consideration through the Emergency Management Coordinator. The request shall be accompanied by a detailed rationale. The Arapahoe County Office of Emergency Management will evaluate all such requests and determine whether the update request should be acted upon. If the decision is in the affirmative, an assignment will be made for an individual to author the update. The draft updated section along with a detailed rationale will be submitted to the Arapahoe County MPWG. The committee will circulate the draft updated section to every jurisdiction participating in the plan for comment and after an appropriate period of time, the committee shall make a decision to update the plan at least partially based on the feedback received from the other jurisdictions. County and municipal adoptions will then occur as necessary.

As was done during the development of the 2015 Hazard Mitigation Plan, the Arapahoe County MPWG will involve the public during the evaluation and update of future plans through multiple communication and outreach methods and meetings. The public will have access to the current Plan through their local municipal office and the Arapahoe County Office of Emergency Management. Information on upcoming events related to this Plan or solicitation for comments will be announced via newsletters, newspapers, mailings, and the County website. Public stakeholders are encouraged to submit comments on the Plan at any time. The Arapahoe County MPWG will review and determine relevant comments to include during the next update of the hazard mitigation plan.

APPENDIX A: MEETING MINUTES / SIGN-IN SHEETS / SURVEYS

ARAPAHOE COUNTY
COLORADO'S FIRST

minutes

Local Emergency Planning Committee Minutes

1/14/2014
1:00pm – 2:00pm
South Metro Fire Rescue Authority
West Conference Room
9195 E. Mineral Ave., Centennial

Introductions:

In attendance: Matt Ziska, Karl Ditus, Bill Oliver, Eric Eddy, Marianne Schilling, Mike Garner, Enessa Janes, Chris Garner, Rick Boyer, Dylan Larrson, Clinton Anderson, Laura Herblan, Rose Lynch, Ken Killip, Ashley Wallin, Jerry Rhodes, Nathan Fogg, Greg Thornton, Kevin Kay

New Business:

Lt. Nate Fogg discusses that the county is retiring the all hazards mitigation plan, and that Baker and Associates are going to be using the LEPC to facilitate the new hazard mitigation plan.

Mike Garner with Baker & Associates discusses that the hazard plan has a 5 year expiration date. It was explained that hazard mitigation is for the long term effects of hazard planning. Mitigation is a different approach than response and preparedness, because we are talking about adding everything together. Hazard mitigation plan is important for funding and to act on appropriate mitigation activities and was explained that it makes communities safer and also for communities to return to normalcy more quickly. It was explained that there is a number of hazards that will be addressed and in the hazard analysis, that Arapahoe County has an elevated hazard rating, a top ten for displacement. Matt noted that there is FEMA requirements that they need to fulfill and have a larger group as possible for a better risk assessment and vulnerability for the need to increase response. The DRCOG plan as per Matt was to make Arapahoe County hazard plan to better fit the county. Each jurisdiction should be able to adopt this plan when done.

Matt Ziska – Xcel Energy presentation. Matt discussed that how Xcel energy approaches the emergency management functions, which has infrastructure that is all round the state, this includes eight states. Xcel has a very large amount (300,000) of electric transmission/ and 35,000 gas lines. Under enterprise continuity, is where they approach emergency management. In 2007 after 9/11 they introduced the all hazards approach.

ARAPAHOE COUNTY
COLORADO'S FIRST

minutes

They focus on the life cycle of the emergency response. They have pandemic preparedness program and voluntary antiviral medication. 1000 doses per year to their employees, so those people are healthy to keep power up. Employees undergo many hours of training which fulfills according to Matt the ICS equivalent training. He states that the floods were a great learning experience to review their own safety training and emergency action plans. Mission Mode training, used internally to communicate to executives for guidance, and this cycles down to other emergency management people in the field. Remote producers which couldn't get aid quickly enough, so they have their own strike teams for response. Xcel looks at natural, manmade, system, and public safety. Matt discussed that it is critical to their plan to provide critical response plan. Matt discussed that around Boulder they were able to better work with the Boulder EOC. Matt discussed that if a cyber-security breach in Xcel that would be similar to Target, they believe that the relationship between the company and law enforcement is better prepared. Matt said that they haven't fully integrated ICS yet, but they are working to do that by the end of the calendar year. However they use a modular mission approach. They decided that looking at the NIMS infrastructure they will be able to communicate better with other agencies. Matt said that Xcel had people at the state EOC during the fires to advice on the location of gas lines, and power lines.

The group discussed the yearly meeting dates proposed. There were no disagreements about the proposed dates. Approved unanimously.

Lt. Fogg discussed that Baker was hoping to use the LEPC as a council for review of the all hazards review plan by Baker. A working group or sub-committee was formed with the members below volunteering to participate.

Rose Lynch – subcommittee
Ashley Wallin – subcommittee
Chris Garner – subcommittee
Rick Boyer – subcommittee

Old Business

None to report

Adjournment

The meeting adjourned at 13:45hrs
Next meeting: April 9th, 2014

Arapahoe County LEPC

14-Jan-14

Name	Agency (Address)	Phone Number	Email
MATT ZISKA		720-278-1018	Matthew.R.Ziska@Xcel Energy.Com.
KARL DITUS	13101 E. BRONCOS PKWY. CENTENNIAL, CO	720-874-4029	KDITUS@ARAPAHOEGOV.COM
BILL OLIVER	2255 W. BERRY AVE LITTLETON, CO 80120	303-795-3965	boliver@littletongov.org
ERIC EDDY	18183 E. ARAPAHOE RD CENTENNIAL CO 80112	3/754-3334	EEDDY@CENTENNIALCO.GOV
Marianne Schilling	13133 E Arapahoe Rd centennial, CO 80112	3/754-3319	mschilling@centennialco.gov
MIKE GARNER	MICHAEL BAKER JR. 165 S. UNION BLVD. STE 200 LAKEWOOD	7/514.1105	MGARNER@MBAKERCORP.COM
Enessa Janes	" "	720/479-3162	enessa.janes@mbakercorp.com
CHRIS GARNER	ALSO 13101 E BRONCOS PKWY CENTENNIAL CO 80112	7/874-4031	CGARNER@ARAPAHOEGOV.COM
Rick Boyer	7700 S Broadway Littleton CO 80122	7/738 2643	rickboyer@centura.org
DYLAN GARRISON	TRI COUNTY 6162 S WILLOW DR GV	7/200 1578	DGARRISON@TCHD.ORG
CLINTON ANDERSEN	"	7/200-1478	CANDERSEN@TCHD.ORG
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Rose Lynch	Englewood OEM	3/748-5409	RLynch@englewoodgov.org
Ken Killip	SMFRA	720-989-2242	Ken.Killip@southmetro.org
Ashley Wallin	13101 E Broncos Pkwy Centennial, CO 80112	7/874 4044	awallin@arapahoegov.com
Jerry Rhodes	Cunningham FPD	3-901-5380	jrhodes@cfpd.org
NATHAN FOGG	13101 E. Broncos Pkwy	7/874-3659	nfogg@arapahoegov.com

Risk Assessment Meeting: 04/24/14

Sheriff's Office: 13101 E Broncos Pkwy, Centennial Colorado 80112

Last Name	First Name	Affiliation	Email	Signature
Atkin	Gary	ACWWA	gatkin@arapahoewater.org	
Manson De Rabe	Christine	American Red Cross	christine.mansonderabe@redcross.org	
Gardner	Monica	Arapahoe County Council on Aging (ACCOA)	mgardner@regis.edu	
Harris	Mel	Arapahoe County Council on Aging (ACCOA)	jmelharris@me.com	
Kirsten	Debra	Arapahoe County Council on Aging (ACCOA)	debrakirsten@coloradoassistedliving.com	
Katzer	James	Arapahoe County Infrastructure Manager	JKatzer@arapahoegov.com	
Peterson	Allen	Arapahoe County Road & Bridge	apeterson@arapahoegov.com	
Wallin	Ashley	Arapahoe County Sheriff's Office: OEM	awallin@arapahoegov.com	
Garner	Chris	Arapahoe County Sheriff's Office: OEM	cgarner@arapahoegov.com	
Ditus	Karl	Arapahoe County Sheriff's Office: OEM	kditus@arapahoegov.com	
Fogg	Nathan	Arapahoe County Sheriff's Office: OEM	NFogg@arapahoegov.com	
Perea	Louie	Arapahoe County Sheriff's Office: Undersheriff	lperea@arapahoegov.com	
DiMaria	Joan	Arapahoe/Douglas Mental Health Network	JOAN@admhn.org	
Boddy	Mark	ARES	planning@arapahoeares.org	
Cumley	Earl	Bennet Fire Department	ecumley941@aol.com	
McCawley	Tim	Bennet Fire Department	(invited by earl cumley)	
Disher	Mike	Byers Fire Rescue	mike.disher@byersfirerescue.org	
Olislagers	Robert	Centennial Aiport Authority	rolislagers@centennialairport.com	
Boyer	Rick	Centura Health: OEM	rickboyer@centura.org	
Brackney	John	Chamber of Commerce	jbrackney@bestchamber.com	
Vilkofsky	Dan	Cherry Creek School District	dvilkofsky@cherrycreekschools.org	
Councell	Randy	Cherry Creek School District	rcouncell@cherrycreekschools.org	
Eddy	Eric	City of Centennial	eeddy@centennialco.gov	
Schilling	Marianna	City of Centennial	mschilling@centennialco.gov	
		Colorado Coalition for the Homeless	Colorado.HMIS@coloradocoalition.org	
Houck	Kevin	Colorado Water Conservation Board	kevin.houck@state.co.us	
Aston	Tim	CSU Extension	taston@arapahoegov.com	
Rhodes	Jerry	Cunningham Fire Department	jrhodes@cfpd.org	

Arapahoe County
Multi-Hazard Mitigation Plan Risk Assessment Meeting
Location: ARAPAHOE COUNTY SHERIFF Date: 4/24/14

Sign-In Sheet

NAME	ORGANIZATION	PHONE	E-MAIL
KEVIN KAY	ACSO		KKAY@ARAPAHOEGOV.COM
Earl Conley	BENNETT FIRE	303-644-3572	EConley9418@aol.com
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Tim McGawlay	BENNETT FIRE	303-500-9211	TIMOTHY McGawlay@ BennettFireRescue.org
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Lorie Hinton	ACPAA (Centennial Airport)	303-790-0598	LHinton@ Centennialairport.com
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JIM OLSEN	LITTLETON	3-591-4962	JOLSEN@ LITTLETONGOV.ORG
Ashley Wallin	Arapahoe OEM	7/874 4046	awallin@arapahoegov.com
Chuck Haski	Arapco PWD	7 874 6535	Chaski@arapahoegov.
Christine Rohe	Red Cross	303-916-7913	Christine.monsurcleatee@ redcross.org
Kerry Webster	CO DHSEM	3/915-2848	Kerry.webster@ state.co.us
Ken Burke	DHSEM	720 852 6695	Kenneth.burke@ state.co.us

Baker

Michael Baker INTERNATIONAL

ARAPAHOE COUNTY COLORADO'S FIRST

In order by affiliation

Cox	Tim	Cunningham Fire Department	dcox@cfpd.org	
Wailes	Sheryl	Deer Trail Conservation District (Soil Conservation)	Sheryl.wailes@co.nacdnet.net	
Loveless	Rick	Deer Trail Fire	RCLoveless5@netecin.net	
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Lynch	Rose	Englewood Fire Department: OEM	rlynch@englewoodgov.com	
Figueroa	Ray	EPA	figueroa.raymond@epamail.epa.gov	
Lane	Bill	Heritage Eagle Bend HOA	twobadgers48@comcast.net	
McNeill	Denise	Home Builders Association	dmcneill@hbadenver.com	
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Oliver	Bill	Littleton Fire Department	Boliver@littletongov.org	
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Grace	Guy	Littleton Public Schools	ggrace@lps.k12.co.us	
		Metro Denver Homeless Initiative	mdhi@unitedwaydenver.org;	
Mayer	Rebecca	Metro Denver Homeless Initiative	rebecca.mayer@unitedwaydenver.org	
Glancy	Bob	NOAA/NWS	robert.glancy@noaa.gov	
Zeitler	Melanie	Plains Conservation Center	mzeitler@plainscenter.org	
		Rocky Mountain Human Services	info@rmhumanservices.org	
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Manson	Sherry	Salvation Army	sherry.manson@usw.salvationarmy.org	
Thompson	Stacey	SEMSWA: Floodplain Planner	sthompson@semswa.org	
Campbell	Mark	Sheridan Police Department	mcampbell@sheridangov.org	
Graham	Chuck	South Metro Fire Rescue Authority	c.graham@southmetro.org	
Qualman	Dan	South Metro Fire Rescue Authority	dan.qualman@southmetro.org	
Killip	Ken	South Metro Fire Rescue Authority	ken.killip@southmetro.org	
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Moody	Veronica	Tri County Health Department	vmoody@tchd.org	
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Andersen	Clinton	Tri County Health Department	candersen@tchd.org	
Stewart	Keving	Urban Drainage and Flood Control District	kstewart@udfcd.org	
Ziska	Matt	Xcel Energy	matthew.r.ziska@xcelenergy.com	

Arapahoe County
Multi-Hazard Mitigation Plan
Mitigation Strategy Meeting

Location: ARAPAHOE COUNTY SHERIFF Date: 6/11/2014

Sign-In Sheet

NAME	ORGANIZATION	PHONE	E-MAIL
Ashley Wallin	ACSO OEM	7/874 4046	awallin@arapahoegov.com
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TROY Schlichting	ADMHN	3-514-6425	tschlic@ADMHN.org
MIKE DISHER	Byers Fire	3-475-6505	MIKE.DISHER@ByersFireRescue.org
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Marianne Schilling	City of Centennial	303 354 3319	mschilling@centennialco.gov
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Chuck Haskins	ArapCo PW	7 874-6560	Chaskins@arapahoegov.com
Stacey Thompson	SEMSWA	3.858.8844	sthompson@semswa.org

Baker

NAME	ORGANIZATION	PHONE	E-MAIL
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Rose Lynch	Englewood OEM	3/748-5409	Rlynch@englewoodgov.org

Arapahoe County
Multi-Hazard Mitigation Plan
Public Outreach Meeting

Location:________________________ **Date:**____________

Sign-In Sheet

NAME	ORGANIZATION	PHONE	E-MAIL
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George Brady	ARES	3/773-6244	
Jim Hammond	ARAPCO ARES	3/488-2684	KCØYYF@ARRL.NET
ORVAL WICK	HEB	3/693-1537	opwick@aol.com
Bill Lane	HEB	3/400-9474	twobadgers48@comcast.net
Jerry Rhodes	CFRD	3/755-9202	jrhodes@cfpd.org

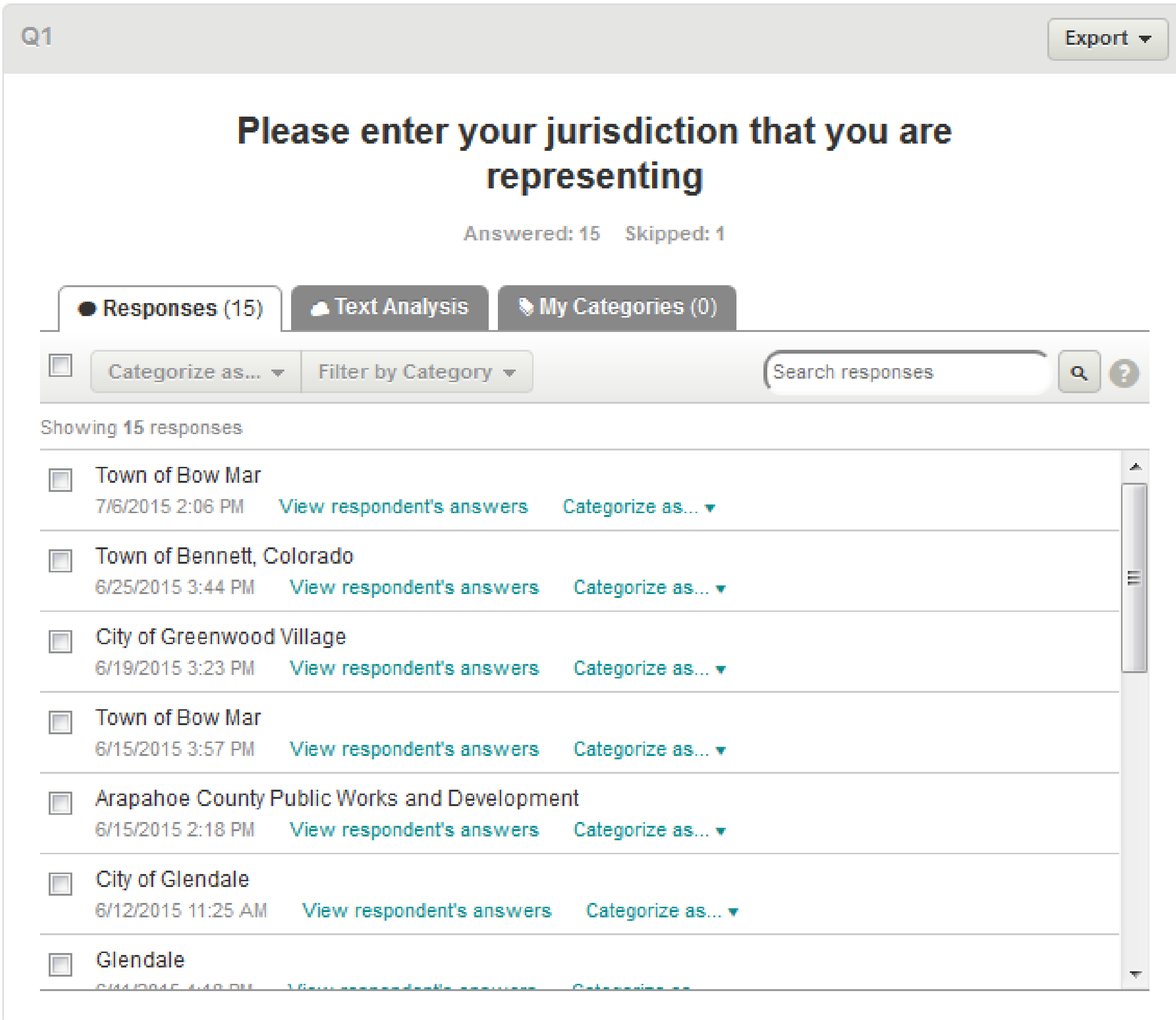
Baker

Arapahoe County
Multi-Hazard Mitigation Plan
Public Outreach Meeting
Location:__________Deer Trail Fire_______ Date:______8/28/14__

Sign-In Sheet

NAME	NAME
Steve Vetter, I-70 Scout	
Dee Reaves	
NILES DINGMAN	
KEN DINGMAN	

Baker



Q1

Export

Please enter your jurisdiction that you are representing

Answered: 15 Skipped: 1

Responses (15) | Text Analysis | My Categories (0)

Categorize as... | Filter by Category | Search responses

Showing 15 responses

Town of Bow Mar
7/6/2015 2:06 PM View respondent's answers Categorize as...

Town of Bennett, Colorado
6/25/2015 3:44 PM View respondent's answers Categorize as...

City of Greenwood Village
6/19/2015 3:23 PM View respondent's answers Categorize as...

Town of Bow Mar
6/15/2015 3:57 PM View respondent's answers Categorize as...

Arapahoe County Public Works and Development
6/15/2015 2:18 PM View respondent's answers Categorize as...

City of Glendale
6/12/2015 11:25 AM View respondent's answers Categorize as...

Glendale

Q1 Export

Please enter your jurisdiction that you are representing

Answered: 15 Skipped: 1

Responses (15) | Text Analysis | My Categories (0)

Categorize as... Filter by Category Search responses

Showing 15 responses

Glendale
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Cherry Hills Village
6/3/2015 8:51 AM View respondent's answers Categorize as...

City of Littleton
6/1/2015 10:40 AM View respondent's answers Categorize as...

Town of Deer Trail
5/29/2015 9:14 AM View respondent's answers Categorize as...

Town of Foxfield
5/28/2015 1:31 PM View respondent's answers Categorize as...

Sheridan
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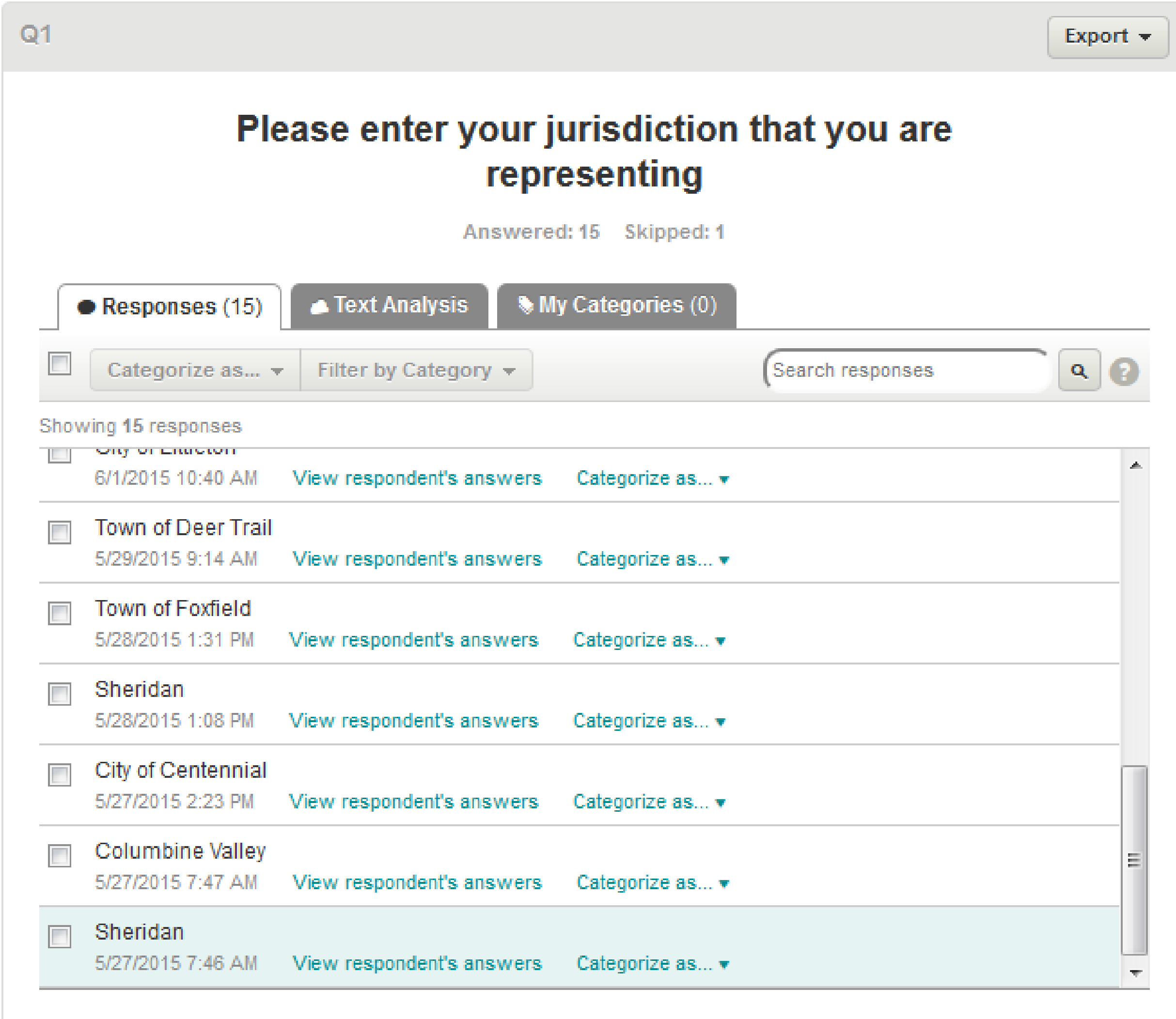
City of Centennial
5/27/2015 2:23 PM View respondent's answers Categorize as...


Q1
Export
Please enter your jurisdiction that you are representing
Answered: 15 Skipped: 1
Responses (15)
Text Analysis
My Categories (0)
Categorize as...
Filter by Category
Search responses
Showing 15 responses
6/1/2015 10:40 AM
View respondent's answers
Categorize as...
Town of Deer Trail
5/29/2015 9:14 AM
View respondent's answers
Categorize as...
Town of Foxfield
5/28/2015 1:31 PM
View respondent's answers
Categorize as...
Sheridan
5/28/2015 1:08 PM
View respondent's answers
Categorize as...
City of Centennial
5/27/2015 2:23 PM
View respondent's answers
Categorize as...
Columbine Valley
5/27/2015 7:47 AM
View respondent's answers
Categorize as...
Sheridan
5/27/2015 7:46 AM
View respondent's answers
Categorize as...

APPENDIX B: FEMA's SAFE GROWTH INTEGRATION TOOL AND HOW-TO GUIDE

(Source: Integrating Hazard Mitigation into Local Planning: Case Studies and Tools for Community Officials. FEMA, March 2013)

Safe Growth Integration Tool Worksheet (Page 1)

✓ = Area of Existing Overlap

★ = Gap Between Mitigation Plan and Planning Framework

				PLANNING FRAMEWORK							
				Comprehensive/ General Plan Elements			Zoning Ordinances and Development Regulations			Capital Improvement and Infrastructure Programs	
HAZARD MITIGATION	Risk Assessment										
HAZARD MITIGATION	Mitigation Goals and Objectives										
HAZARD MITIGATION	Mitigation Actions	Local Plans and Regulations									
HAZARD MITIGATION	Mitigation Actions	Education and Awareness Programs									
HAZARD MITIGATION	Mitigation Actions	Natural Systems Protection									
HAZARD MITIGATION	Mitigation Actions	Structure and Infrastructure Projects									

A HOW TO USE THE SAFE GROWTH INTEGRATION TOOL

Safe Growth Integration Tool Worksheet (Page 2)

✓ = Area of Existing Overlap

★ = Gap Between Mitigation Plan and Planning Framework

				PLANNING FRAMEWORK									
				Area Plans			Functional Plans			Special Programs		Public and Stakeholder Engagement	
HAZARD MITIGATION	Risk Assessment												
HAZARD MITIGATION	Mitigation Goals and Objectives												
HAZARD MITIGATION	Mitigation Actions	Local Plans and Regulations											
HAZARD MITIGATION	Mitigation Actions	Local Plans and Regulations											
HAZARD MITIGATION	Mitigation Actions	Local Plans and Regulations											
HAZARD MITIGATION	Mitigation Actions	Education and Awareness Programs											
HAZARD MITIGATION	Mitigation Actions	Education and Awareness Programs											
HAZARD MITIGATION	Mitigation Actions	Education and Awareness Programs											
HAZARD MITIGATION	Mitigation Actions	Natural Systems Protection											
HAZARD MITIGATION	Mitigation Actions	Natural Systems Protection											
HAZARD MITIGATION	Mitigation Actions	Natural Systems Protection											
HAZARD MITIGATION	Mitigation Actions	Structure and Infrastructure Projects											
HAZARD MITIGATION	Mitigation Actions	Structure and Infrastructure Projects											
HAZARD MITIGATION	Mitigation Actions	Structure and Infrastructure Projects											
HAZARD MITIGATION	Mitigation Actions	Structure and Infrastructure Projects											

How to Use the Safe Growth Integration Tool

The Safe Growth Integration Tool can be used to inventory your community's hazard mitigation approach and components of your planning framework and help identify integration opportunities. The blank tool included in this appendix can be used as-is, or can be modified to reflect the unique circumstances of your community. The Safe Growth Integration Tool is intended to be concise and flexible and can be an effective way to structure your integration conversation.

To use the tool, complete these five simple steps:

1. Review your community's hazard mitigation plan and list specific mitigation actions along the Z (vertical) axis of the matrix.

The matrix is organized by the basic categories of a hazard mitigation plan, including risk assessment, mitigation goals and objectives, and mitigation actions. The mitigation actions are further organized into the typical categories of local plans and regulations, education and awareness programs, natural systems protection, and structure and infrastructure projects. Within each of these categories, identify and list specific actions called for in your plan.

HAZARD MITIGATION			
	Risk Assessment		
	Mitigation Goals and Objectives		
	Mitigation Actions	Local Plans and Regulations	Hazard Area Avoidance
			Parks and Open Space Planning
			Stormwater Regulations
		Education and Awareness Programs	Hazard and Risk Awareness
			Mitigation Best Practices
			Monitoring and Reporting
		Natural Systems Protection	Watershed Management
			Wetland Preservation
			Erosion and Sedimentation
		Structure and Infrastructure Projects	Levees
			Structural Retrofits
			Acquisition
			Stormwater Structures

2. List the components of your community's planning framework along the X (horizontal) axis.

The x axis has been organized into categories that include comprehensive/general plan elements, zoning ordinances and development regulations, capital improvement and infrastructure programs, area plans, functional plans, special programs, and public and stakeholder engagement. Within these categories, identify the specific plans, policies, regulations, and programs that exist in your community. Try to identify everything that affects land use and development in some way, including those that you may not typically associate with planning such as an economic development plan or capital improvement program.

PLANNING FRAMEWORK		
Zoning Ordinances and Development Regulations		
Zoning	Subdivision	Critical Areas

3. Identify areas of existing overlap between your hazard mitigation plan and planning framework.

For example, your community may have a floodplain development ordinance that is called out as an action in your hazard mitigation plan and also exists within your land development ordinance. The simplest method for identifying overlap is to put a checkmark in the boxes where overlap exists. If you need more detail you could include specific code or plan citations.

✓ = Area of Existing Overlap ★ = Gap Between Mitigation Plan and Planning Framework		PLANNING FRAMEWORK		
		Comprehensive/ General Plan Elements		
		Hazards	Land Use	Environment
Risk Assessment		✓	✓	✓
Mitigation Goals and Objectives		✓	✓	✓
Local Plans and Regulations	Hazard Area Avoidance	✓	✓	✓
	Parks and Open Space Planning		✓	✓
	Stormwater Regulations	★		

4. Identify gaps between your hazard mitigation plan and planning framework.
For example, if your hazard mitigation plan calls for open space preservation of a hazard area to provide a buffer from developed areas, but there is no existing program to acquire open space, then identify where in your planning framework this action would best be integrated. You can use a different mark, or symbol, to distinguish gaps from existing overlaps.

✓ = Area of Existing Overlap
★ = Gap Between Mitigation Plan and Planning Framework

		PLANNING FRAMEWORK		
		Comprehensive/ General Plan Elements		
		Hazards	Land Use	Environment
Risk Assessment		✓	✓	✓
Mitigation Goals and Objectives		✓	✓	✓
Local Plans and Regulations	Hazard Area Avoidance	✓	✓	✓
	Parks and Open Space Planning		✓	✓
	Stormwater Regulations	★		

5. Identify further opportunities for integration.
For example, your hazard mitigation plan may call for wetland preservation to provide additional flood storage, and you may have an ordinance that requires wetland preservation. However, there may be other opportunities to integrate this action, such as tying wetland preservation into an existing Transfer of Development Rights (TDR) program, or by acquiring and preserving wetlands as part of your open space acquisition program.

✓ = Area of Existing Overlap
★ = Gap Between Mitigation Plan and Planning Framework

		PLANNING FRAMEWORK		
		Comprehensive/ General Plan Elements		
		Hazards	Land Use	Environment
Risk Assessment		✓	✓	✓
Mitigation Goals and Objectives		✓	✓	✓
Local Plans and Regulations	Hazard Area Avoidance	✓	✓	✓
	Parks and Open Space Planning		✓	✓
	Stormwater Regulations	★		
Education and Awareness Programs	Hazard and Risk Awareness	✓		
	Mitigation Best Practices	✓		
	Monitoring and Reporting	✓		
Natural Systems Protection	Watershed Management			✓
	Wetland Preservation			✓
	Erosion and Sedimentation			

Once you have filled in the matrix, you can quickly see where overlaps exist, where they are needed, and what future integration opportunities are available. The completed matrix can also help to identify priorities for your integration strategy. (Refer to Chapter 3, Figure 3-2 for a completed example.)

APPENDIX C: FOLLOW-UP PARTICIPATION LETTERS

02/11/2015

To Whom It May Concern,

As the Mayor for the Town of Deer Trail, I have reviewed the mitigation actions (Wildfire mitigation; mowing for fire control) Arapahoe County Sheriff's Office representative Chris Garner included in the Arapahoe County Colorado Multi-Hazard Mitigation Plan when he was representing our community during the mitigation planning process and agree with its inclusion in the plan. Further, should funding become available or the opportunity present itself I would be the point of contact for the implementation of this project.

Best regards,

Kent Vashus

Kent Vashus
Deer Trail Colorado Town Mayor