SECTION FOUR
RISK ASSESSMENT

Introduction

The ultimate purpose of this hazard mitigation plan is to minimize the loss of life and property across the county due to natural or man-made hazards. This section contains a county and local risk assessment including descriptions of potential hazards, vulnerabilities and exposures, probability of future occurrences, and potential impacts and losses. By conducting a county and local risk assessment, participating jurisdictions can develop specific strategies to address areas of concern identified through this process. The following table defines terms that will be used throughout this section of the plan.

Table 1: Term Definitions

Term	Definition
Hazard	A potential source of injury, death, or damage
Asset	People, structures, facilities, and systems that have value to the community
Risk	The potential for damages, loss, or other impacts created by the interaction of hazards and assets
Vulnerability	Susceptibility to injury, death, or damages to a specific hazard
Impact	The consequences or effect of a hazard on the community or assets
Historical Occurrence	The number of hazard events reported during a defined period of time
Extent	The strength or magnitude relative to a specific hazard
Probability	Likelihood of a hazard occurring in the future

Requirement §201.6(c)(2): Risk assessment. The plan shall include a risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.
Requirement §201.6(c)(2)(i): The risk assessment shall include a] description of the type … of all natural hazards that can affect the jurisdiction.
Requirement §201.6(c)(2)(i): The risk assessment shall include a] description of the … location and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.
Requirement §201.6(c)(2)(ii): The risk assessment shall include a] description of the jurisdiction’s vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description shall include an overall summary of each hazard and its impact on the community.
Requirement §201.6(c)(2)(ii): The risk assessment] must also address National Flood Insurance Program (NFIP) insured structures that have been repetitively damaged floods.
Requirement §201.6(c)(2)(ii)(A): The plan should describe vulnerability in terms of the types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard area.
Requirement §201.6(c)(2)(iii): For multi-jurisdictional plans, the risk assessment must assess each jurisdiction’s risks where they vary from the risks facing the entire planning area.

Methodology

The risk assessment methodology utilized for this plan follows the risk assessment methodology outlined in the FEMA Local Mitigation Planning Handbook. This process consists of four primary steps:

1. Describe the hazard
2. Identify vulnerable community assets
3. Analyze risk
4. Summarize vulnerability

When describing the hazard, this plan will examine the following items: previous occurrences of the hazard within the county; locations where the hazard has occurred in the past or is likely to occur in the future; extent of past events and likely extent for future occurrences; and probability of future occurrences. While the identification of vulnerable assets will be conducted across the entire county, *Section Seven* will discuss community-specific assets at risk for relevant hazards. Analysis for risk will examine historic impacts and losses and what is possible should the hazard occur in the future. Risk analysis will include both qualitative (i.e., description of historic or potential impacts) and quantitative data (i.e. assigning values and measurements for potential loss of assets). Finally, each hazard identified in the plan will provide a summary statement encapsulating the information provided during each of the previous steps of the risk assessment process.

For each of the hazards profiled, the best and most current appropriate data available will be considered. Further discussion relative to each hazard is discussed in the hazard profile portion of this section.

Average Annual Damages and Frequency

FEMA *Requirement §201.6(c)(2)(ii)(B)* suggests that when the appropriate data is available, hazard mitigation plans should also provide an estimate of potential dollar losses for structures in vulnerable areas. This risk assessment methodology includes an overview of assets at risk and provides historic average annual dollar losses for all hazards for which historic event data is available. Additional loss estimates are provided separately for those hazards for which sufficient data is available. These estimates can be found within the relevant hazard profiles.

Average annual losses from historical occurrences can be calculated for those hazards for which there is robust historic record and for which monetary damages are recorded. There are three main pieces of data used throughout this formula.

- **Total Damages in Dollars:** This is the total dollar amount of all property damages and crop damages as recorded in federal, state, and local data sources. The limitation to these data sources is that dollar figures usually are estimates and often do not include all damages from every event, but only officially recorded damages from reported events.

- **Total Years on Record:** This is the span of years there is data available for recorded events. During this planning process, vetted and cleaned up National Centers for Environmental Information (NCEI) was primarily used from between January 1996 and June 2021. Although some data is available back to 1950, this plan update only utilizes the more current and accurate data available. Other periods of record for data sets are supplied where appropriate.

- **Number of Hazard Events:** This shows how often an event occurs. The frequency of a hazard event will affect how a community responds. A thunderstorm may not cause much damage each time, but multiple storms can have an incremental effect on housing and utilities. In contrast, a rare large tornado can have a widespread effect on a community.

An example of the event damage estimate is found below:

$$Annual\ Damages\ (\$) = \frac{Total\ Damages\ in\ Dollars\ (\$)}{Total\ Years\ Recorded\ (\#)}$$

Annual probability can be calculated based on the total years of record and the total number of years in which an event occurred. An example of the annual probability estimate is found below:

$$Annual\ Probability\ (\%) = \frac{Total\ Years\ with\ an\ Event\ Recorded (\#)}{Total\ Years\ of\ Record\ (\#)}$$

Each hazard will be addressed in this plan, while those which have caused significant damages or occurred in significant numbers are discussed in greater detail. It should be noted NCEI data is not all inclusive and the database provides very limited information on crop losses. To provide a better picture of the crop losses associated with the hazards within the county, crop loss information provided by Arizona State University's Spatial Hazard Events and Losses Database for the United States (SHELDUS) was utilized for this update of the plan. The SHELDUS collected data were from 1960 to 2018. Data for all the hazards are not always available, so only those with an available dataset are included in the loss estimation.

Hazard Identification

The identification of relevant hazards for the county began with a review of the 2018-2023 Colorado Hazard Mitigation Plan. Las Animas County representatives and key contacts reviewed, discussed, and determined the list of hazards to be profiled in this HMP update at the Kick-off Meeting. It was decided that the hazards address in the 2017 HMP were still applicable and would be used for this plan update. One additional hazard was added to the list, Hazardous Materials Release, to address concerns on Interstate 25 running through the county and the high number of oil and gas wells present in the county. The hazards for which a risk assessment was completed are listed in the table below.

Table 2: Hazards Addressed in the Plan

Hazards Addressed in the 2022 Las Animas County HMP		
Avalanche	Extreme Heat	Severe Wind
Dam and Levee Failure	Flooding	Subsidence
Drought	Hail	Tornadoes
Earthquakes	Hazardous Materials Release	Wildfire
Erosion and Deposition	Landslide, Mud/Debris Flow, Rockfall	Winter Storms
Expansive Soil	Lightning	

Hazards identified in the 2018-2023 Colorado Enhanced Hazard Mitigation Plan that were not identified in this HMP update include the following list.

- Dense Fog
- Radon, Carbon Monoxide, Methane Seeps
- Animal Disease
- Pandemic
- Wildlife-Vehicle Collisions
- Pest Infestation
- Infrastructure Failure
- Mine Accidents
- Power Failure
- Radiological Release
- Chemical, Biological, Radiological, and Nuclear Attack
- Cyber Attack
- Explosive Attack

These hazards were reviewed during the Kick-off Meeting and were chosen to not be included in this HMP due to a variety of reasons including either a lack of historical events/impacts, discussion/inclusion in already identified hazards, posing minimal risk to the county, or would be better addressed in other planning documents or mechanisms.

Hazard Assessment Summary Tables

The following table provides an overview of the data contained in the hazard profiles. Hazards listed in this table and throughout the section are in alphabetical order. This table is intended to be a quick reference for people using the plan and does not contain source information. Source information and full discussion of individual hazards are included later in this section. Annual probability is based off the number of years that had at least one event.

Table 3: County Risk Assessment

Hazard	Previous Occurrences (events/year)	Approximate Annual Probability (years with an event recorded/total years)	Likely Extent
Avalanche	0/59	< 1%	Damage to structures and vehicles in avalanche prone areas.
Dam and Levee Failure	1/128	< 1%	Levee Failure: Minor flooding of private property. Dam Failure: Flooding greater than the 1% Annual Flood Risk Area.
Drought	549/1,513 months	36%	Mild Drought
Earthquakes	26/121	21%	5.0 or less magnitude
Erosion and Deposition	0	N/A	Minor erosion with minimal impacts.
Expansive Soil	0	< 1%	Minimal impacts.
Extreme Heat	74/74	42%	>100°F
Flooding	28/26	50%	Some inundation of structures and roads near streams and rivers. Some evacuations of people may be necessary.
Hail	221/26	96%	Avg: 1.1 inch Range: 0.75-2.75 inches
Hazardous Materials Release	Fixed: 12/32 Oil & Gas: 76/4 Transportation: 10/51	Fixed: 38% Oil & Gas: 100% Transportation: 15%	Range: 0 – 500 gallons May affect an area <1/4 mile.
Landslide, Mud/Debris Flow, Rockfall	0/26	< 1%	Minimal to no damage to property.
Lightning	6/59	100%	Some damage to property.
Severe Wind	207/26	100%	Avg: 68 mph Range: 49-98 mph
Subsidence	0	< 1%	Minimal to no damage to property.
Tornadoes	17/26	46%	EF0-EF1
Wildfire	759/26	100%	Avg: 454 acres Range: <1 – 45,814 acres
Winter Storms	399/26	100%	20°-40° below zero (wind chill) 1-12” snow 35-50 mph winds

Table 4: Hazard Loss Estimate for Las Animas County

Hazard		Count	Property[10]	Crop[2]
Avalanche[2]		0	$0	$0
Dam and Levee Failure	**Dam Failure[3]**	1	$0	N/A
	Levee Failure[4]	0	$0	$0
Drought[5]		549 out of 1,513 months	$0	$943,396
Earthquakes[6]		457	$1,000,000	N/A
Erosion and Deposition[7]		0	N/A	N/A
Expansive Soil[8]		0	N/A	N/A
Extreme Heat[9]		Avg. 1 day a year	N/A	$0
Flooding[10]	**Flash Flood**	13	$50,000	$365,000
	Flood	4	$500,000	
	Heavy Rain	11	$0	
Hail[10]		221	$10,000	$87,129
Hazardous Materials Release	**Fixed Site[11]**	12	$0	N/A
	Oil & Gas[12]	76	N/A	N/A
	Transportation[13]	10	$22,157	N/A
Landslide, Mud/Debris Flow, Rockfall[10]		0	$0	N/A
Lightning[2] *1 Fatality*		6	$895	$0
Severe Wind[10] *1 Fatality* *103 Injuries*	**High Winds**	183	$560,000	$1,209,643
	Thunderstorm Winds	24	$1,000	
Subsidence[8]		0	N/A	N/A
Tornadoes[10] *1 Injury*		18	$43,000	$0
Wildfire[1] *6 Injuries*		759	$1,080,000	$0
Winter Storms[10]	**Blizzard**	16	$550,000	$98,069
	Extreme Cold/Wind Chill	2	$0	
	Heavy Snow	97	$0	
	Ice Storm	1	$0	
	Winter Storm	258	$0	
	Winter Weather	25	$0	
Total		**2,194**	**$3,817,052**	**$2,703,237**

N/A – Data not available
1 – Colorado State Forest Service, 1992-2017
2 – SHELDUS, 1960-2018
3 – Stanford University, 1890-2018
4 – National Levee Database, September 2021
5 – NCEI, 1895-January 2021
6 – USGS, 1990-2020
7 – None Available
8 – Colorado Geological Survey, March 2022
9 – NOAA, 1948-September 2021
10 – NCEI, 1996-June 2021
11 – USACE NLN, 1900-September 2021
12 – Colorado Oil and Gas Conservation Commission, 1994-March 2022
13 – PHMSA, 1971-2021

Historical Disaster Declarations

The following tables show past disaster declarations that have been granted within the county.

Farm Service Agency Small Business Administration Disasters

The U.S. Small Business Administration (SBA) was created in 1953 as an independent agency of the federal government to aid, counsel, assist, and protect the interests of small business concerns, to preserve free competitive enterprise, and maintain and strengthen the overall economy of our nation. A program of the SBA includes disaster assistance for those affected by major natural disasters. The following table summarizes the SBA Disasters involving the county in the last decade.

Table 5: SBA Declarations

Disaster Declaration Number	Declaration Year	Description	Home or Business	Loan Amount
3424	2002	Wildfire	Business	$131,700
9Q60	2002	Wildfire	Business	$20,100

Source: Small Business Administration, 2001-2019[1]

Presidential Disaster Declarations

The presidential disaster declarations involving the county from 1962 to September 2021 are summarized in the following table. Declarations prior to 1962 are not designated by county and are not included.

Table 6: Presidential Disaster Declarations

Disaster Declaration Number	Declaration Date	Title
200	6/19/1965	Tornadoes, Severe Storms, & Flooding
1276	5/17/1999	Flooding
1421	6/19/2002	Wildfires
2412	6/3/2002	Spring Fire
2413	6/3/2002	James John / Fisher Fire
2613	1/8/2006	Mauricio Canyon Fire
3025	1/29/1977	Drought
3185	4/9/2003	Snow
3224	9/5/2005	Hurricane Katrina Evacuation
3270	1/7/2007	Snow
3271	1/7/2007	Snow
3436	3/13/2020	Covid-19
4498	3/28/2020	Covid-19 Pandemic

Source: FEMA, 1962-2021[2]

Hazard Profiles

Based on research and experiences of the participating jurisdictions, the hazards profiled were determined to either have a historical record of occurrence and/or the potential for occurrence in the future. Local hazard concerns and events that deviate from the county's norm are discussed in greater detail in *Section Seven: Participant Profiles.*

1 Small Business Administration. 2001-2019. "SBA Disaster Loan Data." Accessed March 2022. https://www.sba.gov/offices/headquarters/oda/resources/1407821.
2 Federal Emergency Management Agency. 2021. "Disaster Declarations." Accessed September 2021. https://www.fema.gov/openfema-data-page/disaster-declarations-summaries-v2.

Avalanche

An avalanche is a mass of snow, ice and debris flowing and sliding rapidly down a steep slope. Avalanches are also referred to as snow slides. Avalanches can be extremely destructive due to the great impact forces of the rapidly moving snow and debris and the burial of areas in the run-out zone. Four factors contribute to an avalanche: a steep slope, a snow cover, a weak layer in the snow cover, and a trigger. There are six different types of avalanches that could occur.

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

<u>Climax Avalanches</u>
An avalanche involving multiple layers of snow, usually with the ground as a bed surface.

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

<u>Powder Snow Avalanches</u>
An avalanche that occurs when sliding snow has been pulverized into powder, either by rapid motion of low-density snow or by vigorous movement over rugged terrain.

<u>Surface Avalanches</u>
An avalanche that occurs only in the uppermost snow layers.

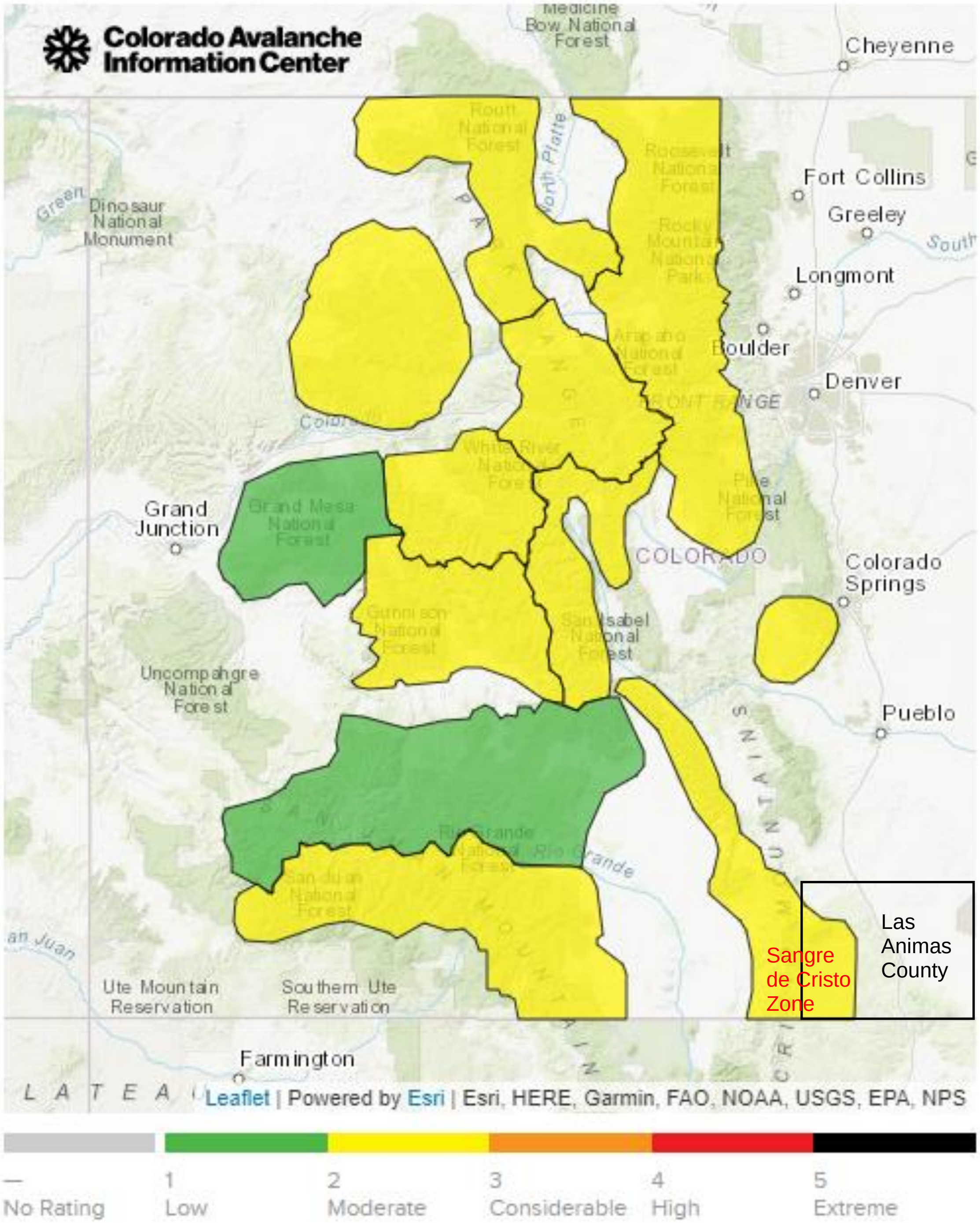
<u>Wet Snow Avalanches</u>
An avalanche in wet snow, also referred to as a wet loose avalanche or a wet slab avalanche. Often the basal shear zone is a water-saturated layer that overlies an ice zone.

Location

The greatest avalanche threats are in the mountainous areas of Las Animas County. Steeply sloped areas (30 to 45 degrees) are highly subject to avalanches, primarily on south exposed slopes where unstable snow conditions are most likely to occur. The majority of avalanches that occur in the state take place on slopes of 25-50 degrees. The Colorado Avalanche Information Center (CAIC) forecasts backcountry avalanche and mountain weather conditions for ten zones in the mountains of Colorado (Figure 1).[3] This figure is not intended to show current avalanche risk, as conditions are constantly changing throughout the winter season. This figure is included to show forecast zone boundaries as an indication of where avalanches tend to occur. The western part of Las Animas County is located within the Sangre de Cristo forecast zone.

3 State of Colorado. “Colorado Avalanche Information Center.” Accessed 2022. http://avalanche.state.co.us/.

Figure 1: CAIC Avalanche Forecast Zones



Source: Colorado Avalanche Information Center, 2022

Extent

Since local avalanche extent data is limited, the following information is taken from the state plan. The maximum measured impact pressure of an avalanche is 10 ton/ft^2 while 1 ton/ft^2 is more common. A typical avalanche is from 0.5 to 5.0 ton/ft^2. Air blasts from powder avalanches commonly exert a pressure of 100 lbs./ft^2 of force. Pressures of only 20-50 lbs./ft^2 can knock out most windows and doors. Additional damages associated with impact pressure are shown below.

Table 7: Avalanche Impact Pressure Damage Estimates

Impact Pressure (lbs./ft^2)	Potential Damage
40 – 80 lbs./ft^2	Break Windows.
60 – 100 lbs./ft^2	Push in doors, damage walls, roofs.
200 lbs./ft^2	Severely damage wood frame structures.
400 – 600 lbs./ft^2	Destroy wood-frame structures, break trees.
1,000 – 2,000 lbs./ft^2	Destroy mature forests.
>6,000 lbs./ft^2	Move large boulders.

Source: 2018-2023 Colorado Enhanced Hazard Mitigation Plan

Structures in avalanche prone areas, roads or highways, recreation areas, and vehicles in the way of an avalanche are all at risk of damage or destruction during an avalanche.

Historical Occurrences

According to the SHELDUS, there were no reported avalanche events in Las Animas County between 1960-2018.

Average Annual Losses

The average annual losses estimate was taken from the SHELDUS database. This does not include losses from displacement, functional downtime, economic loss, injury, or loss of life. With no historical reported avalanche events the average annual losses for property and crops is $0.

Probability

While no reported avalanches have occurred in the past, there is still a risk of avalanches, specifically in western Las Animas County. For the purposes of this plan the annual probability of avalanche is less than 1%.

Climate Change

Impacts from climate change are anticipated to affect the frequency and magnitude of avalanche events. The 2018-2023 Colorado Enhanced Hazard Mitigation Plan indicated that avalanche risk will become more common due to thinner snowpacks that do not bond well to new layers of snow and warming temperatures.

Jurisdictional Top Hazard Status

No jurisdictions identified avalanche as a top hazard of concern.

Future Development

Any future development in the western, more mountainous region of Las Animas County increases the risk to avalanche events. Prior to construction, developers and the county should evaluate surrounding grades, annual average snowpack loads, and run-out potential zones in high-risk areas. Emergency access should also be reviewed as these areas tend to be limited due to the terrain.

According to the 2018-2023 Colorado Enhanced Hazard Mitigation Plan, Las Animas County's exposure rating incorporating growth (2010-2030) is negligible. This takes into account projected population change and combined risk (deaths and past events).

County Vulnerabilities

The following table provides information related to county vulnerabilities; for jurisdictional-specific vulnerabilities, refer to *Section Seven: Participant Profiles.*

Table 8: County Avalanche Vulnerabilities

Sector	Vulnerability
People	-Backpackers and hikers in the mountainous areas -Motorists and homeowners in the western portion of the county -First responders to avalanche areas where snow is still unstable
Economic	-Road closures could prevent short term travel and access to local businesses by residents and tourists
Built Environment	-Localized impacts to homes in the western portion of the county
Infrastructure	-Road closures in the western portion of the county -Damage to power lines and poles causing localized power outages in the western portion of the county
Community Lifelines	-Road closures in the western portion of the county -Damage to power lines and poles causing localized power outages in the western portion of the county

Dam and Levee Failure

Dam Failure

Dam failure floods are primarily a result of hydrologic or structural deficiencies. The operation of a man-made reservoir can also influence the safety of the structure. Dam failure by hydrologic deficiency is a result of inadequate spillway capacity, which can cause the level of a reservoir to exceed the capacity or height of the dam, also known as overtopping, during large flows into the reservoir. Dam failure by hydrologic deficiency typically occurs from excessive runoff after unusually heavy precipitation in the basin. Large waves generated from landslides into a reservoir, or the sudden inflow from upstream dam failures, are other causes of dam failure by overtopping. Overtopping is especially dangerous for an earth dam, because the down-rush of water over the crest erodes the dam face. If it continues long enough, the down-rush of water breaches the dam embankment and suddenly releases all the stored water into the downstream floodplain.

The mechanics of a structural failure depend on the type of dam and the mode of failure. While they can occur at any time, earthen dams appear to be most susceptible to structural failure during the fall and spring freezing and thawing cycles.

Examples of structural deficiencies include seepage through the embankment, piping along internal conduits, erosion, cracking, sliding, overturning, rodent tunneling, and other weakness in the structure. Old age is often at the root of structural deficiencies. Seismic activity in Colorado has also been recognized as a potential source of structural problems due to liquefaction of sand layers in the embankment of a dam.

The Colorado Division of Water Resources (DWR) has classified dams into two main types: Jurisdictional Dams and Non-Jurisdictional Dam.

- **Non-Jurisdictional Dam** is a dam creating a reservoir with a capacity of 100 acre-feet or less and a surface area of 20 acres or less and with a height measured as defined in Rules 4.2.5.1 and 4.2.19 of 10 feet or less.

- **Jurisdictional Dam** is a dam creating a reservoir with a capacity of more than 100 acre-feet or creates a reservoir with a surface area in excess of 20 acres at the high-water line or exceeds 10 feet in height measured vertically from the elevation of the lowest point of the natural surface of the ground where that point occurs along the longitudinal centerline of the dam up to the crest of the emergency spillway of the dam.

Jurisdictional dams are further classified by the potential hazard each poses to human life and economic loss. The following are classifications and descriptions for each hazard class of Jurisdictional Dams:

- **No Public Hazard (NPH)** – dams assigned the NPH hazard potential classification are those for which no loss of human life is expected, and for which damage only to the dam owner’s property will result from failure.

- **Low Hazard Potential** – dams assigned the low hazard potential classification are those where failure or mis-operation results in no probable loss of human life and significant damage to structures and public facilities as defined for a Significant Hazard dam is not expected.

- **Significant Hazard Potential** – dams assigned the significant hazard potential classification are those dams where failure or mis-operation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns.

- **High Hazard** – dams assigned the high hazard potential classification are those where loss of human life is expected in the event of a failure.[4]

Dams that are classified with high hazard potential require the creation of an Emergency Action Plan (EAP). The EAP defines responsibilities and provides procedures designed to identify unusual and unlikely conditions which may endanger the structural integrity of the dam within sufficient time to take mitigating actions and to notify the appropriate emergency management officials of possible, impending, or actual failure of the dam. The EAP may also be used to provide notification when flood releases will create major flooding. An emergency situation can occur at any time; however, emergencies are more likely to happen when extreme conditions are present. The EAP includes information regarding the notification of emergency response entities so that proper action can be taken to prevent the loss of life and property. Local emergency response entities generally included in an EAP include but are not limited to 911 Dispatch, County Sheriffs, Local Fire Departments, Emergency Management Agency Director, County Highway Department, and the National Weather Service (NWS).

<u>Levee Failure</u>
According to FEMA:

> The United States has thousands of miles of levee systems. These manmade structures are most commonly earthen embankments designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water to provide some level of protection from flooding. Some levee systems date back as far as 150 years. Some levee systems were built for agricultural purposes. Those levee systems designed to protect urban areas have typically been built to higher standards. Levee systems are designed to provide a specific level of flood protection. No levee system provides full protection from all flooding events to the people and structures located behind it. Thus, some level of flood risk exists in these levee-impacted areas.

Levee failure can occur several ways. A breach of a levee is when part of the levee breaks away, leaving a large opening for floodwaters to flow through. A levee breach can be gradual by surface or subsurface erosion, or it can be sudden. A sudden breach of a levee often occurs when there are soil pores in the levee that allow water to flow through causing an upward pressure greater than the downward pressure from the weight of the soil of the levee. This under seepage can then resurface on the backside of the levee and can quickly erode a hole to cause a breach. Sometimes the levee actually sinks into a liquefied subsurface below.

Another way a levee failure can occur is when the water overtops the crest of the levee. This happens when the flood waters simply exceed the lowest crest elevation of the levee. An overtopping can lead to significant erosion of the backside of the levee and can result in a full breach and thus a levee failure.

---

4 Colorado Department of Natural Resources Division of Water Resources. November 2010. "Guidelines for Hazard Classification". Accessed February 2022. https://damfailures.org/wp-content/uploads/2019/08/Colorado-Guidelines-for-Hazard-Classification.pdf.

The USACE, who is responsible for federal levee oversight and inspection of levees, has three ratings for levee inspections.

Table 9: USACE Levee Rating Categories

Ratings	Description
Acceptable	All inspection items are rated as Acceptable.
Minimally Acceptable	One or more inspection items are rated as Minimally Acceptable or one or more items are rated as Unacceptable and an engineering determination concludes that the Unacceptable inspection items would not prevent the segment/system from performing as intended during the next flood event.
Unacceptable	One or more items are rated as Unacceptable and would prevent the segment/system from performing as intended, or a serious deficiency noted in past inspections has not been corrected within the established timeframe, not to exceed two years.

Source: USACE

Location

Dams

Communities or areas downstream of a dam, especially high hazard dams, are at greatest risk of property or infrastructure damage and loss of life due to dam failure. In total there are 59 dams located within Las Animas County. Figure 2 maps the locations of dams in the county. Non-jurisdictional dams were not mapped as location data was not available for all of them.

Table 10: Dams in Las Animas County

Non-Jurisdictional	No Public Hazard	Low Hazard	Significant Hazard	High Hazard	Total
15	30	7	0	7	59

Source: DWR, 2022[5]

The following table lists dams classified as "High Hazard" in the county.

Table 11: High Hazard Dams in the County

NID	Dam Name	Owner	Condition Assessment	Downstream Town
CO00543	Monument Lake	City of Trinidad	Fair	Monument
CO00544	North Lake	City of Trinidad	Fair	Vigil
CO02259	Apishapa Mitotes	Todd Huffman	Unsatisfactory	Aguilar
CO00105	Pinon Canyon Detention	City of Trinidad	Satisfactory	Trinidad
CO00534	Fisher Peak Det. Fpc-2	City of Trinidad	Fair	Trinidad
CO00533	Fisher Peak Det. Fpc-1	City of Trinidad	Satisfactory	Trinidad
CO00050	Trinidad Dam	USACE – Albuquerque District	Not Available	Trinidad

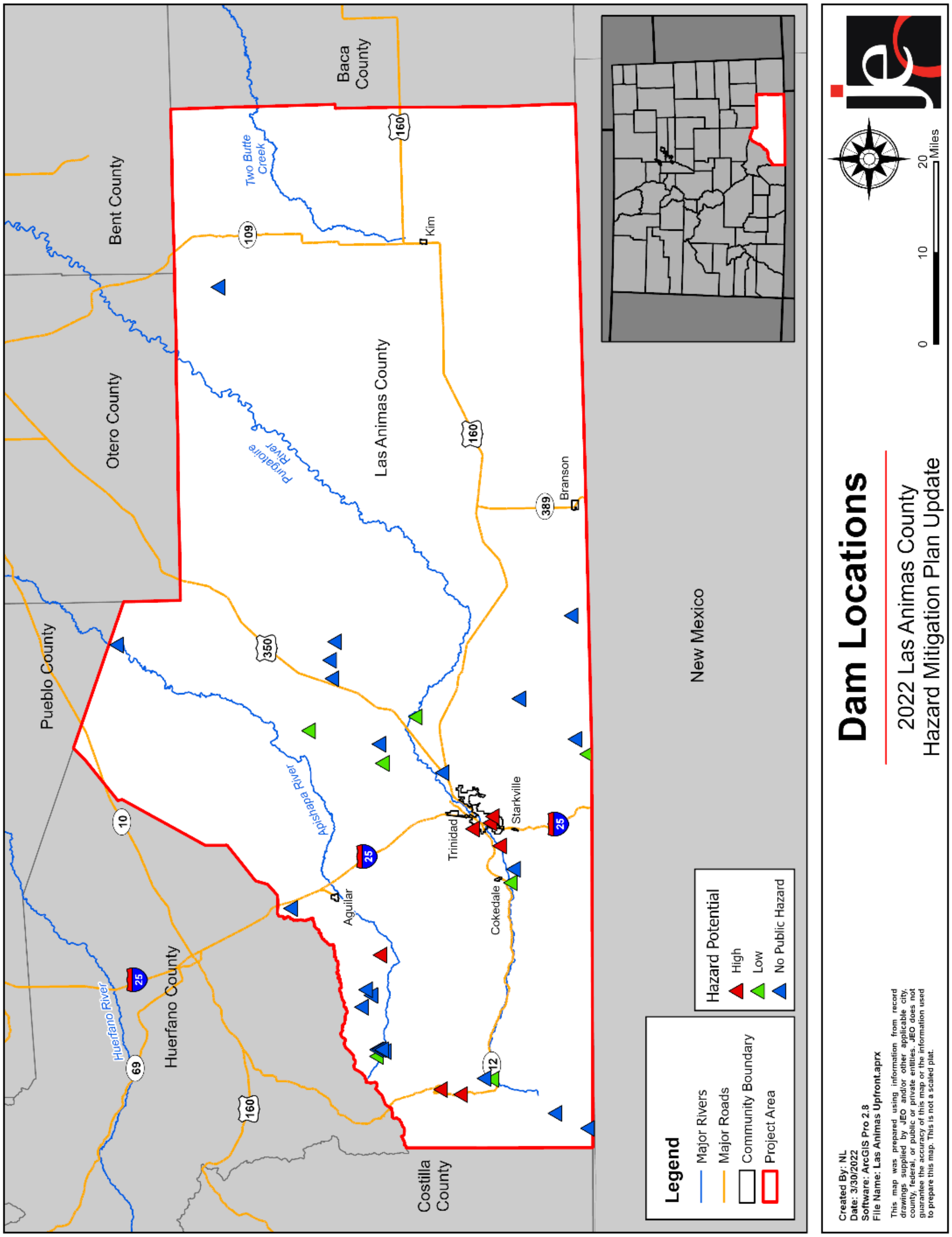
Source: DWR, 2022

Levees

According to USACE's National Levee Database, there are no levees in Las Animas County. However, there could be unmapped private levees along the rivers and creeks in the county that are unknown at this time.

5 Colorado Department of Natural Resources Division of Water Resources. February 2022. "Dam Safety". https://dwr.colorado.gov/services/dam-safety.

Figure 2: Dam Locations in the County



Dams and Levees of Concern Outside the County

There are no identified dams or levees outside the county that would affect Las Animas County.

Extent

Dam Failure

The extent of dam failure is indicated by its hazard classification and dam inundation maps. Note that hazard classification does not indicate the likelihood of a dam failure event to occur, but rather the extent of potential damages that may occur in case of a failure. Thus, the high hazard dams in the county would have the greatest impacts if they were to fail.

Dam inundation maps for Monument Lake Dam, North Lake Dam, Pinon Canyon Detention Dam, Fisher Peak Detention Fpc-1 Dam, and Fisher Peak Detention FPC-2 Dam are not shown due to security concerns by the City of Trinidad's local planning team. The owner of the Apishapa Mitotes Dam was contacted but no response was received. Therefore, the dam inundation map is not available for this planning effort. Those who wish to see the inundation maps may contact the local dam owners. For the purposes of this plan, dam inundation areas are estimated to be slightly larger than the 100-year floodplain.

Trinidad Dam

In 2018, the USACE completed a risk assessment of Trinidad Dam which included an estimate of the potential consequences of various dam failures. The table below shows the most damaging scenario, but it should be noted that consequences will be different depending on the type of failure that occurs. In addition, the risk assessment noted that if a dam breach were to occur, flood inundation would be life-threatening and cause catastrophic downstream damages to residences and infrastructure (including levees) along the Purgatoire and Arkansas Rivers to John Martin Reservoir. Impacted communities include Trinidad, El Moro, Hoehne, Las Animas, and communities located in between.[6]

Table 12: Trinidad Dam Failure Consequences Estimate

Scenario	Daytime People at Risk	Nighttime People at Risk	Economic Cost
Maximum High Pool – Breach	7,036	8,441	$659,076,263

Source: USACE, 2022

Dam inundation maps for Trinidad Dam are shown in Figure 3 and Figure 4. The flood inundation information shown in the maps should be used as a guideline only. Actual flooding conditions will vary depending actual conditions during the dam failure. According to the USACE one communication facility, six electrical substations, one heliport, one intermodal shipping facility, a wastewater treatment plant, and three school facilities are located in the dam inundation area.

6 U.S. Army Corps of Engineers. 2022. "National Inventory of Dams." https://nid.usace.army.mil/#/dams/search/sy=@countyState:Las%20Animas,%20Colorado&viewType=map&resultsType=dams&advanced=false&hideList=false&eventSystem=false.

Reservoir Release Rates During Base Floods

Although the Trinidad Dam project has successfully reduced flooding, it does not eliminate all flood risk caused by rainfall downstream of the dam or due to higher release rates and emergency operation of the dam. During infrequent emergency operation, larger required releases through the project's gated outlet works could surpass downstream river channel capacity and flood low-lying areas along the Purgatoire and Arkansas Rivers. Although the progression of events leading to much larger, uncontrolled flow through the spillways has never occurred, uncontrolled spillway flows could greatly surpass downstream channel capacity, and be life-threatening. Flood inundation caused by uncontrolled spillway flow could cause catastrophic downstream damages to residences and infrastructure (including levees) along the Purgatoire and Arkansas Rivers to John Martin Reservoir. Impacted communities include Trinidad, El Moro, Hoehne, Las Animas, and communities located in between.

Levee Failure

Given that there are no mapped levees within the county, we are not able to identify the exact impacts of levee failure. If any unmapped levees were to fail, they would likely result in minor flooding of private property.

Historical Occurrences

Dam Failure

According to Stanford University's National Performance of Dams Program, there has been one dam incident in Las Animas County. No damages, injuries, or fatalities were reported with the dam incident event. In the event that dam failure is imminent, the Emergency Action Plan (EAP) for the dam governs the course of action.

Table 13: Dam Incidents in the County

NID	Dam Name	Hazard Class	Year of Failure	Description of Incident
CO00544	North Lake	High	2000	Seepage

Source: Stanford University, 2018[7]

Levee Failure

There have been no recorded instances of levee failure in the county.

Average Annual Losses

Dam Failure

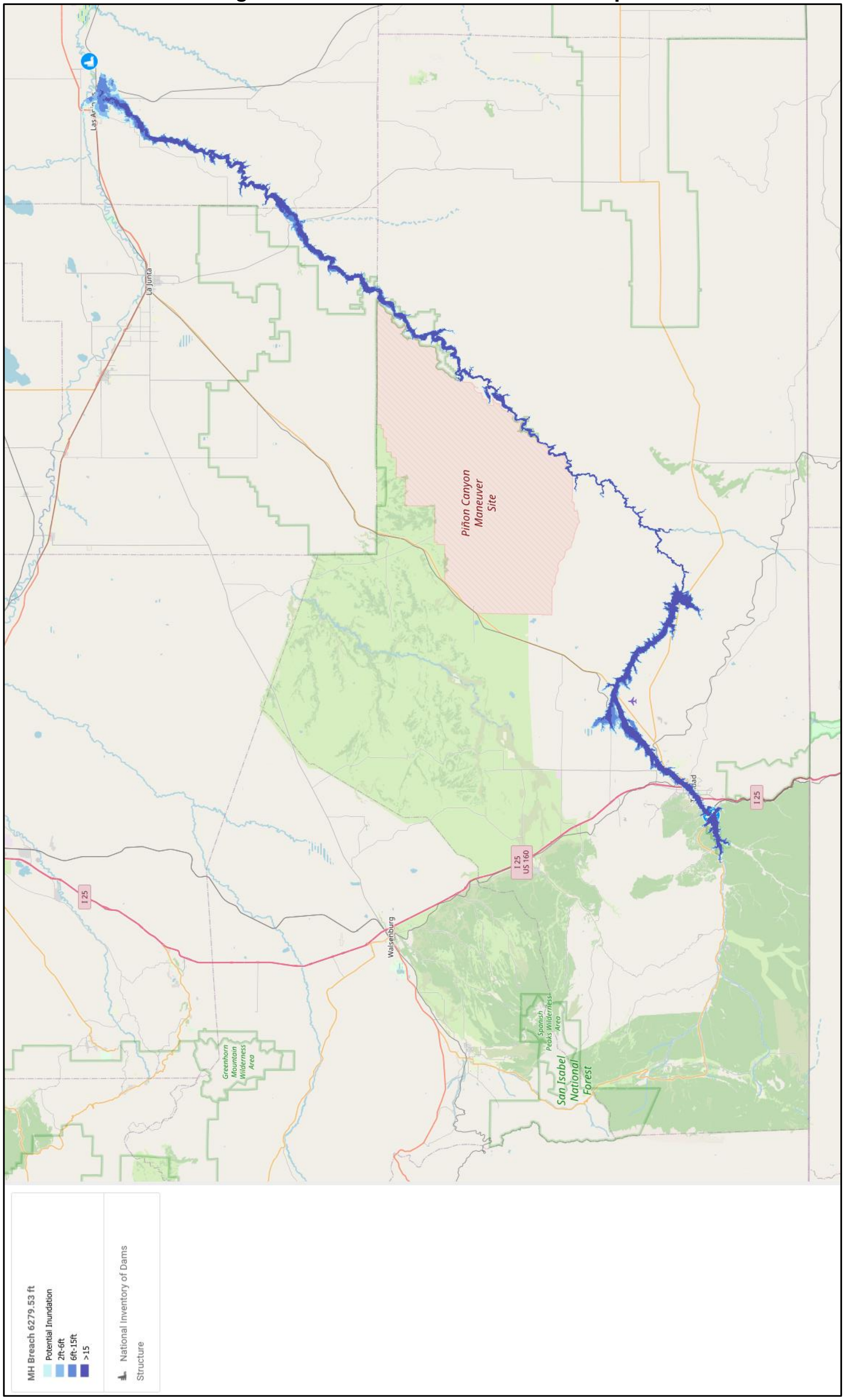
The one reported dam incident did not have any reported damages. Therefore, the average annual losses are $0

Levee Failure

There are no recorded instances of levee failure in the county, so average annual losses are $0.

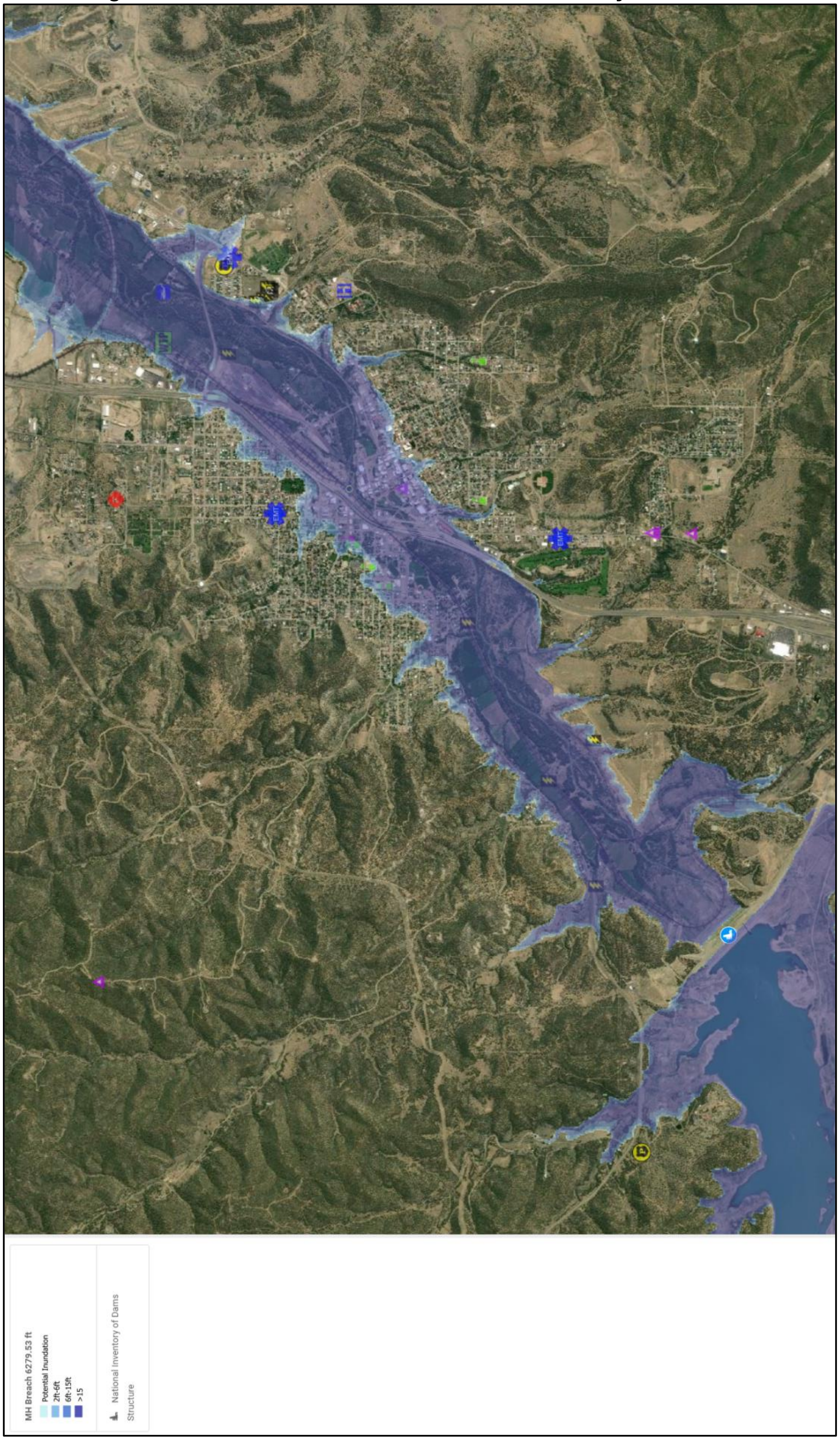
7 Stanford University. December 2018. "National Performance of Dams Program: Dam Incident Database." Accessed February 2022. http://npdp.stanford.edu/dam_incidents.

Figure 3: Trinidad Dam Inundation Map



Source: USACE, 2022

Figure 4: Trinidad Dam Inundation - Zoom on City of Trinidad



Source: USACE, 2022

Probability

Dam Failure

There has been one year with a reported dam failure out of 128 years, so the probability of dam failure will be stated as less than one percent annually.

For Trinidad Dam, the 2018 risk assessment results:

> "Characterize dam breach risk as low due to the combination of life loss consequences and low likelihood of dam breach occurring either during normal operations or as the result of an extreme event. Specifically, the occurrence of dam breach caused by overtopping the dam was identified as the consequence of an extreme storm event (less than 1 in 200,000 year or 0.0005% per year). The annual probability of dam breach due to overtopping caused by an extreme storm event is estimated to be low (1 in 2,000,000)."

Levee Failure

With no mapped levees in the county, there is a less than 1% chance that levee failure will occur in the county annually.

Climate Change

Dams are designed partly based on assumptions about a river's flow behavior, expressed as hydrographs. Changes in weather patterns can have significant effects on the hydrograph used for the design of a dam. If the hydrograph changes, it is conceivable that the dam can lose some or all of its designed margin of safety, also known as freeboard. If freeboard is reduced, dam operators may be forced to release increased volumes earlier in a storm cycle in order to maintain the required margins of safety. Such early releases can increase flood potential downstream. Changes in precipitation and temperatures are also likely to strain unmapped private levees and berms.

Jurisdictional Top Hazard Status

The following table lists jurisdictions which identified dam and levee failure as a top hazard of concern.

Jurisdictions	
City of Trinidad	

Future Development

Any future growth in high hazard dam inundation areas increases the risks from dam failure. Additionally, any increase in development downstream of existing low and significant hazard dams may elevate these dams to a high hazard rating. As many dam inundation areas are also floodplain areas, developing outside these areas will reduce vulnerability to both hazards. Communities could implement requirements for new development in dam inundation areas similar to floodplain ordinances to minimize hazard creeping. This would help reduce the number of people and property impacted during a dam failure event.

According to the 2018-2023 Colorado Enhanced Hazard Mitigation Plan, Las Animas County's exposure rating incorporating growth (2010-2030) is negligible. This takes into account projected population change and risk (number of high hazard dams).

County Vulnerabilities

County vulnerabilities to dam failure vary based on surrounding development and other flood control measures. When dams fail, suddenly their contents are released at a high rate of speed, increasing the potential to cause injuries, loss of life, or property damage. The following table provides information related to the county vulnerabilities; for jurisdictional-specific vulnerabilities, refer to Section Seven: Participant Profiles. The City of Trinidad is at greater risk than other communities in the county due to multiple high hazard dams nearby.

Table 14: County Dam and Levee Failure Vulnerabilities

Sector	Vulnerability
People	-Those living downstream of high hazard dams -Evacuations likely with high hazard dams -Hospitals, nursing homes, and the elderly at greater risk due to low mobility -Minimal risk from unmapped private levees and berms
Economic	-Businesses located in the inundation areas would be impacted and closed for an extended period of time -Employees working in the inundation area may be out of work for an extended period of time -Localized crop and rangeland loss
Built Environment	-Flood damage to homes and buildings in the inundation areas -Minimal impact to private property from levee failure
Infrastructure	-Transportation routes could be closed for extended periods of time
Community Lifelines	-Critical buildings in inundation areas are vulnerable to damages -Transportation routes could be closed for extended periods of time

Drought

Drought is generally defined as a natural hazard that results from a substantial period of below normal precipitation. Although many inaccurately consider drought a rare and random event, it is actually a normal, recurrent feature of climate. Drought can occur in virtually all climatic zones, but its characteristics can vary significantly from one region to another. A drought often coexists with periods of extreme heat, which together can cause significant social stress, economic losses, and environmental degradation. Drought conditions can significantly and negatively impact the agricultural economic base and numerous affiliate industries.

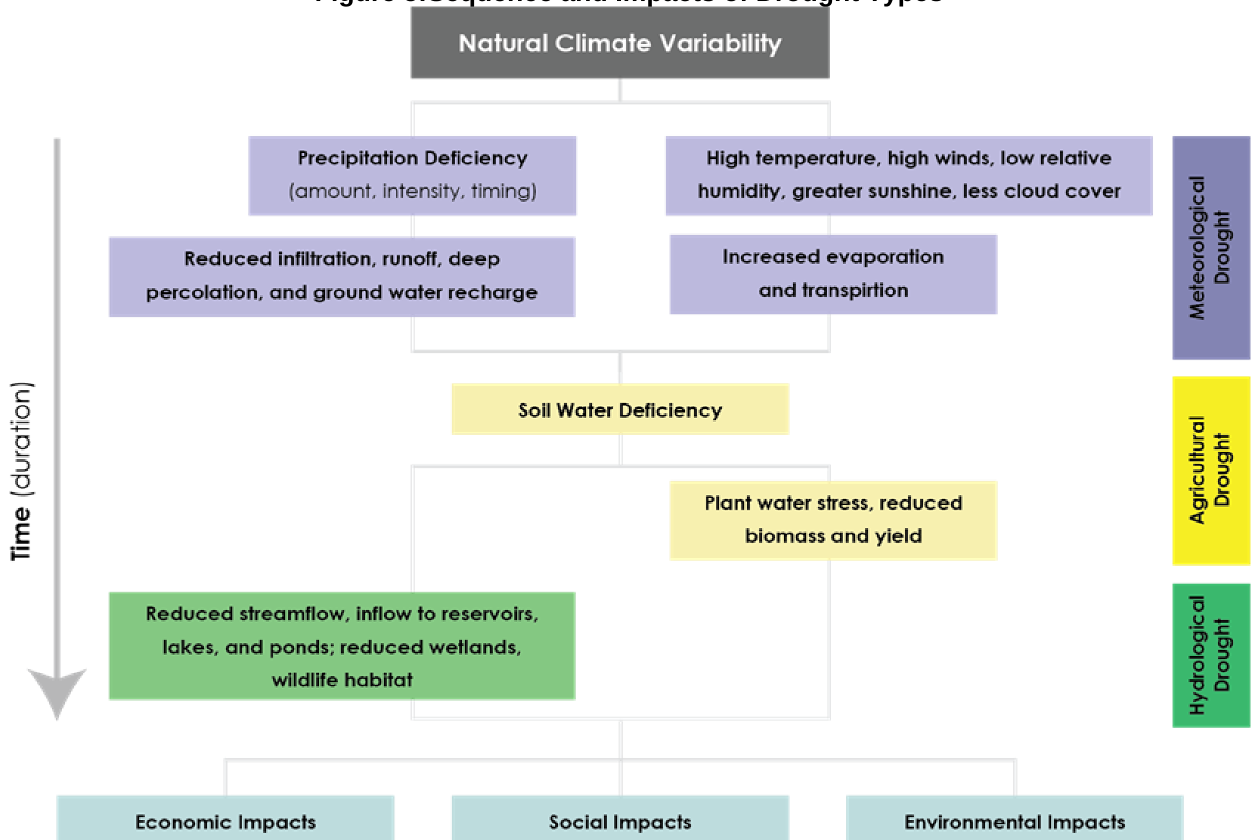
Drought is a slow onset, creeping phenomenon that can affect a wide range of people, livestock, and industries. While many impacts of these hazards are non-structural, there is the potential that during prolonged drought events structural impacts can occur. Drought normally affects more people than other natural hazards, and its impacts are spread over a larger geographical area. As a result, the detection and early warning signs of drought conditions or long-term extreme heat and assessment of impacts are more difficult to identify than that of quick-onset natural hazards (e.g., flood) that results in more visible impacts. According to the National Drought Mitigation Center (NDMC), droughts are classified into four major types:

> **Drought** is a normal, recurrent feature of climate, although many erroneously consider it a rare and random event. It occurs in virtually all climatic zones, but its characteristics vary significantly from one region to another.
> ~National Drought Mitigation Center

- **Meteorological Drought** – is defined based on the degree of dryness and the duration of the dry period. Meteorological drought is often the first type of drought to be identified and should be defined regionally as precipitation rates and frequencies (norms) vary.
- **Agricultural Drought** – occurs when there is deficient moisture that hinders planting germination, leading to low plant population per hectare and a reduction of final yield. Agricultural drought is closely linked with meteorological and hydrological drought; as agricultural water supplies are contingent upon the two sectors.
- **Hydrological Drought** – occurs when water available in aquifers, lakes, and reservoirs falls below the statistical average. This situation can arise even when the area of interest receives average precipitation. This is due to the reserves diminishing from increased water usage, usually from agricultural use of high levels of evapotranspiration, resulting from prolonged high temperatures. Hydrological drought often is identified later than meteorological and agricultural drought. Impacts from hydrological drought may manifest themselves in decreased hydropower production and loss of water-based recreation.
- **Socioeconomic Drought** – occurs when the demand for an economic good exceeds supply due to a weather-related shortfall in water supply. The supply of many economic goods includes, but are not limited to: water, forage, food grains, fish, and hydroelectric power.[8]

8 National Drought Mitigation Center. 2017. “Drought Basics.” http://drought.unl.edu/DroughtBasics.aspx.

Figure 5:Sequence and Impacts of Drought Types



Source: National Drought Mitigation Center, University of Nebraska-Lincoln, 2017[9]

Location

The entire county is susceptible to impacts resulting from drought and extreme heat.

Extent

The Palmer Drought Severity Index (PDSI) is utilized by climatologists to standardize global long-term drought analysis. The PDSI was developed in 1965 to measure dryness based on recent precipitation and temperatures. The data for the county was collected from Climate Division 1 between the years of 1895 and 2021. The table below shows details of the Palmer classifications and Table 16 shows the classification for the Drought Monitor.

Table 15: Palmer Drought Magnitude

Numerical Value	Description	Numerical Value	Description
4.0 or more	Extremely Wet	-0.5 to -0.99	Incipient Dry Spell
3.0 to 3.99	Very Wet	-1.0 to -1.99	Mild Drought
2.0 to 2.99	Moderately Wet	-2.0 to -2.99	Moderate Drought
1.0 to 1.99	Slightly Wet	-3.0 to -3.99	Severe Drought
05.to 0.99	Near Normal	-4.0 or less	Extreme Drought
0.49 to -0.49	Near Normal	--	--

Source: NCEI

9 National Drought Mitigation Center. 2017. “Types of Drought.” http://drought.unl.edu/DroughtBasics/TypesofDrought.aspx.

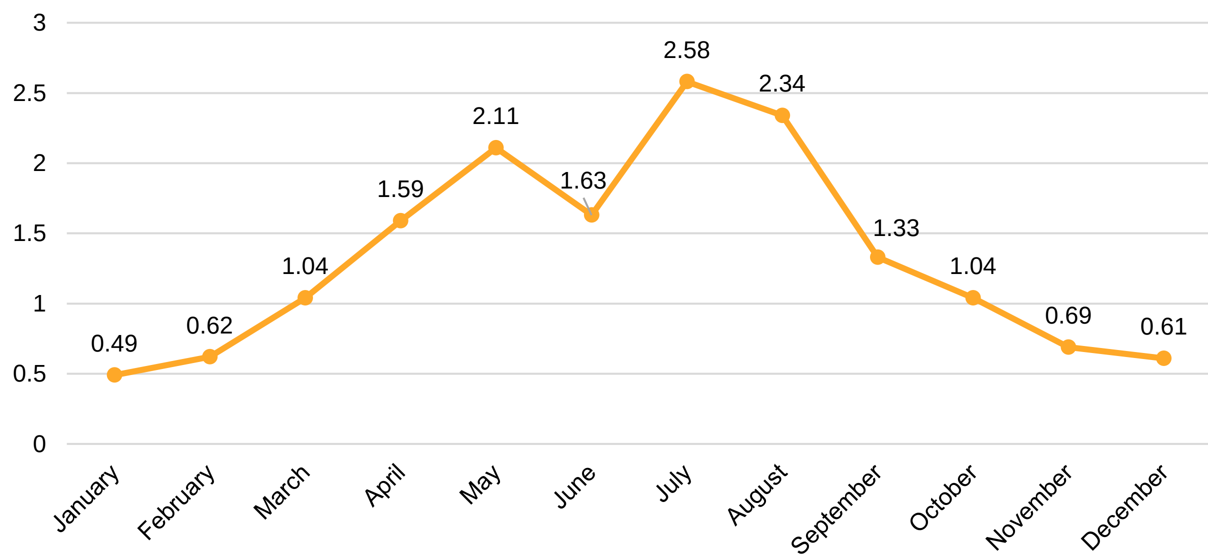
Table 16: United States Drought Monitor Classification

Category	Description	PDSI Ranges	Possible Impacts
D0	Abnormally Dry	-1.0 to -1.9	Going into drought: short-term dryness slowing planting, growth of crops or pastures. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered.
D1	Moderate Drought	-2.0 to -2.9	Some damage to crops, pastures; streams, reservoirs, or wells low, some water shortages developing or imminent; voluntary water-use restrictions requested
D2	Severe Drought	-3.0 to -3.9	Crop or pasture losses likely, water shortages common; water restrictions imposed
D3	Extreme Drought	-4.0 to -4.9	Major crop/pasture losses; widespread water shortages or restrictions
D4	Exceptional Drought	-5.0 or less	Exceptional and widespread crop/pasture losses; shortages of water in reservoirs, streams and wells creating water emergencies.

Source: NDMC, 2017[10]

Figure 6 shows the normal average monthly precipitation for the county, which is helpful in determining whether any given month is above, below, or near normal in precipitation. Prolonged deviation from the norm showcases drought conditions.

Figure 6: Average Monthly Precipitation (in.)



Source: NOAA, 1895-May 2021

Historical Occurrences

The following table indicates it is reasonable to expect drought to occur throughout the county. The county has experienced several 'extreme' droughts and future moderate, severe, and extreme droughts are likely to occur in the future.

10 National Drought Mitigation Center. 2017. "Types of Drought." http://drought.unl.edu/DroughtBasics/TypesofDrought.aspx.

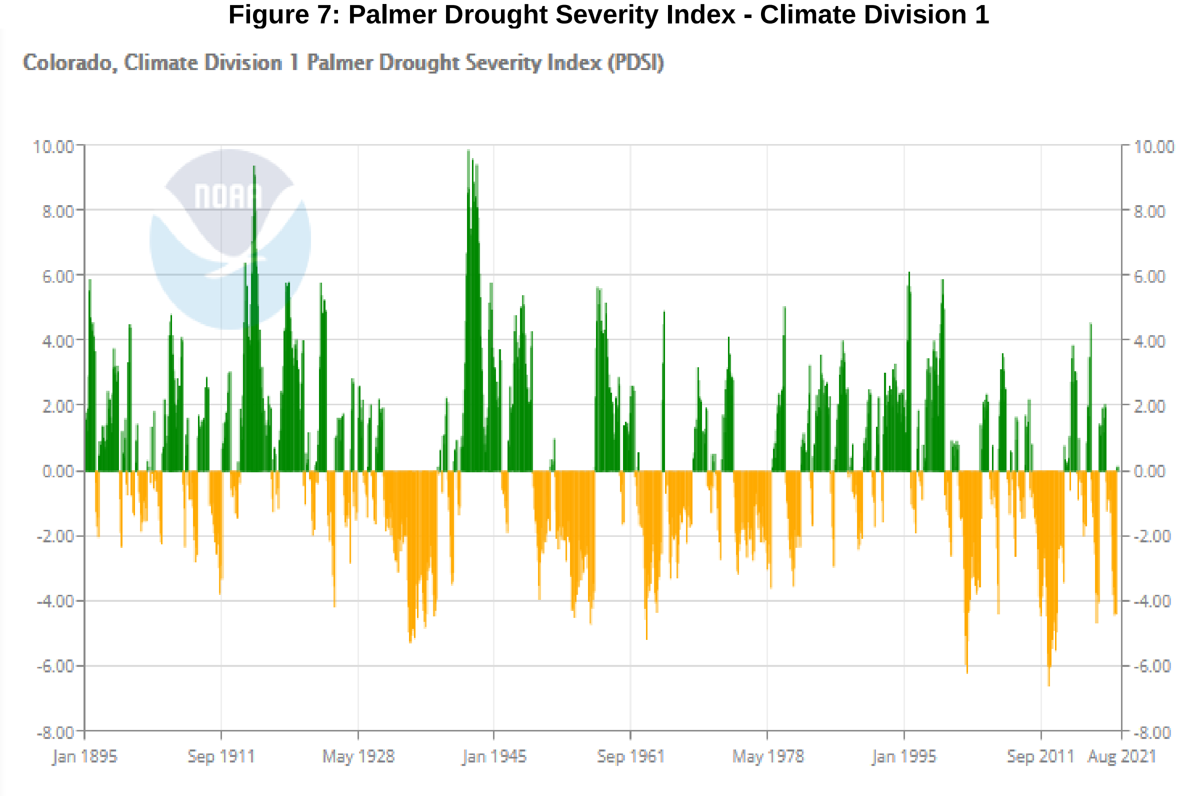
Table 17: Historic Drought Events and Probability

Drought Magnitude	Months in Drought	Percentage
-1 Magnitude (Mild)	234/1,513	15.5%
-2 Magnitude (Moderate)	156/1,513	10.3%
-3 Magnitude (Severe)	90/1,513	5.9%
-4 Magnitude or Greater (Extreme)	69/1,513	4.6%
Total Months in Drought	**549/1,513**	**36.3%**

Source: NCEI, Jan 1895-Jan 2021[11]

The figures below show historical droughts from 1895 to 2021. The negative Y axis represents a drought, for which '-2' indicates a moderate drought, '-3' a severe drought, and '-4' an extreme drought. Major drought events occurred in the 1930s (Dust Bowl era), the early 2000s, 2011-2014, and the current ongoing drought. The county is currently experiencing either a D2 (Severe Drought) or D3 (Extreme Drought), per the US Drought Monitor (Figure 8).

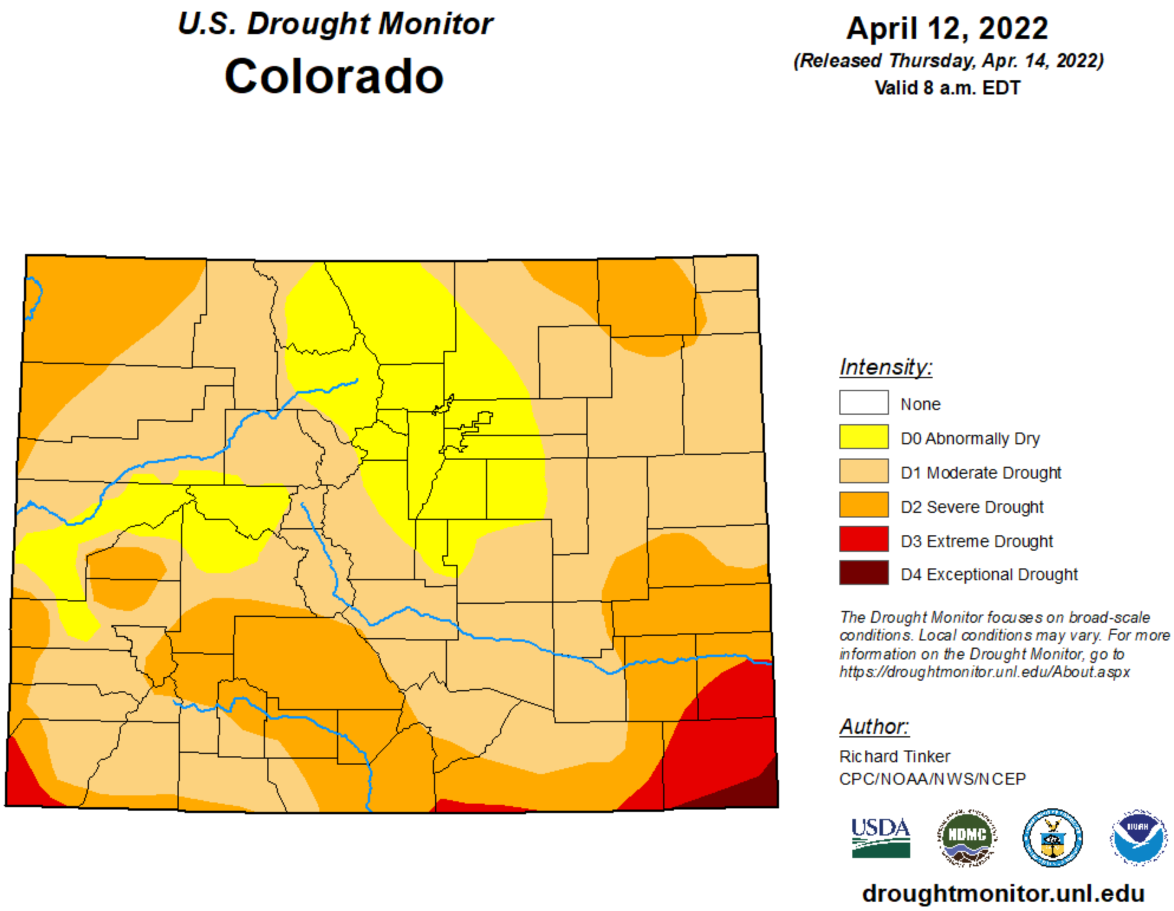
Figure 7: Palmer Drought Severity Index - Climate Division 1



Source: NOAA

11 National Centers for Environmental Information. 1895-2020. Accessed September 28, 2021. https://www.ncdc.noaa.gov/cag/divisional/time-series/0501/pdsi/all/1/1895-2021

Figure 8: U.S. Drought Monitor



Source: National Drought Mitigation Center, April 2022

The Drought Impact Reporter is a database of drought impacts throughout the United States with data going back to 2000. The more impacts that are reported to the National Drought Mitigation Center the more severe the drought.

Recent examples of reported drought impacts include the following.

- Irrigation supplies short in Southeast Colorado (September 2021).
- Cattle in southeast Colorado still receiving supplemental feed (May 2021).
- Winter wheat stressed in eastern Colorado (December 2020).
- Extreme yield losses for meadow grass hay in Southeast Colorado (August 2020).

The Drought Impact Reporter has recorded a total of 78 drought-related impacts throughout the county. This is not a comprehensive list of droughts which may have impacted the county, but only those with reported impacts. The following are the categories and reported number of impacts. Note that some impacts have been assigned to more than one category.

- Agriculture: 48
- Fire: 10
- Plants & Wildlife: 27
- Relief, Response & Restrictions: 29
- Society & Public Health: 5
- Tourism & Recreation: 2
- Water Supply & Quality: 13

Some of these impacts are summarized in the following table.

Table 18: Drought Impacts in Las Animas County

Category	Date	Title
Agriculture, Water Supply & Quality	7/15/2010	Ranches in Las Animas County, Colorado, destocking
Plants & Wildlife	8/15/2010	Drought affecting native plants in Las Animas County
Agriculture, Relief, Response & Restrictions	5/1/2011	Five Colorado counties received federal disaster declarations
Fire, Relief, Response & Restrictions	4/13/2012	High fire danger prompts officials to implement restrictions in Teller, Las Animas, Rio Grande, and Conejos counties, Colorado
Agriculture, Society & Public Health	11/1/2012	Intense dust storm in southeastern Colorado
Agriculture, Plants & Wildlife	1/1/2014	Las Animas County, Colorado, reduction in cow herd, fewer babies born to wildlife
Plants and Wildlife	1/28/2018	Watering trees to keep them alive in Las Animas County, Colorado
Agriculture, Water Supply & Quality	2/1/2018	Low river flows causing problems for producers in southeastern Colorado
Agriculture, Plants & Wildlife, Water Supply & Quality	4/28/2020	Rangelands deteriorating in southeast Colorado
Agriculture, Water Supply & Quality	5/3/2020	Irrigation water concerns in southeast Colorado.

Source: NDMC, 2000-Sept 2021

Several USDA Secretarial Drought Disasters for Las Animas County have occurred since 2003. Table 19 lists these disaster events.

Table 19: USDA Secretarial Drought Disasters (2003-2021)

Year	Type	Declaration Number
2003	Drought, Insects	S1843
2005	Drought	S2031
2005-2006	Drought, Crop Diseases, Insects	S2287
2005-2006	Drought, Fire, High Winds, Heat	S2327
2008	Drought	S2750
2009	Drought	S2996
2011	Drought	S3125, S3133, S3144
2012	Drought, Wind/High Winds, Heat/Excessive Heat	S3260
2013	Drought, Wind/High Winds, Fire/Wildfire, Heat/Excessive Heat, Insects	S3456, S3461, S3518
2014	Drought, High Winds, Wildfire, Heat, Insects	S3627, S3630
2015	Drought, High Winds, Wildfire, Heat, Insects	S3785, S3788
2017	Drought	S4145
2018	Drought	S4280, S4285, S4289, S4291, S4293, S4304, S4313, S4320
2019	Drought	S4468, S4469, S4481
2020	Drought	S4648, S4651, S4680, S4692
2021	Drought	S4917, S4920

Source: USDA, 2003-2021[12]

Average Annual Losses

The annual property estimate was determined based upon NCEI Storm Events Database since 1996. The annual crop loss was determined based upon SHELDUS data from 1960 – 2018. This does not include losses from displacement, functional downtime, economic loss, injury, or loss of life. The direct and indirect effects of drought are difficult to quantify. There was a reported $0 in property damages and $943,396 in crop damages from drought during the period of record.

Table 20: Drought Losses

Hazard Type	Total Property Loss[1]	Average Annual Property Loss	Total Crop Loss[2]	Average Annual Crop Loss
Drought	$0	$0	$943,396	$15,990

Source: 1 NCEI (1996-2021), 2 SHELDUS (1960-2018)

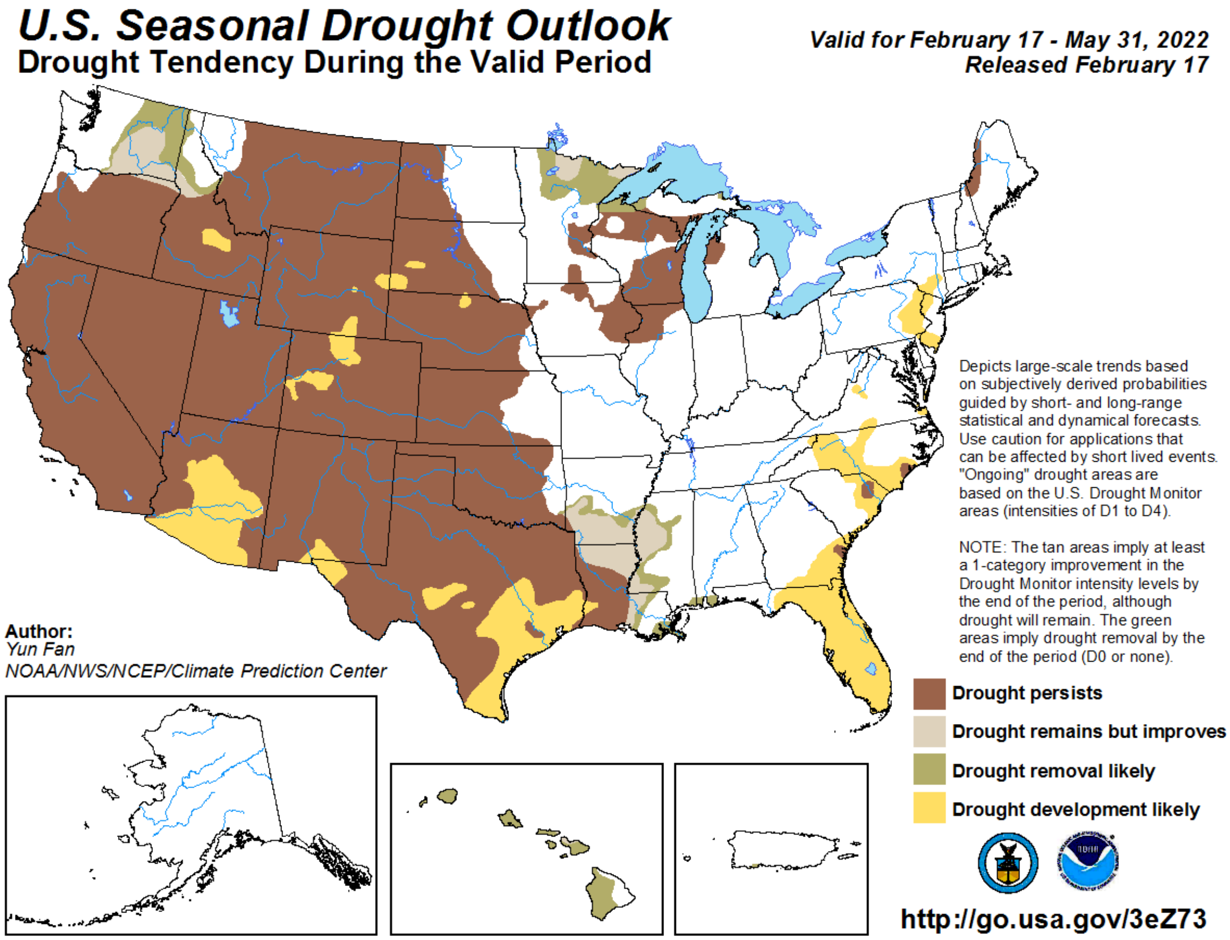
Probability

Drought conditions are also likely to occur regularly in the county. PDSI data shows that drought has occurred in 36% of months (549/1,513) on record.

The U.S. Seasonal Drought Outlook (Figure 9) provides a short-term drought forecast that can be utilized by local officials and residents to examine the likelihood of drought developing or the continuing degradation oof the current situation. The drought outlook is updated consistently throughout the year and should be reviewed on an ongoing basis. The following figure provides the drought outlook from February 2022 as an example.

12 U.S Department of Agriculture. 2021. "Disaster Designation Information" https://www.fsa.usda.gov/programs-and-services/disaster-assistance-program/disaster-designation-information/index.

Figure 9: U.S. Seasonal Drought Outlook



Source: NOAA, February 2022

Climate Change

Drought is expected to increase in frequency and severity in Colorado due to projected overall warming. A specific tool developed and utilized in the State of Colorado includes the Future Avoided Cost Explorer[13] (FACE) for Drought. This tool presents an in-depth look at potential future economic impacts of drought on specific sectors of the Colorado economy. The following table and figures show expected impacts for drought for the current climate and projected future 'Moderate' and 'More Severe Climate' impacts with the anticipated high growth for Las Animas County.

Based on the FACE assessments, it is likely that Las Animas County will experience worsening impacts from climate change regarding drought. At the current growth rate and only moderate climate impacts, the county may experience up to $7.4 million in total damages annually. Damages may vary across sectors and regions such as bridges, buildings, cattle, crops, and fire suppression activities.

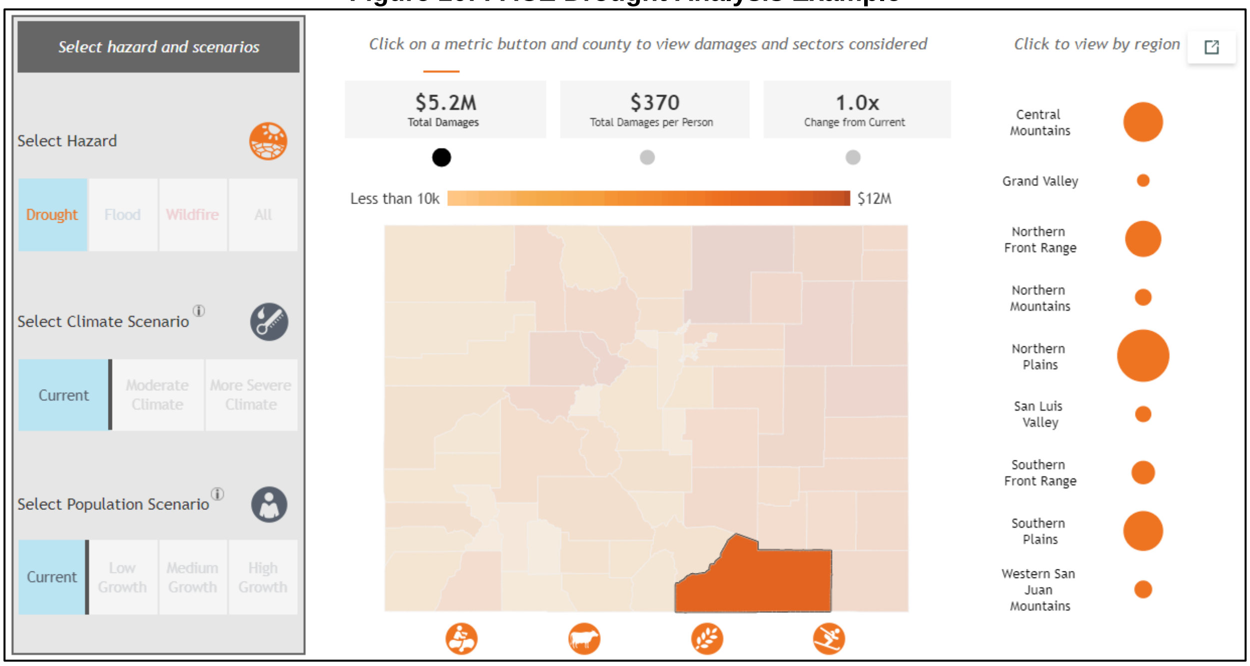
13 Colorado Water Conservation Board. 2020. "Future Avoided Cost Explorer: Colorado Hazards." https://storymaps.arcgis.com/stories/4e653ffb2b654ebe95848c9ba8ff316e.

Table 21: FACE Anticipated Las Animas Damages for Drought Matrix

Population Scenario	Climate Scenario		
	Current Climate	**Moderate Climate**	**More Severe Climate**
Current Growth Rate	\$5.2 million \$370 per person	\$7.4 million \$530 per person	\$8.6 million \$610 per person
Low Growth Rate	\$5.2 million \$370 per person	\$7.5 million \$580 per person	\$8.7 million \$680 per person
Medium Growth Rate	\$5.2 million \$390 per person	\$7.5 million \$570 per person	\$8.7 million \$660 per person
High Growth Rate	\$5.2 million \$380 per person	\$7.5 million \$540 per person	\$8.7 million \$630 per person

Source: CWCB FACE, 2020

Figure 10: FACE Drought Analysis Example



Source: CWCB FACE, 2020

Suggested actions to improve resilience to drought from FACE are shown in the graphic below.

Figure 11: Exploring Resilience Actions for Drought

Source: CWCB FACE, 2020

Jurisdictional Top Hazard Status

The following table lists jurisdictions which identified drought as a top hazard of concern.

Jurisdictions	
Town of Cokedale	Town of Kim
Hoehne Fire Protection District	Kim Reorganized 88

Future Developments

Any future developments throughout the county and in the regional area are likely to increase water demand, increase travel on local transportation routes, and influence continued growth on economic sectors at risk from the impacts of drought. Growing communities will need to adapt and account for increased water demands for residential, commercial and industrial development.

According to the 2018 Colorado Drought Mitigation and Response Plan, Las Animas County was in the lowest susceptibility rating for socioeconomic sector vulnerability to drought.

County Vulnerabilities

Drought is a common feature of Las Animas County and can cause significant economic, environmental, and social impacts. Although agriculture, ranching, and water-based recreation are major sectors affected, impacts on rural and municipal water supplies, fish and wildlife, tourism, water quality, soil erosion, the incidence of wildland fires, and other sectors are also significant. Similarly, the indirect impacts of drought on personal and business incomes, tax revenues, unemployment, and other areas are also important. In general, drought produces a complex web of impacts that ripple through many sectors of the economy. This is largely due to the dependence of so many sectors on water for producing goods and providing services.

The following table provides information related to county vulnerabilities for drought. For jurisdictional-specific vulnerabilities, refer to *Section Seven: Participant Profiles*.

Table 22: County Drought Vulnerabilities

Sector	Vulnerability
People	-Insufficient water supply -Loss of jobs in agriculture and ranching sector -Residents in poverty if food prices increase
Economic	-Closure of water intensive businesses (carwashes, pool, etc.) -Loss of tourism dollars -Losses in crop production -Decrease in cattle prices -Decrease of land prices → jeopardizes educational funds
Built Environment	-Cracking of foundations (residential and commercial structures) -Damages to landscapes
Infrastructure	-Damages to waterlines below ground -Damages to roadways
Community Lifelines	-Damages to waterlines and other pipelines below ground -Damages to roadways

Earthquakes

An earthquake is the result of a sudden release of energy in the Earth's tectonic plates that creates seismic waves. The seismic activity of an area refers to the frequency, type, and size of earthquakes experienced over a period of time. Ground shaking, landslides, liquefaction, and amplification are the specific hazards associated with earthquakes. The severity of these hazards depends on several factors, including soil and slope conditions, proximity to a fault, earthquake magnitude, and type of earthquake.

- **Ground shaking** is the motion felt on the earth's surface caused by seismic waves generated by an earthquake. Ground shaking is the primary cause of earthquake damage. The strength of ground shaking depends on the magnitude of the earthquake, the type of fault, and distance from the epicenter (where the earthquake originates). Buildings on poorly consolidated and thick soils will typically see more damage than buildings on consolidated soils and bedrock.

- **Earthquake-induced landslides** are secondary earthquake hazards that occur from ground shaking. They can destroy roads, buildings, utilities, and other critical facilities necessary to respond to recover from an earthquake.

- **Liquefaction** occurs when ground shaking causes wet granular soils to change from a solid state to a liquid state. This results in the loss of soil strength and the soil's ability to support weight. Buildings and their occupants are at risk when the ground can no longer support these buildings and structures.

- **Amplification** is the phenomenon when soils and soft sedimentary rocks near the earth's surface increase the magnitude of the seismic waves generated by the earthquake. The amount of amplification is determined by the thickness of geologic materials and their physical properties. Buildings and structures built on soft and unconsolidated soils face greater risk.

Location

The most likely locations to experience an earthquake are near a fault line. According to the USGS, there are no major fault lines in Las Animas County, but the Sangre de Cristo Fault runs north/south (at the base of the Sangre de Cristo Mountains along the eastern edge of the San Luis Valley) just west of Las Animas County. The smaller Cheraw Fault lies north of Las Animas County and runs through Kiowa, Otero, and Crowley Counties.

Extent

Earthquakes are measured by magnitude and intensity. Magnitude is measured by the Richter Scale, a base-10 logarithmic scale, which uses seismographs around the world to measure the amount of energy released by an earthquake. Intensity is measured by the Modified Mercalli Intensity Scale, which determines the intensity of an earthquake by comparing actual damage against damage patterns of earthquakes with known intensities. The following tables summarize the Richter Scale and Modified Mercalli Scale. Based on historical record, earthquakes in the county are likely to measure 5.0 or less on the Richter Scale.

Table 23: Richter Scale

Richter Magnitudes	Earthquake Effects
Less than 3.5	Generally not felt, but recorded
3.5 – 5.4	Often felt, but rarely causes damage
Under 6.0	At most, slight damage to well-designed buildings. Can cause major damage to poorly constructed buildings over small regions
6.1 – 6.9	Can be destructive in areas up to about 100 kilometers across where people live
7.0 – 7.9	Major earthquake. Can cause serious damage over larger areas
8 or Greater	Great earthquake. Can cause serious damage in areas several hundred kilometers across.

Source: FEMA, 2016[14]

Table 24: Modified Mercalli Intensity Scale

Scale	Intensity	Description of Effects	Corresponding Richter Scale Magnitude
I	Instrumental	Detected only on seismographs	
II	Feeble	Some people feel it	< 4.2
III	Slight	Felt by people resting, like a truck rumbling by	
IV	Moderate	Felt by people walking	
V	Slightly Strong	Sleepers awake; church bells ring	< 4.8
VI	Strong	Trees sway; suspended objects swing, objects fall off shelves	< 5.4
VII	Very Strong	Mild alarm; walls crack; plaster falls	< 6.1
VII	Destructive	Moving cars uncontrollable; masonry fractures, poorly constructed buildings damaged	
IX	Ruinous	Some houses collapse; ground cracks; pipes break open	< 6.9
X	Disastrous	Ground cracks profusely; many buildings destroyed; liquefaction and landslides widespread	< 7.3
XI	Very Disastrous	Most Buildings and bridges collapse; roads, railways, pipes, and cables destroyed; general triggering of other hazards	< 8.1
XII	Catastrophic	Total destruction: trees fall; ground rises and falls in waves	> 8.1

Source: FEMA, 2020

Historical Occurrences

According to the United States Geological Service, there have been 457 earthquakes within Las Animas County between 1900 – 2020 greater than 1.0 magnitude. SHELDUS data reported $1,000,000 in property damages with no injuries, however, all the reported damages came from one event. The following figures show the breakdown of reported earthquakes by magnitude and the location of the earthquakes.

<u>2011 Trinidad Earthquake</u>

August 22, 2011, a magnitude 5.3 earthquake was recorded approximately nine miles southwest of the City of Trinidad. SHELDUS data reported the earthquake caused $1,000,000 in property damages to 46 nearby structures. The USGS received calls from more than 70 people in Trinidad, 30 people in Colorado Springs, and several dozen people in New Mexico who felt the shaking.

14 Federal Emergency Management Agency. 2020. “Earthquake Risk.” https://www.fema.gov/emergency-managers/risk-management/earthquake.

Figure 12: Earthquake Events in the County

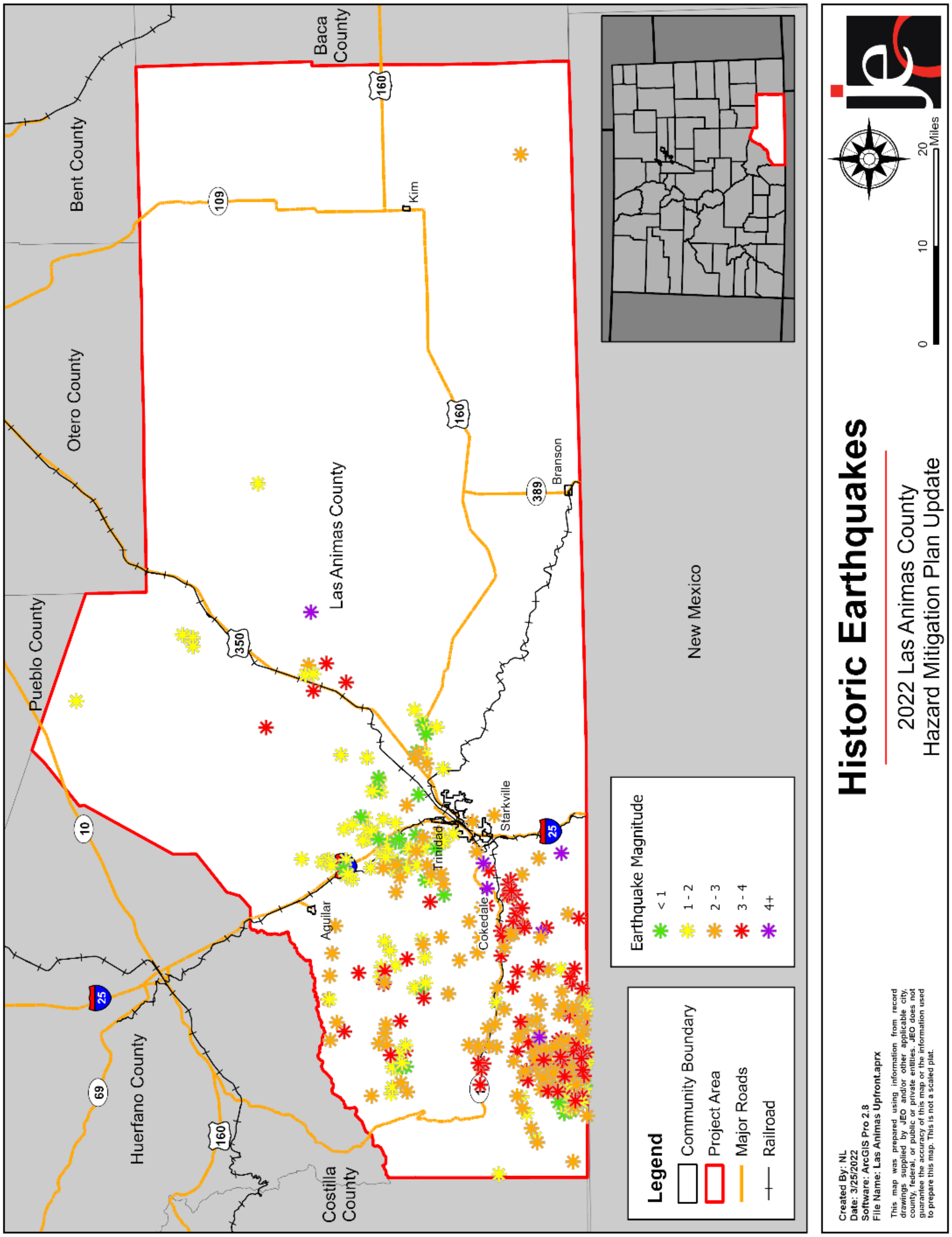
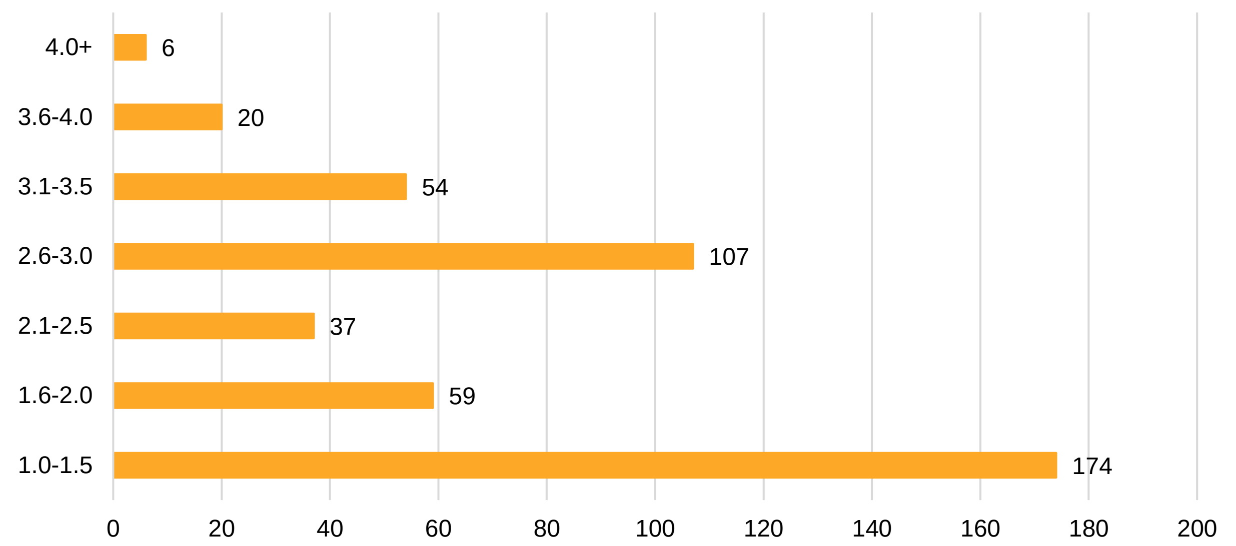


Figure 13: Earthquakes by Magnitude in Las Animas County



Source: USGS, 1900-2020[15]

Average Annual Losses

The annual property and crop loss was determined based upon SHELDUS data from 1960 – 2018. This does not include losses from displacement, functional downtime, economic loss, injury, or loss of life. There was a reported $1,000,000 in property damages and $0 in crop damages from earthquakes.

Table 25: Earthquake Losses

Hazard Type	Total Property Loss	Average Annual Property Loss	Total Crop Loss	Average Annual Crop Loss
Earthquake	$1,000,000	$38,462	$0	$0

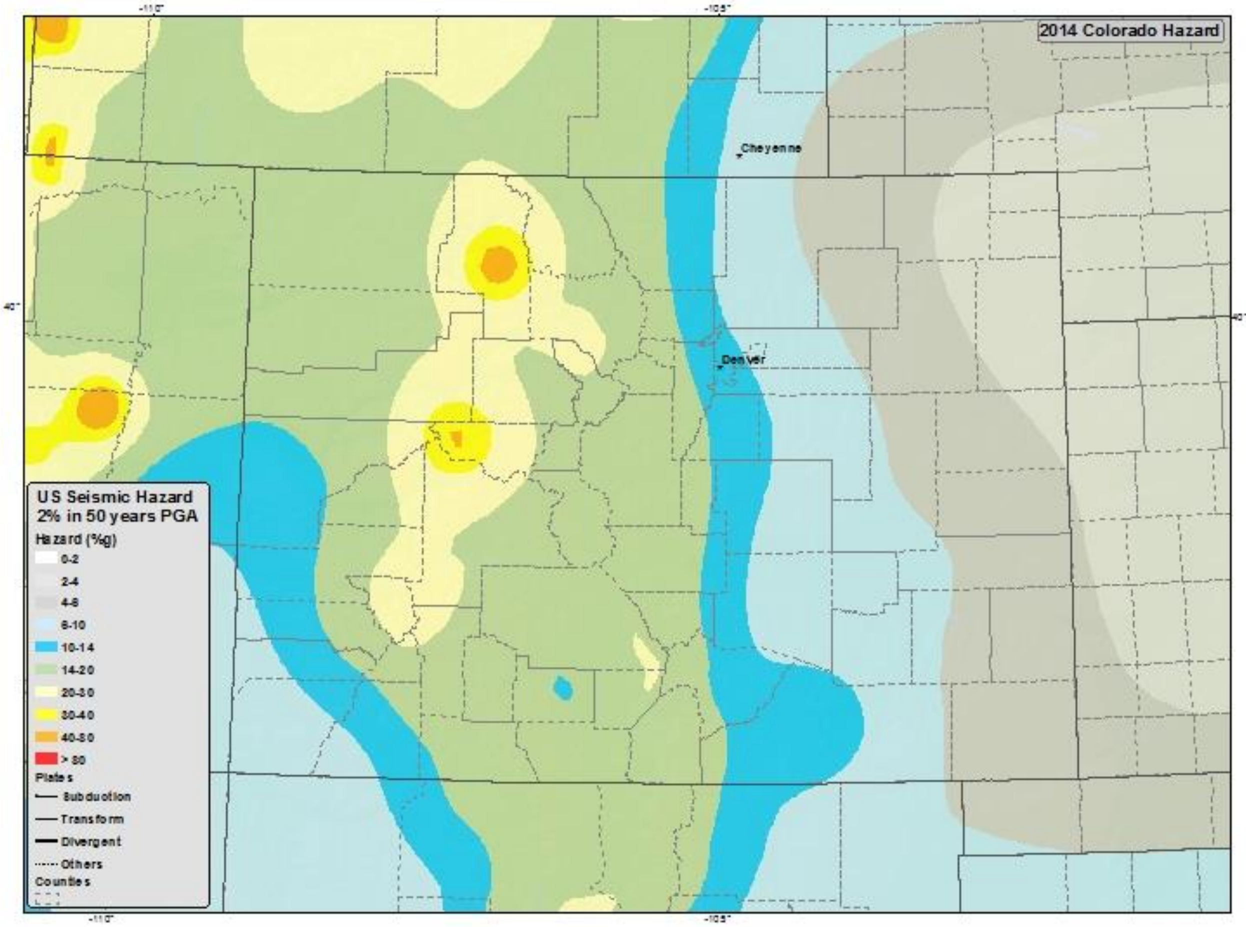
Source: SHELDUS (1960-2018)

Probability

The following figure summarizes the probability of an intense earthquake occurring in the county. Based on the 26 years with a recorded occurrence of an earthquake over a 121-year period, the probability of an earthquake in the county in any given year is approximately 21 percent. However, there has been a recorded earthquake in the county every year since 2003.

15 U.S. Geological Survey. 2021. "Search Earthquake Catalog." https://earthquake.usgs.gov/earthquakes/search/.

Figure 14: 2014 Seismic Hazard Map - Colorado



Source: USGS, 2014[16]

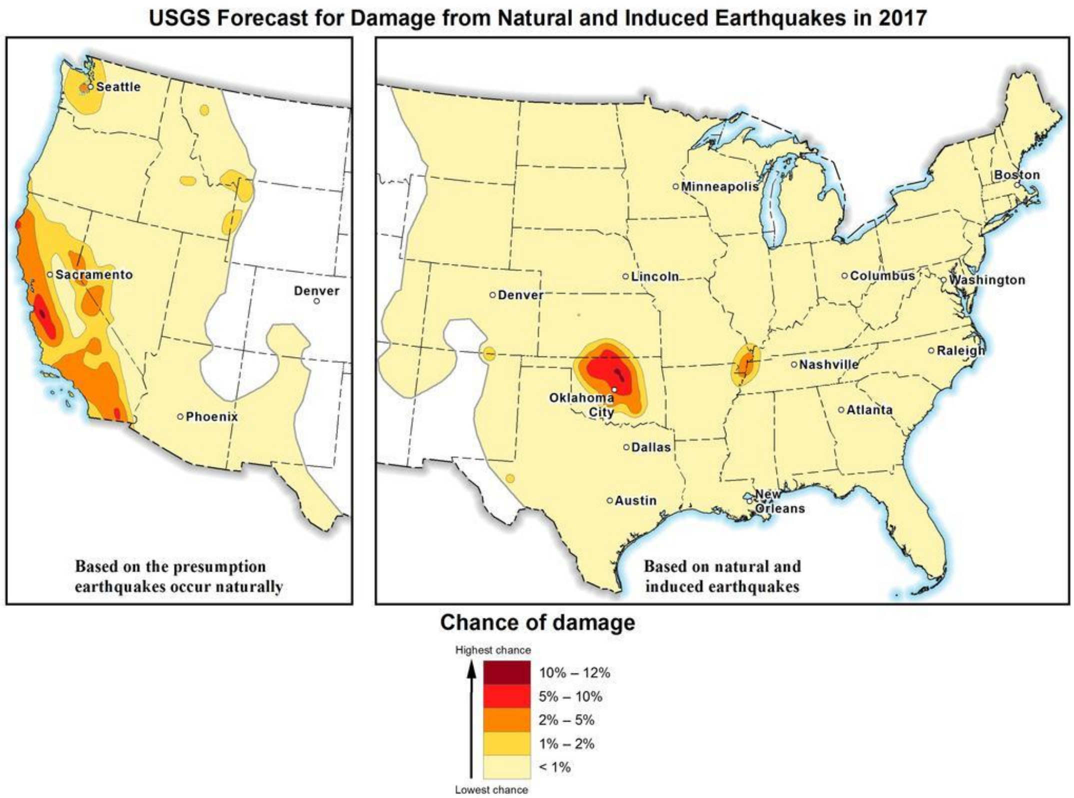
<u>Induced Seismicity</u>

In recent years, induced seismicity has become an increasingly relevant issue. Induced seismicity are earthquakes instigated by human activities and would not have occurred otherwise. There is a range of unique causes of induced seismicity, including impounding surface water reservoirs, removing mass by quarrying, extraction of resources (groundwater, coal, geothermal fluids), injection activities (waste fluid disposal, fracking, research experiments, gas storage, enhanced oil recovery, carbon dioxide sequestration), and nuclear testing.

In more recent years there has been an increase in documented seismic activity potentially induced by waste fluid disposal. In March 2016, the USGS released is first induced earthquake hazard model. The Raton Basin in western Las Animas County was identified as one of the areas of higher potential for induced earthquakes. Figure 15 displays forecasted damage related to induced earthquakes. The Raton Basin area has a higher chance of damage than the rest of the state and county. According to the 2018-2023 the Colorado Enhanced Hazard Mitigation Plan, the 2011, 5.3 magnitude earthquake was an induced earthquake caused by waste fluid disposal and wastewater injection.

16 U.S Geological Survey. 2014. “2014 Seismic Hazard Map – Colorado.” Accessed February 2022. https://www.usgs.gov/media/images/2014-seismic-hazard-map-colorado.

Figure 15: USGS Forecast for Damage from Natural and Induced Earthquakes in 2017



USGS map displaying potential to experience damage from natural or human-induced earthquakes in 2017. Chances range from less than 1 percent to 12 percent.

Source: USGS, 2017[17]

Climate Change

Currently, there is no known direct association with climate change and earthquake events. However, as climate change exacerbates effects on other hazard types such as drought, it may produce more frequent or greater earthquake events. A report in 2017 by NASA's Jet Propulsion Laboratory[18] found that alternating periods of drought and heavy precipitation caused the Sierra Mountain Range in California to rise and fall as the ground swelled/contracted. The study did not specifically look at potential impacts on fault lines, but such stress changes could potentially be felt on faults.

Jurisdictional Top Hazard Status

The following table lists jurisdictions which identified earthquakes as a top hazard of concern.

Jurisdictions	
City of Trinidad	

17 U.S Geological Survey. 2017. "USGS Forecast for Damage from Natural and Induced Earthquakes in 2017." Accessed February 2022. https://www.usgs.gov/media/images/usgs-forecast-damage-natural-and-induced-earthquakes-2017.

18 Argus, D. et al. 2017. "Sierras lost water weight, grew taller during drought." NASA's Jet Propulsion Laboratories. https://climate.nasa.gov/news/2663/sierras-lost-water-weight-grew-taller-during-drought/.

Future Developments

Any population growth and development in the county will not likely be dictated by earthquake risk. Any new construction built to code should be able to withstand earthquakes, but the potential for nonstructural damage will increase with new development. In addition, the number of oil and gas wells are likely to increase over time. This could lead to an increase in the number and intensity of earthquakes in the county.

According to the 2018-2023 Colorado Enhanced Hazard Mitigation Plan, Las Animas County's exposure rating incorporating growth (2010-2030) is negligible. This takes into account projected population change and risk (annualized losses).

County Vulnerabilities

The following table provides information related to county vulnerabilities; for jurisdictional-specific vulnerabilities, refer to *Section Seven: Participant Profiles.*

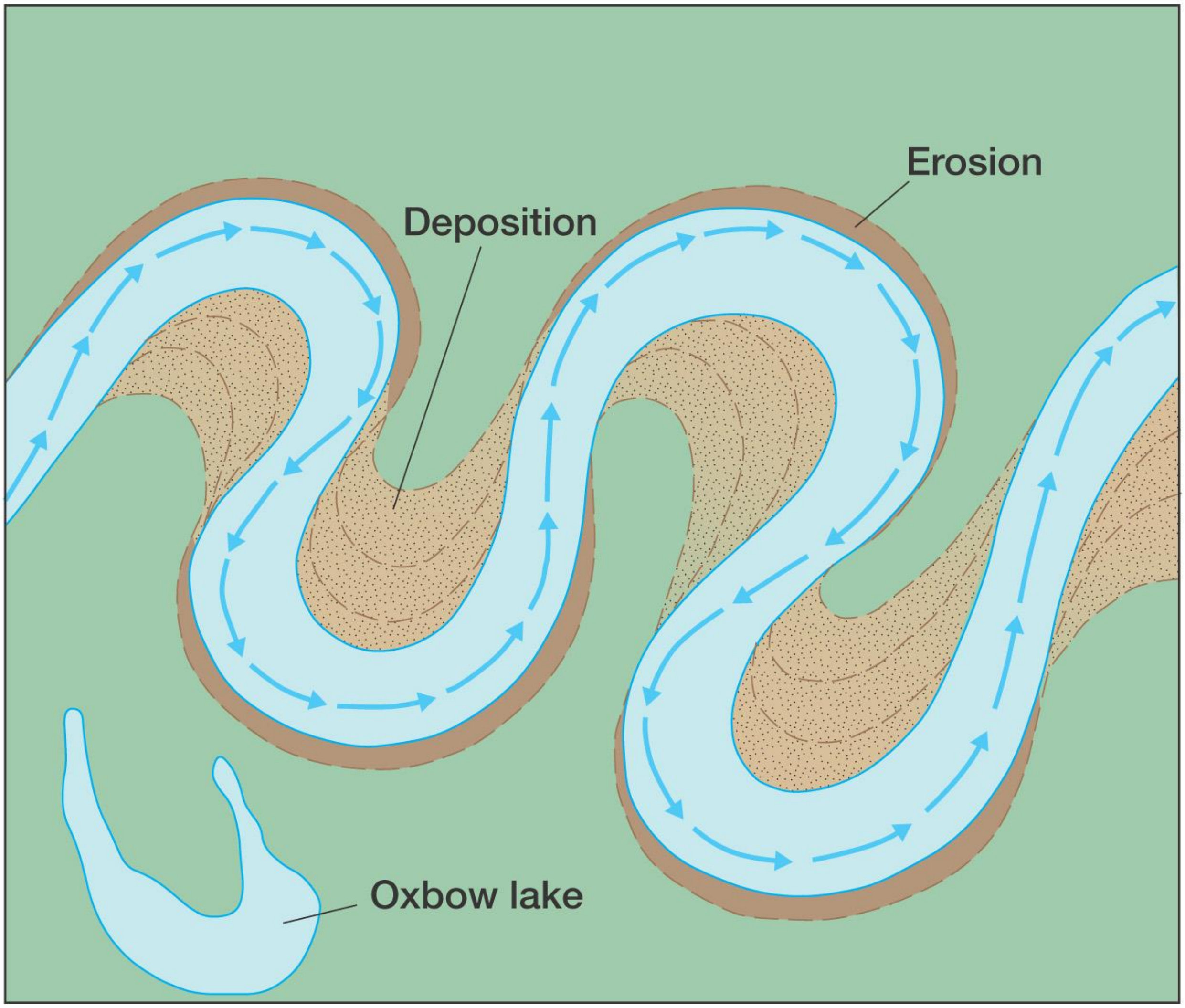
Table 26: County Earthquake Vulnerabilities

Sector	Vulnerability
People	-Risk of injury or death from falling objects and structures -Low-income individuals and families may lack the financial resources to improve their homes to prevent earthquake damage
Economic	-Short term to long term interruption of business -Damage to oil and gas infrastructure
Built Environment	-Damage to buildings, homes, or other structures from foundation cracking, falling objects, shattered windows, etc.
Infrastructure	-Damage to subterranean infrastructure (i.e. waterlines, gas lines) -Power loss from damaged utility poles -Damage to roadways -Damage to oil and gas infrastructure
Community Lifelines	-Damage to subterranean infrastructure (i.e. waterlines, gas lines) -Power loss from damaged utility poles -Damage to roadways -Damage or destruction of buildings -Many critical buildings like fire stations, police stations, and governmental buildings are housed in older buildings that are not up to current seismic codes

Erosion and Deposition

The Colorado Geological Survey (GCS) defines erosion as "the removal and simultaneous transportation of earth materials from one location to another by water, wind, waves or moving ice." Deposition is defined as the placing of eroded material in a new location. An example of one type of erosion and deposition is shown in the following figure.

Figure 16: Stream Erosion and Deposition



Source: Pearson Prentice Hall, Inc., 2005

Location

The State of Colorado has developed a Colorado Hazard Mapping and Risk Map product for fluvial and erosion risk areas.[19] There are no risk areas identified in Las Animas County. However, small areas of erosion and deposition are likely to occur continually throughout Las Animas County but will not impact populated areas.

19 Colorado Water Conservation Board. 2022. "Colorado Hazard Mapping & Risk MAP Portal – MAP Fluvial/Erosion Hazard Mapping." https://coloradohazardmapping.com/hazardMapping/fluvialMapping/Map.

Point sources of erosion often occur in areas where humans interact with exposed earth, such as construction sites. Waterways perpetually remove and carry soil downstream. Erosion and deposition problems are exacerbated in wildfire burn areas. Locations of greatest risk include the Purgatoire River, Highways and Interstate 25, and along burn scars.

Extent

The extent of erosion and deposition is largely related to the impacted area's location. Erosion can result in minor inconveniences or total destruction in a limited area. Events near human development can cause property and infrastructure damage. However, events may also occur in rural areas of Las Animas County with little impact to people, property, or infrastructure.

Erosion and deposition are aggravated by natural events such as heavy rain or high stream flow, high wind, and wildfires. Erosion can remove earth from beneath bridges, roads, expose utility lines, and expose foundations of structures adjacent to streams. The deposition of material can block culverts, aggravate flooding, destroy crops, and cause overall degradation of the water conveyance and the water supply. Undercutting can lead to an increased risk of landslide and rockfall.

Riverine erosion has many consequences including land and development loss. Other problems include water quality reduction due to high sediment loads and native aquatic habitat loss. Erosion and deposition can also increase risk of pollution of surface waters, as nutrients and pesticides from agricultural and residential uses are more easily carried off the surface by runoff. This can affect recreation-based economy that depends highly on quality of waters for fishing, boating, and overall appeal of rivers and reservoirs.

Historical Occurrences

There are no known sources for historical erosion events. Erosion can commonly occur after wildfire events and heavy rains when runoff wash down over dead and loosened trees, grasses, shrubs or other debris. There have been no reported major erosion events in the county.

Average Annual Losses

There are no known sources of erosion losses. Often, damages from erosion and deposition are combined with flooding or severe wind damage, causing erosion and deposition damages to be overlooked an categorized under other hazards.

Probability

Erosion and deposition are ongoing natural events and are expected to continue throughout the county. Due to the lack of available historical occurrences, it is not currently possible to estimate annual probability.

Climate Change

Climate trends may result in decreased snowpack, intensification of precipitation events, and an increased frequency of drought and wildfires. Erosion and deposition will be a secondary hazard following these other hazards. Overall land area exposed to erosion and deposition may increase as wildfire and flooding events occur throughout the county. Additionally, the increase in frequency, duration, and magnitude of drought conditions is anticipated to cause increased wind-born erosion.

Jurisdictional Top Hazard Status
No jurisdictions identified erosion and deposition as a top hazard of concern.

Future Developments
Typically, erosion and deposition do not curtail land use, especially if efforts are made to minimize their effect. Any future development should incorporate erosion mitigation best management practices, as development in at-risk areas may exacerbate existing erosion and deposition conditions. Future development along riverways, creeks, tributaries, and steep slopes are at greatest risk.

According to the 2018-2023 Colorado Enhanced Hazard Mitigation Plan, Las Animas County's exposure rating incorporating growth (2010-2030) is negligible. This takes into account projected population change and housing change.

County Vulnerabilities
The following table provides information related to county vulnerabilities; for jurisdictional-specific vulnerabilities, refer to *Section Seven: Participant Profiles.*

Table 27: County Erosion and Deposition Vulnerabilities

Sector	Vulnerability
People	-Residents living or traveling in areas prone to erosion are at risk of injury
Economic	-Limited loss of accessibility and potential damage to businesses -Impact recreation-based economy at Trinidad Lake due to poor water conditions -Loss of viable cropland
Built Environment	-Damage to buildings, homes, or other structures from exposed foundations and supports -Loss of land area
Infrastructure	-Exposure of subterranean infrastructure (i.e. waterlines, gas lines) -Damage to roadways and bridges
Community Lifelines	-Exposure of subterranean infrastructure (i.e. waterlines, gas lines) -Damage to roadways and bridges -Damage to buildings from exposed foundations and supports

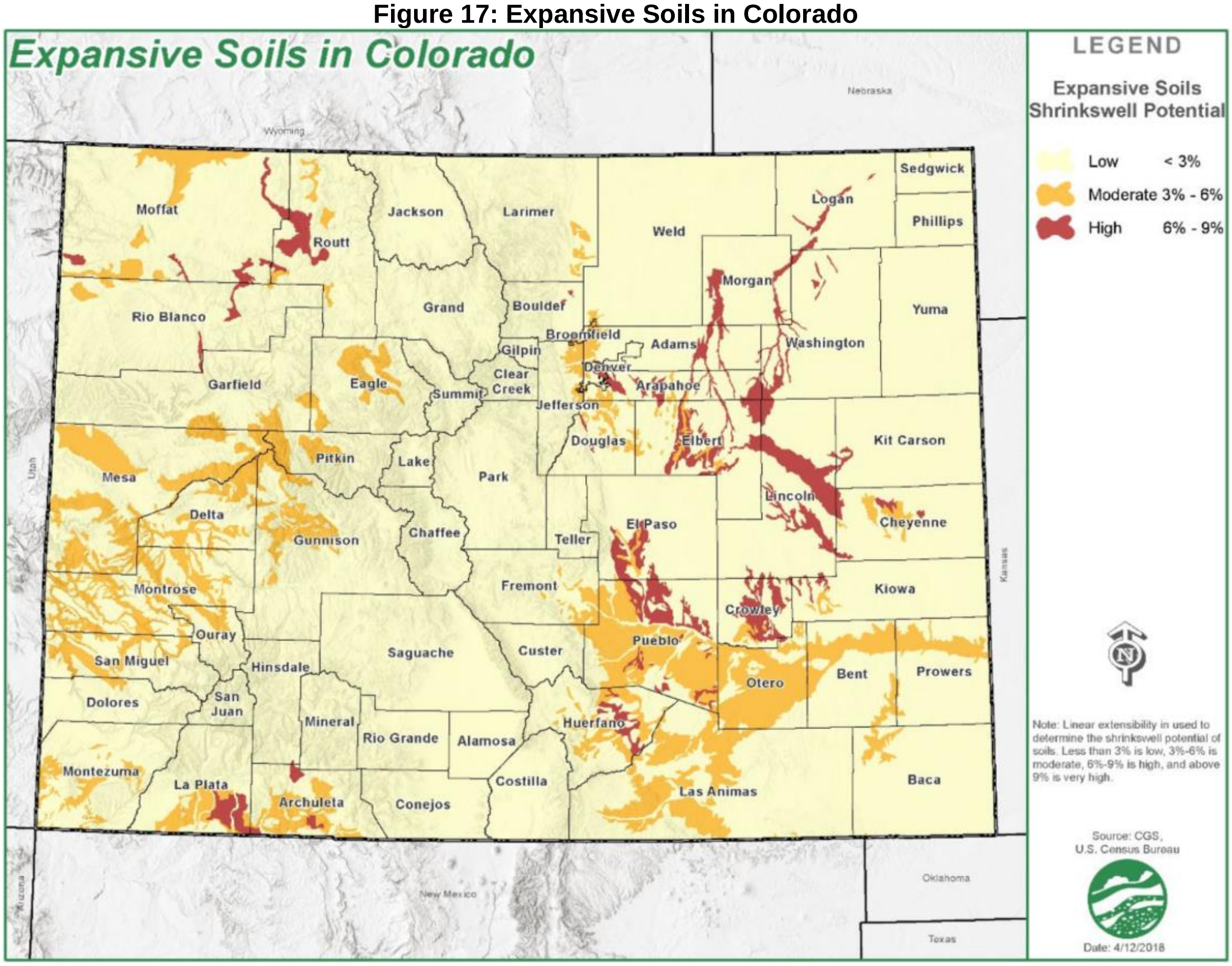
Expansive Soil

Expansive or swelling soils are soils or soft bedrock that increase in volume as they get wet and shrink as they dry out. Swelling soils contain a high percentage of clay particles capable of absorbing large quantities of water. Soil volume may expand ten percent or more as the clay becomes wet. The powerful force of expansion is capable of exerting pressures of 30,000 pounds per square foot or greater on foundations, slabs, or other confining structures. These soils tend to remain at constant moisture content in their natural state. Exposure to natural or human-caused water sources throughout development results in swelling. In many instances, the soils do not regain their original dryness after construction but remain moist and expanded due to the changed environment.

Location

Expansive soils are located primarily in the central portion of Las Animas County along the Purgatoire River and Raton Creek, as seen in the following figure. Due to the softer nature of swelling clay and its increased erosion rate from wind and precipitation, expansive soils are more likely to occur in valleys, plains, and low-lying areas.

Figure 17: Expansive Soils in Colorado



Source: 2018-2023 Colorado Hazard Mitigation Plan

Extent
Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than three percent; moderate if three to six percent; high if six to nine percent; and very high if more than nine percent. If the linear extensibility is more than three, shrinking and swelling can cause damage to buildings, roads, and other structures. Areas in Las Animas County are identified as either low risk or moderate risk.

Historical Occurrences
The Colorado Geological Survey website provides some historical events of expansive soil and the damages across Colorado. There were no reported historical expansive soil events in the county.

Average Annual Losses
With no historical reported expansive soil events, the average annual losses for property and crops is $0.

Probability
Expansion of soils is a naturally occurring process that has occurred historically and will continue to do so across the county. Due to the lack of available historical occurrences, it is not currently possible to estimate annual probability.

Climate Change
It is likely that continued changes to the regional climate will lead to an increase in frequency and intensity of drought or rainfall/flash flooding events across the state. There are periods of heavy rain or prolonged dryness can impact the expansion and swelling of soils. For the purposes of this plan, it is assumed that if current climate trends continue, it is probable that expansive soil events will increase in frequency for Las Animas County.

Jurisdictional Top Hazard Status
No jurisdictions identified expansive soil as a top hazard of concern.

Future Developments
Any development that occurs in the county will continue to be built on soils with moderate or higher shrink-swell potential. With appropriate mitigation taken through development techniques and code enforcement, potential losses can be minimized. Of particular concern are areas surrounding the City of Trinidad, as it is the community most likely to see growth in the future and much of the surrounding land has moderate expansive soil risk.

According to the 2018-2023 Colorado Enhanced Hazard Mitigation Plan, Las Animas County’s exposure rating incorporating growth (2010-2030) is negligible. This takes into account projected population change and housing change.

County Vulnerabilities

The following table provides information related to county vulnerabilities; for jurisdictional-specific vulnerabilities, refer to *Section Seven: Participant Profiles.*

Table 28: County Erosion and Deposition Vulnerabilities

Sector	Vulnerability
People	-Limited potential of injury from unstable buildings and infrastructure
Economic	-Limited losses due to damaged property and infrastructure
Built Environment	-Damage building foundations due to shrinking and swelling of nearby soil
Infrastructure	-Cracking of subterranean lines (i.e. waterlines, gas lines) due to shrinking and swelling of nearby soil -Settling and cracking of roadways
Community Lifelines	-Cracking of subterranean lines (i.e. waterlines, gas lines) due to shrinking and swelling of nearby soil -Settling and cracking of roadways -Damage to critical building foundations due to shrinking and swelling of nearby soil

Extreme Heat

Extreme heat can be characterized by long periods of high temperatures in combination with high humidity. During these conditions, the human body has difficulty cooling through the normal method of the evaporation of perspiration. Health risks arise when a person is overexposed to heat or prolonged drought conditions. Extreme heat can also cause people to overuse air conditioners, which can lead to power failures. Power outages for prolonged periods increase the risk of heat stroke and subsequent fatalities due to loss of cooling and proper ventilation. Extreme temperatures can often occur during periods with low precipitation causing drought conditions.

The National Weather Service (NWS) is responsible for issuing excessive heat outlooks, excessive heat watches, and excessive heat warnings.

- **Excessive heat outlooks** are issued when the potential exists for an excessive heat event in the next 3 to 7 days. Excessive heat outlooks can be utilized by public utility staffs, emergency managers, and public health officials to plan for extreme heat events.
- **Excessive heat watches** are issued when conditions are favorable for an excessive heat event in the next 24 to 72 hours.
- **Excessive heat warnings** are issued when an excessive heat event is expected in the next 36 hours. Excessive heat warnings are issued when an extreme heat event is occurring, is imminent, or has a very high probability of occurring.

Along with humans, animals also can be affected by high temperatures, drought conditions, and humidity levels. For instance, cattle and other farm animals respond to heat by reducing feed intake, increasing their respiration rate, and increasing their body temperature. These responses assist the animal in cooling itself, but this is usually not sufficient. When animals overheat, they will begin to shut down body processes not vital to survival, such as milk production, reproduction, or muscle building.

Additionally, government authorities report that civil disturbances and riots are more likely to occur during heat waves or when water supplies are threatened. In cities, pollution becomes a problem with high heat as the heat traps pollutants in densely populated urban areas. Adding pollution to the stresses associated with the heat magnifies the health threat to the urban population.

Location

The entire county is susceptible to impacts resulting from extreme heat. Las Animas County is a mixture of rural and moderately sized metropolitan areas, which presents an added vulnerability to extreme heat events as the following.

- In rural areas those suffering from an extreme heat event may be farther away from medical resources.
- Cities trap heat to a greater extent, exacerbating extreme heat events for residents.

Extent

A key factor to consider regarding extreme heat situations is the humidity level relative to the temperature. As is indicated in the following figure from the National Oceanic and Atmospheric Administration (NOAA), as the relative humidity increases, the temperature needed to cause a dangerous situation decreases. For example, for 100 percent relative humidity, dangerous levels of heat begin at 86°F whereas a relative humidity of 50 percent requires 94°F. The combination of relative humidity and temperature result in a Heat Index as demonstrated below:

$$100\%\ Relative\ Humidity + 86°F = 112°F\ Heat\ Index$$

Figure 18: NOAA Heat Index

Temperature (°F)

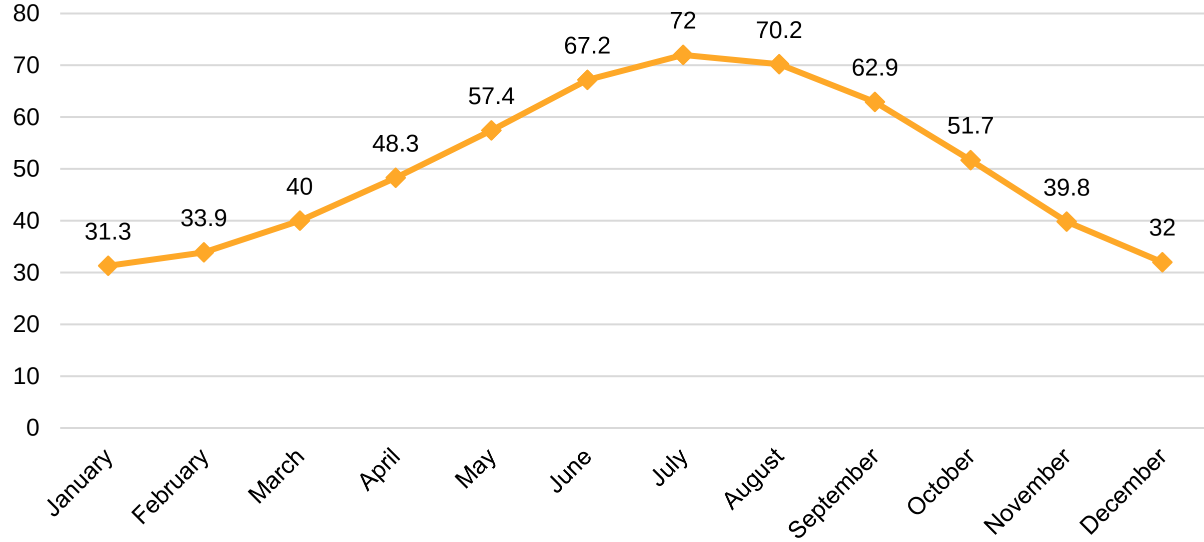
Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60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

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

The figure above is designed for shady and light wind conditions. Exposures to full sunshine or strong hot winds can increase hazardous conditions and raise heat index values by up to 15°F. For the purposes of this plan, extreme heat is being defined as temperatures of 100°F or greater. For the county the months with the highest average temperatures are June, July, and August.

Figure 19: Monthly Max Temperature Average (1895-2021)

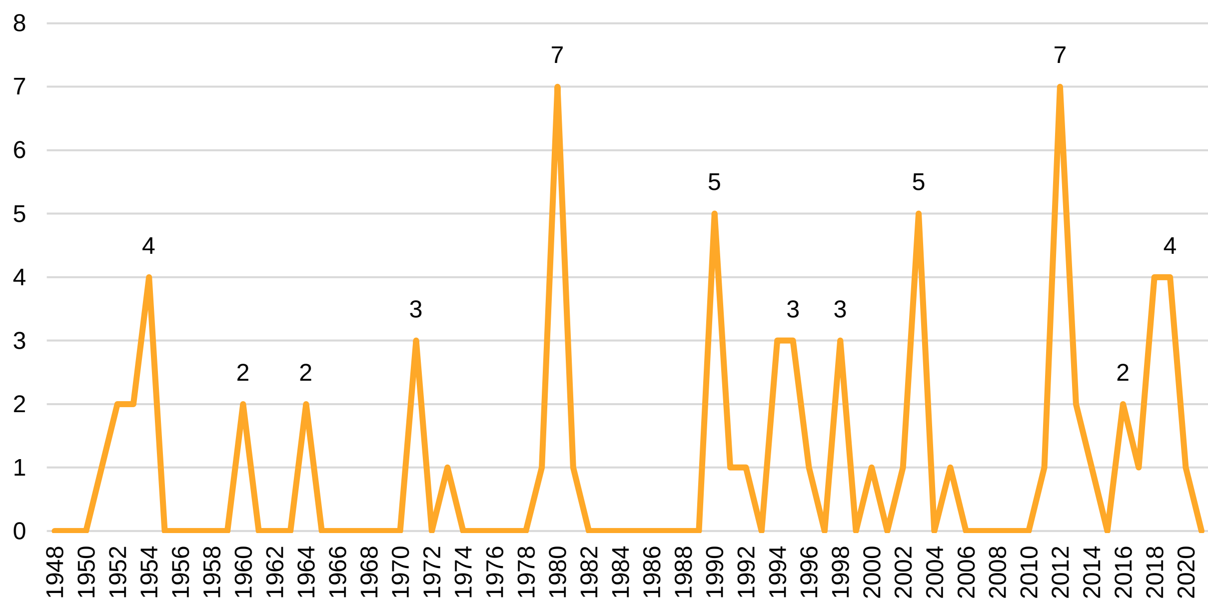


Source: NOAA, 2021

Historical Occurrences

According to NOAA, on average, the county experiences one day above 100°F per year. Las Animas County experienced the most days on record above 100°F in 1980 and 2012 with seven days. Conversely, 2021 was the most recent 'coolest' year on record with no reported day above 100°F.[20]

Figure 20: Number of Days above 100°F



Source: NOAA, 2021

20 NOAA Regional Climate Centers ACIS. 2021. "Monthly Number of Days Max Temperature >=100." http://scacis.rcc-acis.org/.

Average Annual Losses

The annual property loss was determined based upon SHELDUS data from 1960 – 2018. This does not include losses from displacement, functional downtime, economic loss, injury, or loss of life. The annual crop loss was determined based upon USDA RMA data from 2000-2021. There was a reported $165,478 in crop damages and $0 in property damages from extreme heat events.

Table 29: Extreme Heat Losses

Hazard Type	Total Property Loss[1]	Average Annual Property Loss[1]	Total Crop Loss[2]	Average Annual Crop Loss[2]
Extreme Heat	$0	$0	$165,478	$7,522

Source: 1. SHELDUS (1960-2018) 2. USDA RMA (2000-2021)

<u>Estimated Loss of Electricity</u>

According to the FEMA Benefit Cost Analysis (BCA) Reference Guide, if an extreme heat event occurred within the county, the following table assumes the event could potentially cause a loss of electricity for 10 percent of the population at a cost of $126 per person per day.[21] In rural areas, the percent of the population affected, and duration may increase during extreme events. The assumed damages do not take into account physical damages to utility equipment and infrastructure.

Table 30: Loss of Electricity – Assumed Damage per Day

2020 Population	Population Affected (assumed 10%)	Electric Loss of Use Assumed Damage per Day
14,555	1,455	$183,330

Probability

Extreme heat is a regular part of the climate for the county; with 31 years out of 74 having at least one day over 100°F. The average number of days above 100°F for those years was one. Based on the historic record of reported incidents, there is a 42 percent probability (31 out of 74 years with an occurrence) that extreme heat will occur annually in the county.

Climate Change

The Union for Concerned Scientists released a report in July 2019 titled *Killer Heat in the United States: Climate Choices and the Future of Dangerously Hot Days*[22] which included predictions for extreme heat events in the future dependent on future climate actions. These figures show the average number of days per year above a selected heat index, or "feels like" temperature, for three different time periods: historical, midcentury, and late century. The table below summarizes those findings for the county. It is worth noting period of records and available data used in the following report is different than information provided by the more local NOAA data and may not be fully reflected. Climate change is likely to cause the number of extreme heat days to go up in the county.

Table 31: Extreme Heat Predictions for Days over 100F

Historical Average 1971-2000	Midcentury Prediction 2036-2065	Late Century 2070-2099
0 day per year	2 days per year	14 days per year

Source: Union of Concerned Scientists, 1971-2000[23]

21 Federal Emergency Management Agency. June 2009. "BCA Reference Guide."
[22] Union of Concerned Scientists. 2019. "Killer Heat in the United States: Climate Choices and the Future of Dangerously Hot Days." https://www.ucsusa.org/sites/default/files/attach/2019/07/killer-heat-analysis-full-report.pdf.
[23] Union of Concerned Scientists. 2019. "Extreme Heat and Climate Change: Interactive Tool". https://www.ucsusa.org/resources/killer-heat-interactive-tool.

Jurisdictional Top Hazard Status
No jurisdictions identified extreme heat as a top hazard of concern.

Future Developments
Any increases in population and development will elevate exposure levels to extreme heat. There are several ways for communities to minimize the heat island effect that occurs in places where there are dense concentrations of pavement, buildings, and other surfaces that absorb and retain heat. Communities can plant trees and other vegetation, use green roofs, and build green infrastructure improvements. Many of these options can be required during new development but can also be added to areas that are already developed.

According to the 2018-2023 Colorado Enhanced Hazard Mitigation Plan, Las Animas County's exposure rating incorporating growth (2010-2030) is slight. This takes into account projected population change and combined risk (number of historical extreme heat days and number of historical heat waves).

County Vulnerabilities
All segments of the population are vulnerable to the effects of extreme heat, some specific groups have higher levels of vulnerability to extreme heat include the elderly (55 years and older), residents of nursing homes or care facilities, children, those isolated from social interactions, and low-income groups. Elderly residents and people living in nursing homes and care facilities have less tolerance for temperature extremes and can quickly feel the effects of extreme temperatures. Low-income elderly in urban areas and young children under the age of five are especially at risk and susceptible to the effects of extreme temperatures. Young children have a smaller body mass to surface ratio making them more vulnerable to heat-related morbidity and mortality. Children also become dehydrated more quickly than adults making for greater concern. Low-income people and families may lack resources that mitigate the impacts of extreme heat such as air conditioning.

Road materials have a limited range of heat tolerance, and roach buckling occurs with sustained temperatures above 90 degrees. Bridges are particularly vulnerable to extended high temperatures, which stress bridge integrity. Extended periods of extreme heat shorten pavement life and cause bridges to expand, causing negative economic impacts.

The following table provides information related to county vulnerabilities; for jurisdictional-specific vulnerabilities, refer to *Section Seven: Participant Profiles.*

Table 32: County Extreme Heat Vulnerabilities

Sector	Vulnerability
People	-The elderly, children, and low-income families are more susceptible to the effects of extreme heat -People engaged in vigorous outdoor exercise
Economic	-Limited loss of accessibility to business from damaged roadways and bridges
Built Environment	-Increased strain on building cooling systems
Infrastructure	-Increased strain on electrical systems -Power outages -Damage to roadways and bridges
Community Lifelines	-Increased strain on building cooling system -Many critical buildings like fire stations, police stations, and governmental buildings are housed in older buildings that may have aging cooling systems -Increased strain on electrical systems -Power outages -Damage to roadways and bridges

Flooding

Flooding due to rainfall can occur on a local level, sometimes affecting only a few streets, but can also extend throughout an entire region, affecting whole drainage basins and impacting property in multiple states. Heavy accumulations of ice or snow can also cause flooding during the melting and freezing stages. These events are complicated by the freeze/thaw cycles characterized by moisture thawing during the day and freezing at night. There are three main types of flooding in the county: riverine flooding, flash flooding, and urban flooding.

<u>Riverine Flooding</u>
Riverine flooding, typically more slowly developing with a moderate to long warning time, is defined as the overflow of rivers, streams, drains, and lakes due to excessive rainfall, rapid snowmelt or ice melt. The areas adjacent to rivers and stream banks that carry excess floodwater are called floodplains. A floodplain or flood risk area is defined as the lowland and relatively flat area adjoining a river or stream. The terms “base flood” and “100-year flood” refer to the area in the floodplain that is subject to a one percent or greater chance of flooding in any given year. Floodplains are part of a larger entity called a basin or watershed, which is defined as all the land drained by a particular river and its tributaries.

<u>Flash Flooding, including Levee or Dam Failure</u>
Flash floods, typically rapidly developing with little to no warning time, result from convective precipitation usually due to intense thunderstorms or sudden releases due to failure of an upstream impoundment created behind a dam, landslide, or levee. Flash floods are distinguished from regular floods by a timescale of fewer than six hours. Flash floods cause the most flood-related deaths as a result of this shorter timescale and people’s inability to safely retreat from the high-risk area.

<u>Urban Flooding</u>
In some cases, flooding may not be directly attributable to a river, stream, or lake overflowing its banks. Rather, it may simply be the combination of excessive rainfall or snowmelt, saturated ground, and inadequate drainage capacity. With no place to go, the water will find the lowest elevations – areas that are often not in a floodplain. This type of flooding, often referred to as urban flooding, is becoming increasingly prevalent as development exceeds the capacity of drainage infrastructure, therefore limiting its ability to properly convey stormwater. Flooding also occurs due to combined storm and sanitary sewers being overwhelmed by the high flows that often accompany storm events. Typical impacts range from dangerously flooded roads to water backing up into homes or basements, which damages mechanical systems and can create serious public health and safety concerns.

Location

The major rivers in the county include the Purgatoire River and Apishapa River. These rivers as well as smaller streams and creeks are potential locations for flooding to occur.

Table 33 shows the current status of Flood Insurance Rate Map (FIRM) panels within the study areas. Figure 21 shows flood risk hazard areas for the floodway, one percent annual chance, and 0.2 percent annual chance flood events for the county. For jurisdictional-specific maps as well as an inventory of structures in the floodplain, please see *Section Seven: Participant Profiles.* For additional details on localized flood risk such as flood zone types, please refer to the official FIRM panels available from FEMA’s Flood Map Service Center.

Figure 21: Flood Risk Hazards Areas

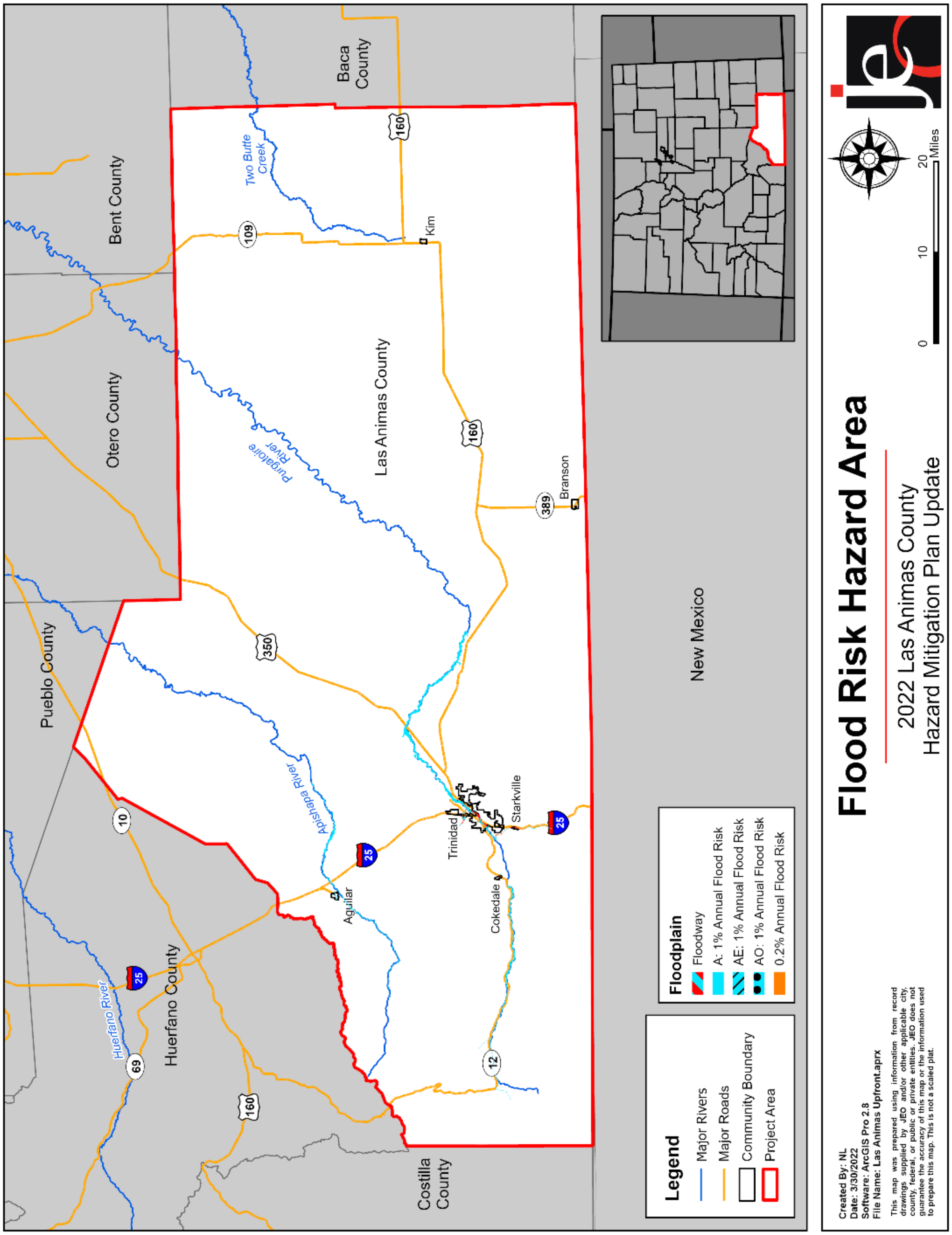


Table 33: FEMA FIRM Panel Status

Jurisdiction	Panel Number	Effective Date
Las Animas County	08071CIND1A; 08071CIND2A; 08071C0845C; 08071C0875C; 08071C0900C; 08071C1275C; 08071C1300C; 08071C1350C; 08071C1375C; 08071C1400C; 08071C1675C; 08071C1700C; 08071C1725C; 08071C1750C; 08071C1759C; 08071C1763C; 08071C1766C; 08071C1767C; 08071C1768C; 08071C1769C; 08071C1778C; 08071C1779C; 08071C780C; 08071C1786C; 08071C1800C; 08071C1850C; 08071C2175C; 08071C2200C; 08071C2207C; 08071C2210C; 08071C2225C;	8/28/2019
City of Trinidad	08071CIND1A; 08071CIND2A; 08071C1759C; 08071C1766C; 08071C1767C; 08071C1768C; 08071C1769C; 08071C1778C; 08071C1779C; 08071C1780C; 08071C1786C; 08071C1800C;	8/28/2019
Town of Aguilar	08071CIND1A; 08071CIND2A; 08071C0845C	8/28/2019
Town of Branson	08071CIND1A; 08071CIND2A	8/28/2019
Town of Cokedale	08071CIND1A; 08071CIND2A; 08071C1750C; 08071C1763C	8/28/2019
Town of Kim	08071CIND1A; 08071CIND2A	8/28/2019
Town of Starkville	08071CIND1A; 08071CIND2A; 08071C2207C	8/28/2019

Source: FEMA[24]

Risk MAP Products

Risk Mapping, Assessment, and Planning (Risk MAP) is a FEMA program that provides communities with flood information and additional flood risk data (e.g., flood depth grids, percent chance grids, etc.) that can be used to enhance their mitigation plans and take action to better protect their citizens. As of March 2022, no parts of the county have been gone through the Risk MAP process.

Extent

The NWS has three categories to define the typical severity of a flood once a river reaches flood stage as indicated in Table 34. Actual impacts will vary by community.

Table 34: Flooding Stages

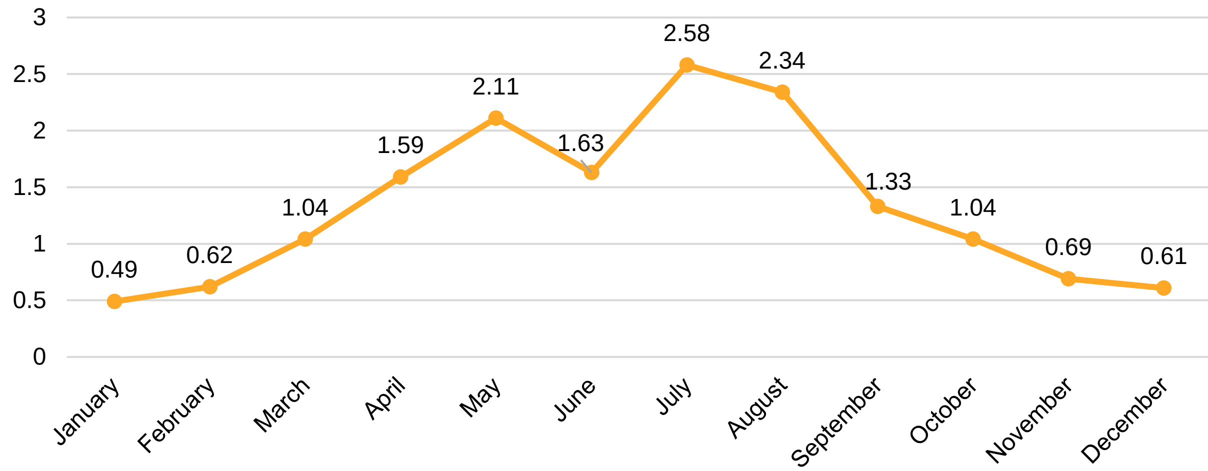
Flood Stage	Description of Typical Flood Impacts
Minor Flooding	Minimal or no property damage, but possibly some public threat or inconvenience
Moderate Flooding	Some inundation of structures and roads near streams. Some evacuations of people and/or transfer of property to higher elevations are necessary
Major Flooding	Extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations

Source: NOAA, 2017[25]

The following figure shows the normal average monthly precipitation for the county, which is helpful in determining whether any given month is above, below, or near normal in precipitation. As indicated in Figure 23, the most common month for flooding within the county is in August.

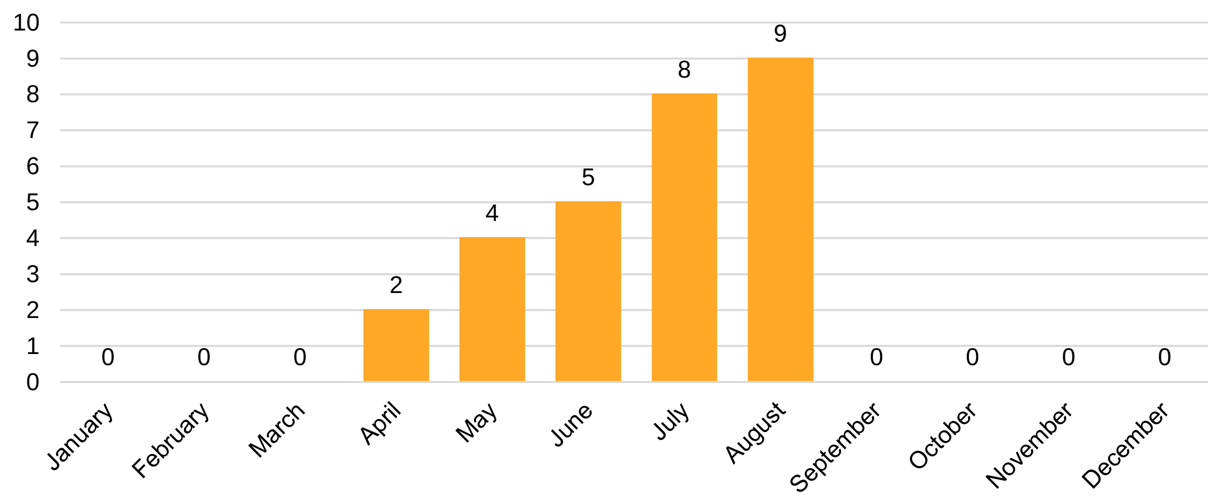
24 Federal Emergency Management Agency. Accessed March 2022. "FEMA Flood Map Service Center." http://msc.fema.gov/portal/advanceSearch.
25 National Weather Service. 2017. "Flood Safety." http://www.floodsafety.noaa.gov/index.shtml.

Figure 22: Average Monthly Precipitation



Source: NOAA, 1895-May 2021

Figure 23: Monthly Events for Flood/Flash Floods in Las Animas County



Source: NCEI, 2021

Historical Occurrences

The NCEI reports events as they occur in each community. A single flooding event can affect multiple communities and counties at a time; the NCEI reports these large-scale events as separate events. The result is a single flood event covering a large portion of the county could be reported by the NCEI as several events. According to the NCEI, 13 flash flooding events resulted in $50,000 in property damage, four riverine flooding events caused $500,000 in property damage, and 11 heavy rain events resulted in no damages. SHELDUS data does not distinguish the difference between riverine flooding damages and flash flooding damages. The total crop loss according to SHELDUS is $365,000. No injuries or fatalities resulted from these events.

<u>April 30, 1999, Flood:</u>
Four to ten inches of rainfall over the course of three days caused the Purgatoire River basin to flood in the Trinidad area. This event caused $500,000 in property damage and was the most damaging flood event in the county from 1996 to 2021.

Average Annual Losses

The average annual property damage estimate was determined based upon the NCEI Storm Events Database since 1996 and the average annual crop damage was determined based upon the SHELDUS data from 1960 to 2018. This does not include losses from displacement, functional downtime, economic loss, injury or loss of life. Flooding caused a total average of $21,154 in property damages and $6,186 in crop losses per year for the county.

Table 35: Flooding Losses

Hazard Type	# of Events[1]	Average # events per year	Total Property Loss[1]	Average Annual Property Loss	Total Crop Loss[2]	Average Annual Crop Loss
Flash Flood	13	0.5	$50,000	$1,923		
Flood	4	0.2	$500,000	$19,231	$365,000	$6,186
Heavy Rain	11	0.4	$0	$0		
Total	**28**	**1.1**	**$550,000**	**$21,154**	**$365,000**	**$6,186**

Source: 1 NCEI (1996-June 2021), 2 SHELDUS (1960-2018)

National Flood Insurance Program (NFIP)

The NFIP was established in 1968 to reduce flood losses and disaster relief costs by guiding future development away from flood hazard areas where feasible; by requiring flood resistant design and construction practices; and by transferring the costs of flood losses to the resident of floodplains through flood insurance premiums.

In return for availability of federally backed flood insurance, jurisdictions participating in the NFIP must agree to adopt and enforce floodplain management standards to regulate development in special flood hazard areas (SFHA) as defined by FEMA's flood maps. The following tables summarize NFIP participation and active policies within the county as of August 2021. In addition, the county and all participants will continue to comply with the Colorado Rules and Regulations for Regulatory Floodplain (2 CCR 408-1). For Las Animas County, the county Floodplain Administrator will oversee compliance with the NFIP and all floodplain regulations.

Table 36: NFIP Participants

Jurisdiction	Participate in NFIP?	Eligible-Regular Program	Date Current Map	Sanction	Suspension	Rescinded
Las Animas County	Yes	9/1/1977	8/28/2019	-	-	-
City of Trinidad	Yes	7/3/1978	8/28/2019	-	-	-
Town of Aguilar	Yes	8/28/2019	8/28/2019(M)	-	-	-
Town of Branson	No	-	-	-	-	-
Town of Cokedale	No	-	-	-	-	-
Town of Kim	No	-	-	-	-	-
Town of Starkville	Yes	8/28/2019	8/28/2019	-	-	-

Source: FEMA, NFIP Community Status Book Report[26]. Note: (M) – No elevation determined – All Zone A, C, and X

26 Federal Emergency Management Agency. 2021. "The National Flood Insurance Program Community Status Book." https://www.fema.gov/cis/CO.html.

It should be noted that while the number of policies in force may change monthly and annually as representatives enroll, maintain, or lapse policies, the total number of losses and payments are cumulative over time.

Table 37: NFIP Policies in Force and Total Payments

Jurisdiction	Policies in-force	Total Coverage	Total Premiums	Closed Losses*	Total Payments*
Las Animas County	2	$600,000	$2,157	1	$0
City of Trinidad	11	$2,617,300	$20,221	3	$10,992
Town of Aguilar	1	$75,000	$2,989	0	$0
Town of Branson	-	-	-	-	-
Town of Cokedale	-	-	-	-	-
Town of Kim	-	-	-	-	-
Town of Starkville	0	$0	$0	0	$0

Source: FEMA, HUDEX Policy Loss Data, August 31, 2021

This plan highly recommends and strongly encourages plan participants to enroll, participate, and remain in good standing with the NFIP. Compliance with the NFIP should remain a top priority for each participant with flooding concerns, regardless of whether or not a flooding hazard area map has been delineated for the jurisdiction. Jurisdictions are encouraged to initiate activities above the minimum participation requirements, such as those described in the Community Rating System (CRS) Coordinator's Manual (FIA-15/2017).[27] At this time no entities participate in the CRS program in Las Animas County.

NFIP Repetitive Loss Structures

The Colorado NFIP Coordinator was contacted to determine if any existing buildings, infrastructure, or community lifelines are classified as NFIP Repetitive Loss Structures or NFIP Severe Repetitive Loss Structures. As of January 2022, there are no repetitive loss structures located within Las Animas County.

Parcel Assessment and Valuation

In order to conduct an analysis of potential impacts utilizing current community lifelines and structure data, GIS was used to identify which structures and community lifelines fell within mapped flood risk hazard areas. GIS parcel data were acquired from the County Assessor. This data was analyzed for the location, number, and value of assessed parcels. The data did not contain the number of structures on each parcel. The following table illustrates the results. It is necessary to note that a location within the flood zone does not necessarily imply significant flood impacts, but it is illustrative of potential risk depending upon building elevation. Specific community lifelines that are located in the floodplain can be found in the corresponding participant profiles in *Section Seven: Participant Profiles*.

27 Federal Emergency Management Agency. May 2017. "National Flood Insurance Program Community Rating System: Coordinator's Manual FIA-15/2017." Accessed October 2020. https://www.fema.gov/media-library-data/1493905477815-d794671adeed5beab6a6304d8ba0b207/633300_2017_CRS_Coordinators_Manual_508.pdf.

Table 38: Assessed Parcels and Value in the 1% Annual Flood Risk Area

Jurisdiction	# of Total Parcels	# of Total Improvements	Total Improvements Value	# of Improvements in Floodplain	Total Improvements Value in Floodplain
Las Animas County	16,383	$504,658,280	824	$20,464,370	5.0%
City of Trinidad	4,832	$369,316,050	333	$11,610,410	7%
Town of Aguilar	454	$4,633,770	104	$1,459,910	23%
Town of Branson	126	$2,309,490	0	$0	0%
Town of Cokedale	109	$674,960	0	$0	0%
Town of Kim	150	$5,622,000	0	$0	0%
Town of Starkville	87	$362,800	14	$44,960	16%

Source: County Assessors, 2021

Table 39: Assessed Parcels and Value in the 0.2% Annual Flood Risk Area

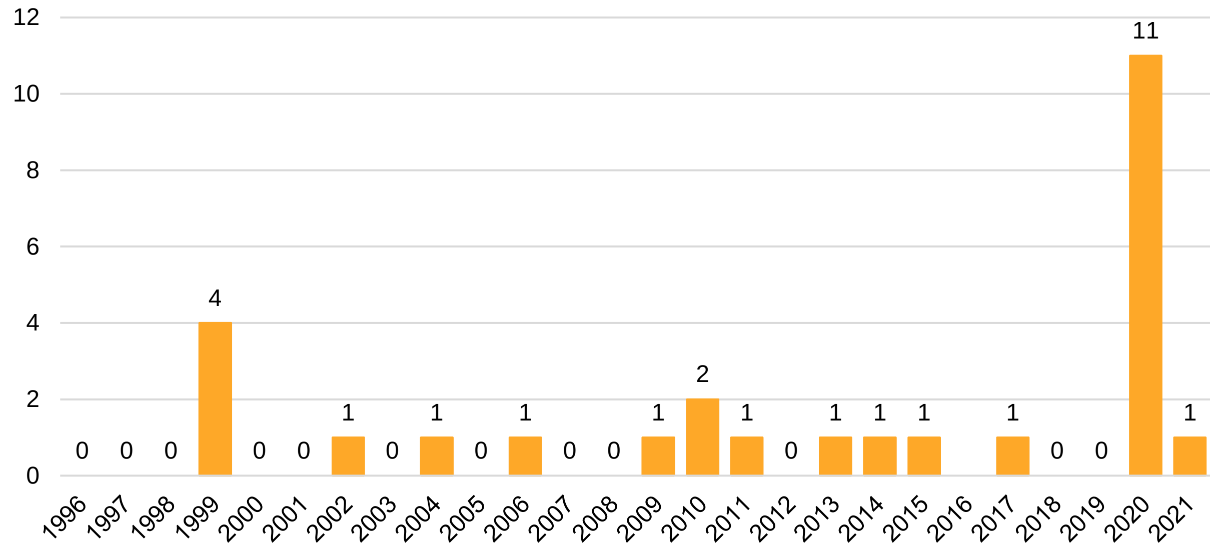
Jurisdiction	# of Total Parcels	# of Total Improvements	Total Improvements Value	# of Improvements in Floodplain	Total Improvements Value in Floodplain
Las Animas County	16,383	$504,658,280	407	$14,449,160	2.5%
City of Trinidad	4,832	$369,316,050	342	$13,945,890	7%
Town of Aguilar	454	$4,633,770	0	$0	0%
Town of Branson	126	$2,309,490	0	$0	0%
Town of Cokedale	109	$674,960	0	$0	0%
Town of Kim	150	$5,622,000	0	$0	0%
Town of Starkville	87	$362,800	1	$4,060	1%

Source: County Assessors, 2021

Probability

The NCEI reports four flooding, 13 flash flooding, and 11 heavy rain events from January 1996 to June 2021. Some years had multiple flooding events. The following figure shows the events broken down by year. Based on the historic record (13 out of 26 years with a flood event), there is a 50 percent probability that flooding will occur annually in the county.

Figure 24: Flood Events by Year



Source: NCEI, 1996-June 2021

Climate Change

Current climatic trends are expected to result in decreased summer precipitation and streamflow in Colorado's major rivers. As a result, the risk of riverine flooding may reduce. However, it is probable that the state will experience an increase in frequency and magnitude of winter precipitation,[28] this in combination with warming air and surface temperatures may produce earlier spring runoff. This may lead to an increase in riverine flooding during the early months of the year, and a decrease in riverine flooding towards the end of the year.

A specific tool developed and utilized in the State of Colorado includes FACE for flooding.[29] This tool presents an in-depth look at potential future economic impacts of flooding on specific sectors of the Colorado economy. The following figures show expected impacts for flooding for the current climate and projected future "Moderate" and "More Severe Climate" impacts with the anticipated growth for Las Animas County.

Based on the FACE assessments, it is likely that Las Animas County will experience worsening impacts form climate change regarding flooding. At the current growth rate and only moderate climate impacts, the county may experience up to $12 million in total damages annually. Damages may vary across sectors and regions such as bridges, buildings, cattle, crops, and fire suppression activities.

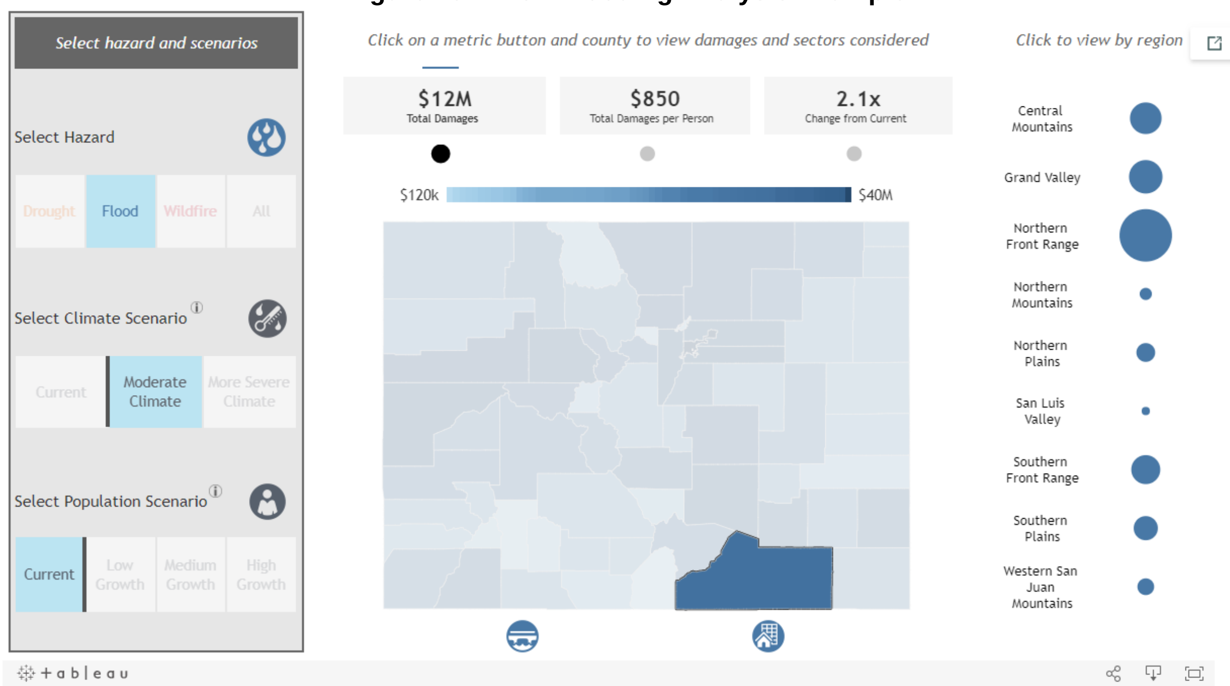
28 Colorado Department of Transportation. May 14, 2021. "Climate Study: Changing Climate and Extreme Weather Impacts on Geohazards in Colorado". https://www.codot.gov/programs/planning/data-studies/cdot-climate-resilience-study.pdf.
29 Colorado Water Conservation Board. 2022. "Future Avoided Cost Explorer: Colorado Hazards." https://storymaps.arcgis.com/stories/4e653ffb2b654ebe95848c9ba8ff316e.

Table 40: FACE Anticipated Damages for Flooding Matrix

Population Scenario	Climate Scenario		
	Current Climate	Moderate Climate	More Severe Climate
Current Growth Rate	$5.6 million $400 per person	$12 million $850 per person	$12 million $850 per person
Low Growth Rate	$5.5 million $430 per person	$11 million $860 per person	$11 million $860 per person
Medium Growth Rate	$5.5 million $420 per person	$11 million $830 per person	$11 million $830 per person
High Growth Rate	$5.5 million $400 per person	$11 million $800 per person	$11 million $800 per person

Source: CWB FACE, 2022

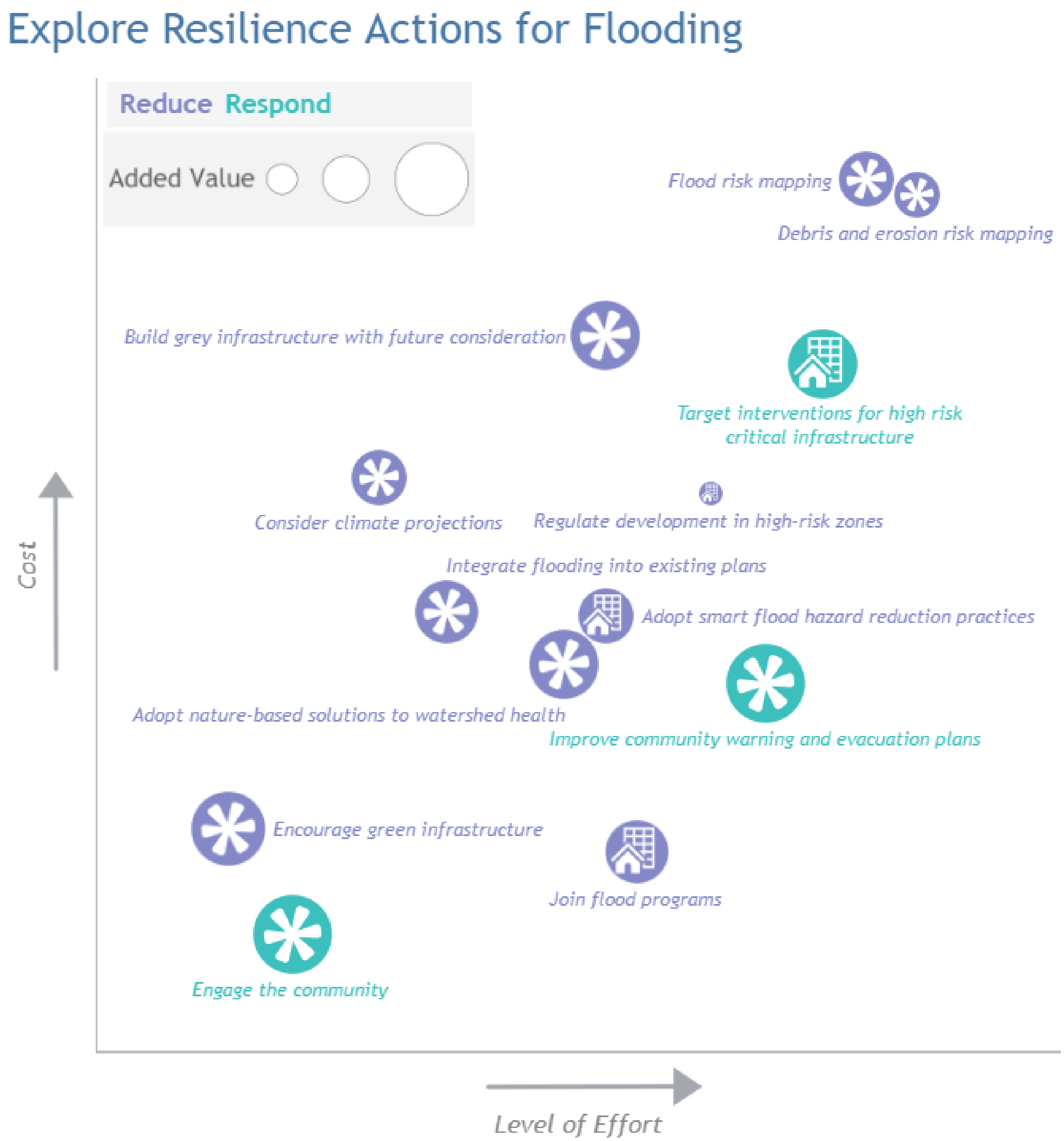
Figure 25: FACE Flooding Analysis Example



Source: CWB FACE, 2022

Suggested actions to improve resilience to flooding from FACE are show in the graphic below.

Figure 26: Exploring Resilience Actions for Flooding



Source: CWB FACE, 2022

Jurisdictional Top Hazard Status

The following table lists jurisdictions which identified flooding as a top hazard of concern.

Jurisdictions	
City of Trinidad	Town of Aguilar
Town of Starkville	

Future Developments

Any population growth and new development will increase risk to flooding, especially if it is located in flood hazard areas. Both the county and City of Trinidad have comprehensive plans that address frequently flooded areas. Trinidad, Aguilar, Starkville, and the county all participate in the NFIP program and have adopted floodplain ordinances. All communities within the county should try to reduce new development from occurring in known floodplain areas and require elevation for any structures that choose to build in those areas. To further reduce future risk to flooding communities can implement stormwater management plans, participate in the National Pollutant Discharge Elimination System program, or participate in the NFIP or Community Rating System programs.

According to the 2018-2023 Colorado Enhanced Hazard Mitigation Plan, Las Animas County's exposure rating incorporating growth (2010-2030) is negligible. This takes into account projected population change and estimated total economic losses.

County Vulnerabilities

An updated national study examining social vulnerability as it relates to flood events found that low-income and minority populations are disproportionately vulnerable to flood events.[30] These groups may lack needed resources to mitigate potential flood events as well as resources that are necessary for evacuation and response. In addition, low-income residents and renters are more likely to live in areas vulnerable to the threat of flooding yet lack the resources necessary to purchase flood insurance.

Other groups that may be more vulnerable to floods, specifically flash floods, include the elderly, those outdoors during rain events, and those in low-lying areas. Elderly residents may suffer from a decrease or complete lack of mobility and as a result, be caught in flood-prone areas. Residents in campgrounds or public parks may be more vulnerable to flooding events. Many of these areas exist in natural floodplains and can experience rapid rise in water levels resulting in injury or death.

The following table is a summary of county vulnerabilities. For jurisdictional-specific vulnerabilities, refer to *Section Seven: Participant Profiles*.

30 Tate, E., Rahman, M.A., Emrich, C.T. *et al.* Flood exposure and social vulnerability in the United States. *Nat Hazards* (2021). https://doi.org/10.1007/s11069-020-04470-2.

Table 41: County Flooding Vulnerabilities

Sector	Vulnerability
People	-Low income and minority populations may lack the resources needed for evacuation, response, or to mitigate the potential for flooding -Elderly or residents with decreased mobility may have trouble evacuating -Residents in low-lying areas, especially campgrounds, are vulnerable during flash flood events -Residents living in the floodplain may need to evacuate for extended periods
Economic	-Business closures or damages may have significant impacts -Agricultural and ranching losses from flooded fields -Closed roads and railroads would impact commercial transportation of goods
Built Environment	-Building may be damaged
Infrastructure	-Damages to roadways and railways -Possible contamination of drinking water supplies
Community Lifelines	-Wastewater facilities are at risk, particularly those in the floodplain -Critical buildings, especially those in the floodplain, are at risk to damage (community lifelines are noted within individual jurisdictional profiles) -Damage to roadways and railways -Possible contamination of drinking water supplies -There are seven community lifelines that are located within 1% annual flood risk area and two that are located within the 0.2% annual flood risk area

Hail

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

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

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

Location

The entire county is at risk to hail and its associated damages. The Colorado Resilience Framework notes that “hail conditions are typical of spring and summer storms on the Eastern Plains of Colorado and are exacerbated by strong updraft potential along the front of the mountains.”

Extent

The Tornado and Storm Research Organisation (TORRO) scale is used to classify hailstones and provides some detail related to the potential impacts from hail. Table 64 outlines the TORRO Hail Storm Intensity Scale.

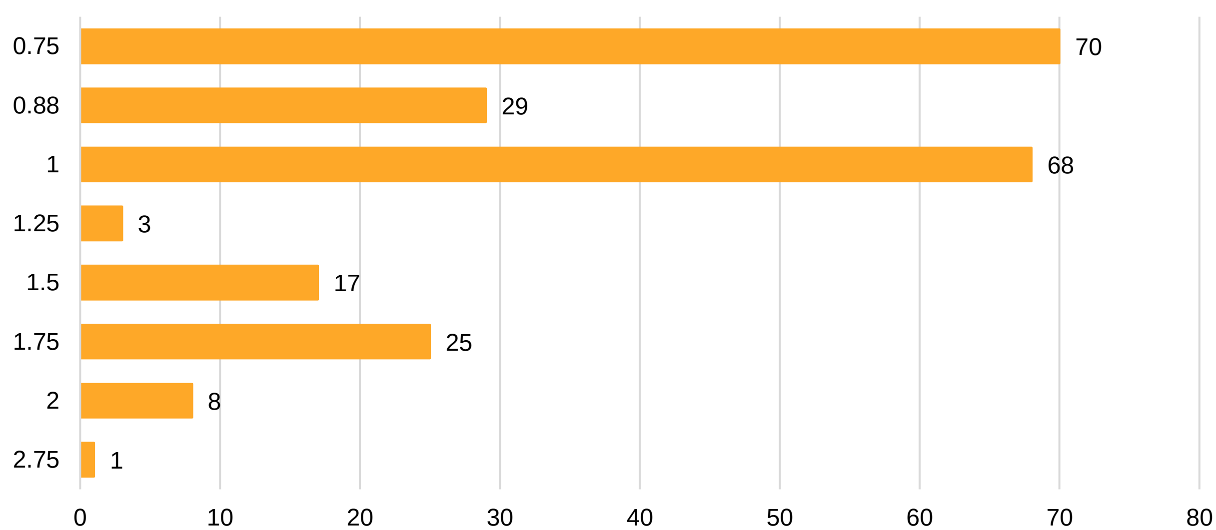
Table 42: TORRO Hail Ranking

Class	Type of Material	Divisions
H0: Hard Hail	5 mm; 0.2 in (pea size)	No damage
H1: Potentially Damaging	5-15 mm; 0.2-0.6in (marble)	Slight general damage to plants and crops
H2: Significant	10-20 mm; 0.4-0.8 in (grape)	Significant damage to fruit, crops, and vegetation
H3: Severe	20-30 mm; 0.8-1.2 in (walnut)	Severe damage to fruit and crops, damage to glass and plastic structures
H4: Severe	30-40mm; 1.2-1.6 in (squash ball)	Widespread damage to glass, vehicle bodywork damaged
H5: Destructive	40-50 mm; 1.6-2.0 in (golf ball)	Wholesale destruction of glass, damage to tiled roofs; significant risk of injury
H6: Destructive	50-60 mm; 2.0-2.4 in (chicken egg)	Grounded aircrafts damaged, brick walls pitted; significant risk of injury
H7: Destructive	60-75 mm; 2.4-3.0 in (tennis ball)	Severe roof damage; risk of serious injuries
H8: Destructive	75-90 mm; 3.0-3.5 in (large orange)	Severe damage to structures, vehicles, airplanes, risk of serious injuries
H9: Super Hail	90-100 mm; 3.5-4.0 in (grapefruit)	Extensive structural damage, risk of severe or even fatal injuries to persons outdoors
H10: Super Hail	>100 mm; >4 in (melon)	Extensive structural damage; risk of severe or even fatal injuries to persons outdoors.

Source: TORRO, 2017[31]

The average hailstone size in Las Animas County was 1.08 inches. Events of this magnitude correlate to an H3 Severe classification. It is reasonable to expect H3 classified events to occur several times in a year throughout the county. In addition, it is reasonable, based on the number of occurrences, to expect larger hailstones to occur in the county. The county has had nine H6 hail events (2.0-2.4 inches) during the period of record. Figure 27 shows hail events based on the size of the hail.

Figure 27: Hail Events by Magnitude



Source: NCEI, 1996-June 2021

31 Tornado and Storm Research Organisation. 2017. "Hail Scale." http://www.torro.org.uk/hscale.php.

Historical Occurrences

The NCEI reports events as they occur in each community. A single hail event can affect multiple communities at a time; the NCEI reports these large-scale events as separate events. The result is a single hail event covering the entire county could be reported by the NCEI as several events.

The NCEI reports a total of 221 hail events in the county from January 1996 to June 2021. In total these events were responsible for $10,000 in property damages and $87,129 in total crop losses. There were no injuries or fatalities associated with these events.

Average Annual Losses

The average annual damage estimate was determined based upon recorded damages from NCEI Storm Events Database since 1996. The average annual crop loss estimate was determined based on recorded damages from SHELDUS data from 1960 to 2018. This does not include losses from displacement, functional downtime, economic loss, injury, or loss of life. Hail causes an average of $385 per year in property damages and $1,477 per year in crop loss.

Table 43: Hail Loss

Hazard Type	# of Events[1]	Average # events per year	Total Property Loss[1]	Average Annual Property Loss	Total Crop Loss[2]	Average Annual Crop Loss
Hail	221	8.5	$10,000	$385	$87,129	$1,477

Source: 1 NCEI (1996-June 2021), 2 SHELDUS (1960-2018)

Probability

Based on historical records and reported events (25 out of 26 years with a reported hail event), there is a 96 percent probability that hail will occur annually in the county.

Climate Change

The 2018-2023 Colorado Enhanced Hazard Mitigation Plan states that hail events are likely to be nearly eliminated from 2041-2070. Because of this extent, duration, and intensity of hail events are likely to decrease.

Jurisdictional Top Hazard Status

The following table lists jurisdictions which identified hail as a top hazard of concern.

Jurisdictions	
Town of Cokedale	Kim Reorganized 88
Trinidad School District #1	

Future Development

All future development will be affected by hail. The ability to withstand impacts lies in sound land use practices and consistent enforcement of building codes and regulations for new construction. Municipalities that have adopted the current International Building Codes have a lower risk for damage as the code has sections designed to deal with the impacts of hail events.

According to the 2018-2023 Colorado Enhanced Hazard Mitigation Plan, Las Animas County's exposure rating incorporating growth (2010-2030) is negligible. This takes into account projected population change and combined risk (deaths/injuries and number of hail events).

County Vulnerabilities

The older building stock (48.9% built prior to 1970) in the county is built to low code standards or none at all. These structures could be highly vulnerable to hail events. The following table provides information related to county vulnerabilities; for jurisdictional-specific vulnerabilities, refer to *Section Seven: Participant Profiles.*

Table 44: County Hail Vulnerabilities

Sector	Vulnerability
People	-Elderly citizens with decreased mobility may have trouble seeking shelter -Injuries can occur from: not seeking shelter, standing near windows, and shattered windshields in vehicles -Power outages can be life threatening to those depending on electricity for life support -Injuries to those outside, specifically hikers and campers who may not have a location to take shelter
Economic	-Damages to buildings and property can cause significant losses to business owners and employees -Damage to crops
Built Environment	-Roofs, siding, windows, gutters, HVAC systems, etc. can incur damage
Infrastructure	-Power outages from downed tree limbs
Community Lifelines	-Critical buildings may sustain damage -Power outages from downed tree limbs

Hazardous Materials Release

The following description for hazardous materials is provided by the Federal Emergency Management Agency (FEMA):

> Chemicals are found everywhere. They purify drinking water, increase crop production and simplify household chores. But chemicals also can be hazardous to humans or the environment if used or released improperly. Hazards can occur during production, storage, transportation, use or disposal. You and your community are at risk if a chemical is used unsafely or released in harmful amounts into the environment where you live, work or play.[32]

Hazardous materials in various forms can cause fatalities, serious injury, long-lasting health effects, and damage to buildings, homes, and other property. Many products containing hazardous chemicals are used and stored in homes routinely. Chemicals posing a health hazard include carcinogens, toxic agents, reproductive toxins, irritants, and many other substances that can harm human organs or vital biological processes.

Chemical manufacturers are one source of hazardous materials, but there are many others, including service stations, hospitals, and hazardous materials waste sites. Varying quantities of hazardous materials are manufactured, used, or stored in an estimated 4.5 million facilities in the United States—from major industrial plants to local dry-cleaning establishments or gardening supply stores.

Hazardous materials come in the form of explosives, flammable and combustible substances, poisons, and radioactive materials. Hazardous materials incidents are technological (meaning non-natural hazards created or influenced by humans) events that involve large-scale releases of chemical, biological or radiological materials. Hazardous materials incidents generally involve releases at fixed-site facilities that manufacture, store, process or otherwise handle hazardous materials or along transportation routes such as major highways, railways, navigable waterways and pipelines. A large number of spills also occur during the loading and unloading of chemicals. The Environmental Protection Agency (EPA) requires the submission of the types and locations of hazardous chemicals being stored at any facility within the state over the previous calendar year. This is completed by submitting a Tier II form to the EPA as a requirement of the Emergency Planning and Community Right-to-Know Act of 1986. Likewise, the U.S. Department of Transportation, through the U.S. Pipeline and Hazardous Materials Safety Administration (PHMSA), has broad jurisdiction to regulate the transportation of hazardous materials, including the discretion to decide which materials shall be classified as hazardous. These materials are placed into one of nine hazard classes based on their chemical and physical properties. The hazard schedules may be further subdivided into divisions based on their characteristics. Because the properties and characteristics of materials are crucial in understanding the dynamics of a spill during a transportation incident, it is important for response personnel to understand the hazard classes and their divisions.

The transportation of hazardous materials is defined by PHMSA as "…a substance that has been determined to be capable of posing an unreasonable risk to health, safety, and property when

[32] Federal Emergency Management Agency. 2017. "Hazardous Materials Incidents." https://www.ready.gov/hazardous-materials-incidents.

transported in commerce…" According to PHMSA, hazardous materials traffic in the U.S. now exceeds 1,000,000 shipments per day. Nationally, the U.S. has had 108 fatalities associated with the transport of hazardous materials between 2007 through 2016. While such fatalities are a low probability risk, even one event can harm many people.

Fixed sites are those that involve chemical manufacturing sites and stationary storage facilities; while transportation spills include any incident that occurs during the movement or transport of a chemical. Table 45 demonstrates the nine classes of hazardous material according to the 2016 Emergency Response Guidebook.

Table 45: Hazardous Material Classes

Class	Type of Material	Divisions
1	Explosives	1.1 Explosives with a mass explosion hazard 1.2 Explosives with a projection hazard but not a mass explosion hazard 1.3 Explosives which have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard 1.4 Explosives which present no significant blast hazard 1.5 Very insensitive explosives with a mass explosion hazard 1.6 Extremely insensitive articles which do not have a mass explosion hazard
2	Gases	2.1 Flammable gases 2.2 Non-flammable, non-toxic gases 2.3 Toxic gases
3	Flammable liquids (& combustible liquids)	
4	Flammable solids; Spontaneously combustible materials	4.1 Flammable solids, self-reactive substances and solid desensitized explosives 4.2 Substances liable to spontaneous combustion 4.3 Substances which in contact with water emit flammable gases
5	Oxidizing substances and Organic peroxides	5.1 Oxidizing substances 5.2 Organic peroxides
6	Toxic substances and infectious substances	6.1 Toxic substances 6.2 Infectious substances
7	Radioactive materials	
8	Corrosive materials	
9	Miscellaneous hazardous materials/products, substances, or organisms	

Source: Emergency Response Guidebook, 2016[33]

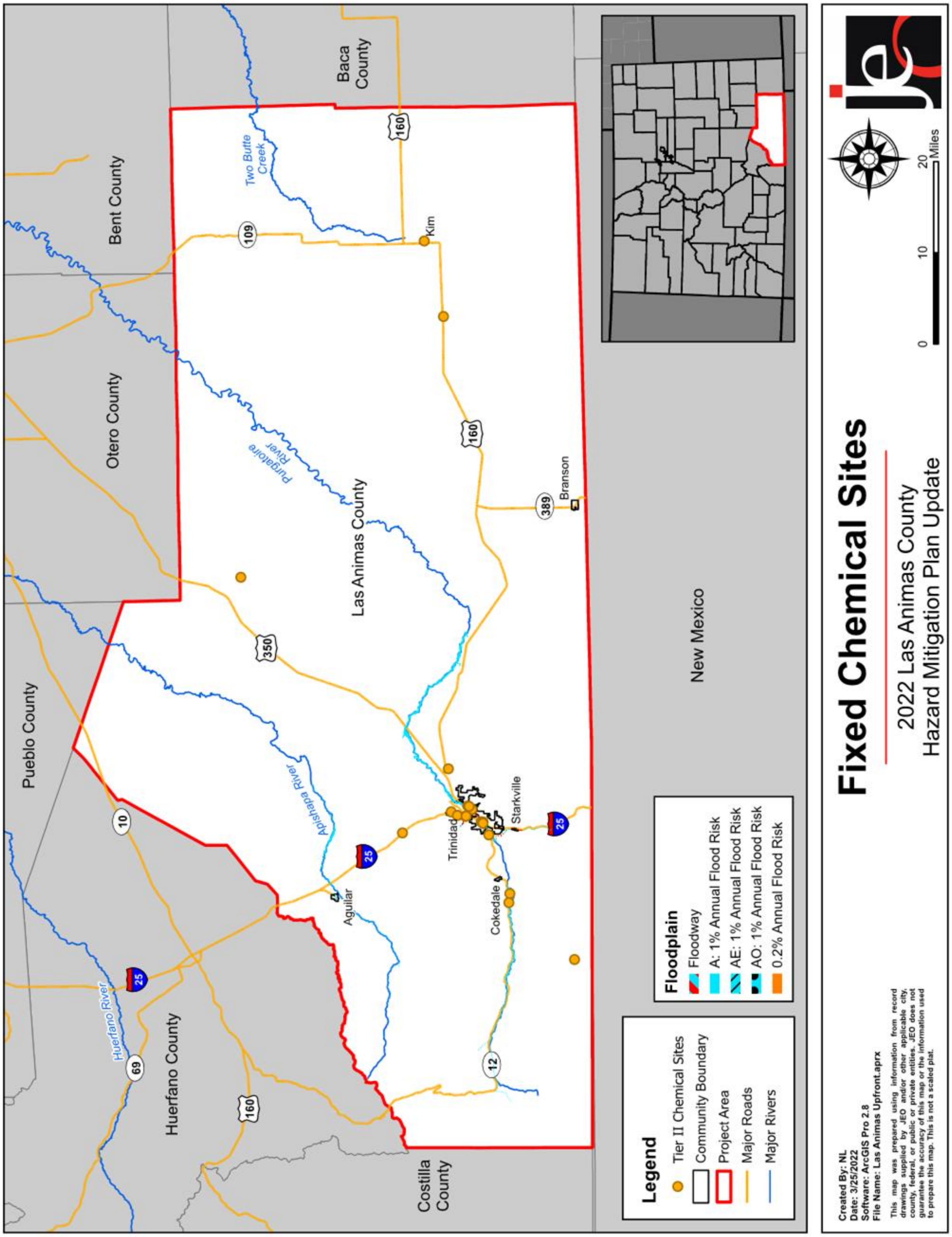
Location

<u>Fixed Site</u>

There are 17 locations across the county that house hazardous materials according to the Tier II reports submitted to the Colorado Department of Public Health and Environment in 2020. These locations are shown in Figure 28. A listing of hazardous material storage sites can be found in *Section Seven: Participant Profiles* for each jurisdiction.

33 U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration. 2016. "2016 Emergency Response Guidebook." https://www.phmsa.dot.gov/hazmat/outreach-training/erg.

Figure 28: Fixed Chemical Sites in the County



The EPA also maintains a National Priority List (NPL) which serves primarily information purposes, identifying known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States. There are no NPL sites in Las Animas County.

The oil and gas industry plays an important role in Colorado's and Las Animas County's economy. As of March 2022, there are 3,991 active, inactive, and plugged wells in Colorado. Figure 29 shows the locations of the oil and gas wells in Las Animas County.

Table 46: Oil and Gas Well in Las Animas County

Active Wells	Inactive Wells	Other Status Wells	Plugged Wells	Total
2,904	521	565	1	**3,991**

Source: Colorado Oil and Gas Conservation Commission[34]

Transportation

Hazardous materials releases during transportation primarily occur on major transportation routes. Participating communities specifically reported transportation along railroads and highways as having the potential to impact their communities. Three Burlington Northern Santa Fe Railroad lines travel through the county. One follows along Interstate 25, one follows along US Highway 350, and one runs from Branson to Trinidad (Figure 30). Railroads providing service through the county have developed plans to respond to chemical releases along rail routes.

Title 42, Article 20 of the Colorado Revised Statues governs the routing of hazardous materials by motor vehicles on all public roads in the State of Colorado. In order to designate a state highway in Colorado as a HAZMAT route, Colorado Department of Transportation staff, local government, or private entities must request the Mobility Section of the Division of Transportation Development to perform an analysis of the route. In Las Animas County Interstate 25 is a designated Hazardous Materials Route and Highways 109, 160, and 350 are designated Gasoline, Diesel Fuel, and Liquified Petroleum Gas Routes (Figure 31). In addition, Colorado is a corridor state through which nuclear materials transit. Interstate 25 is a designated Nuclear Materials Route which runs north south though the western portion of the county including the City of Trinidad, Town of Starkville, and Town of Aguilar.

Pipelines in the county may include large-diameter lines carrying energy products to communities as well as small-diameter lines that may deliver natural gas to businesses and homes. According to PHMSA, there are several gas transmission and hazardous liquid pipelines located in the county (Figure 32).

34 Colorado Oil and Gas Conservation Commission. March 2022. "Daily Activity Dashboard". https://cogcc.state.co.us/dashboard.html#/dashboard.

Figure 29: Oil and Gas Wells

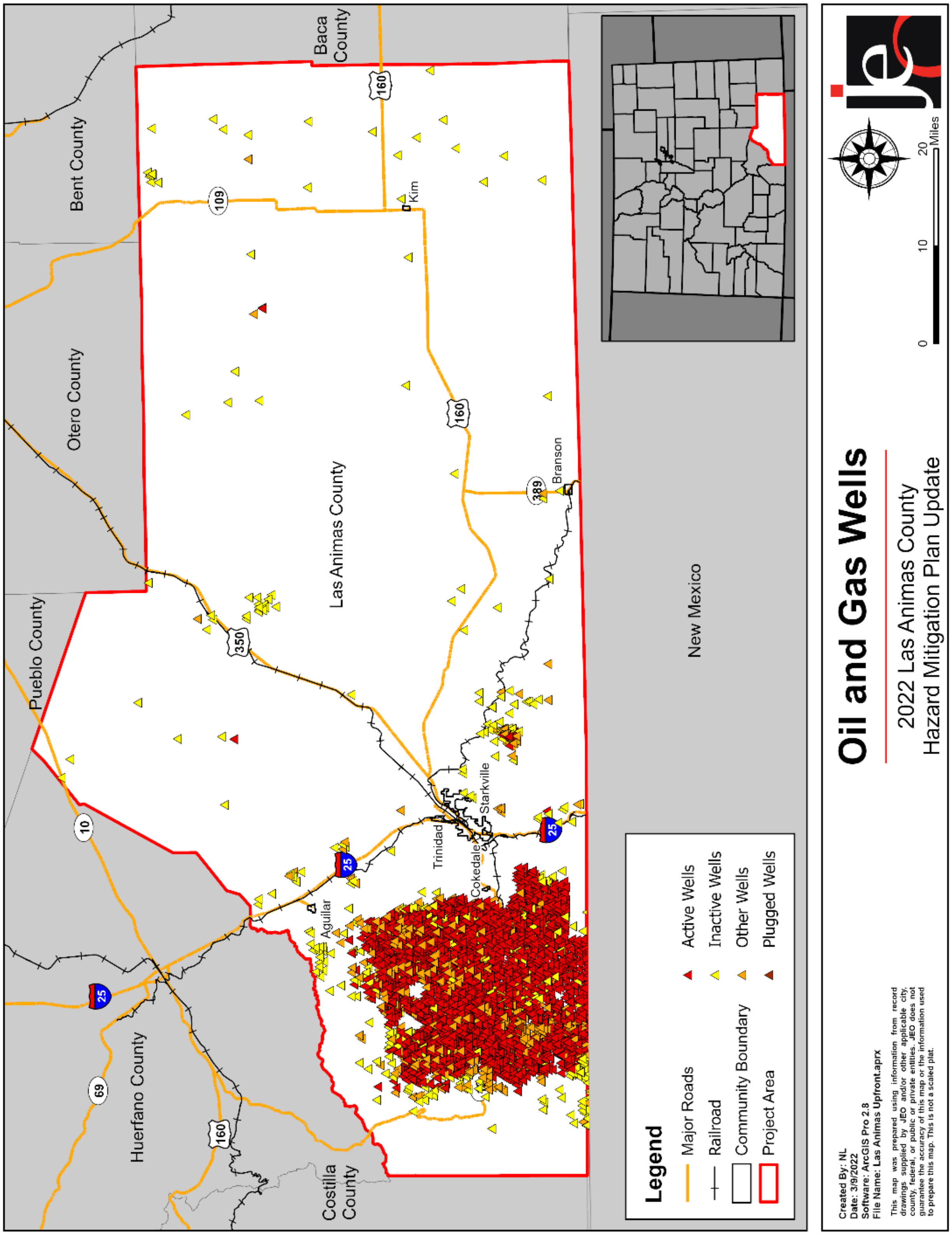


Figure 30: Railroad Routes and Half Mile Buffer

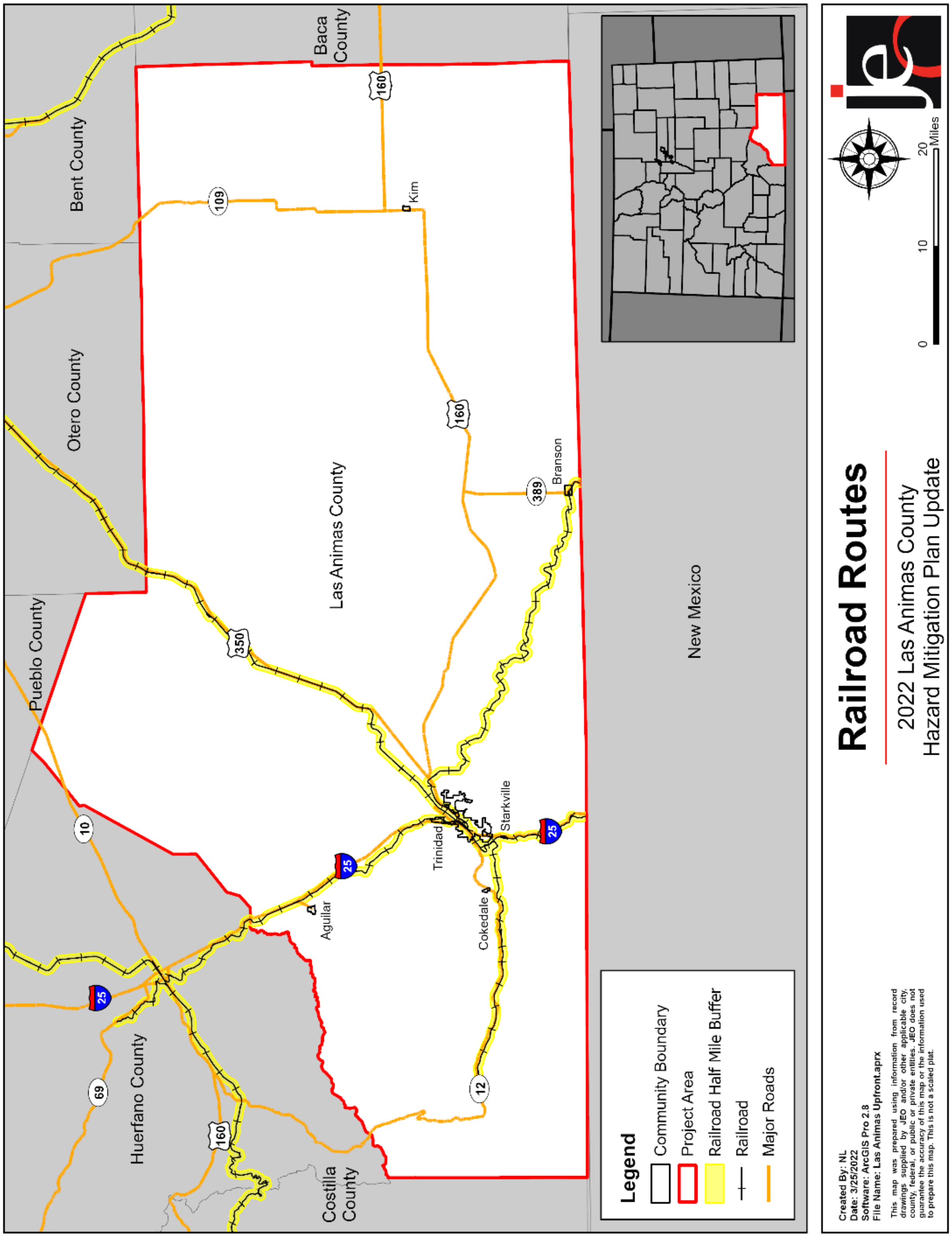
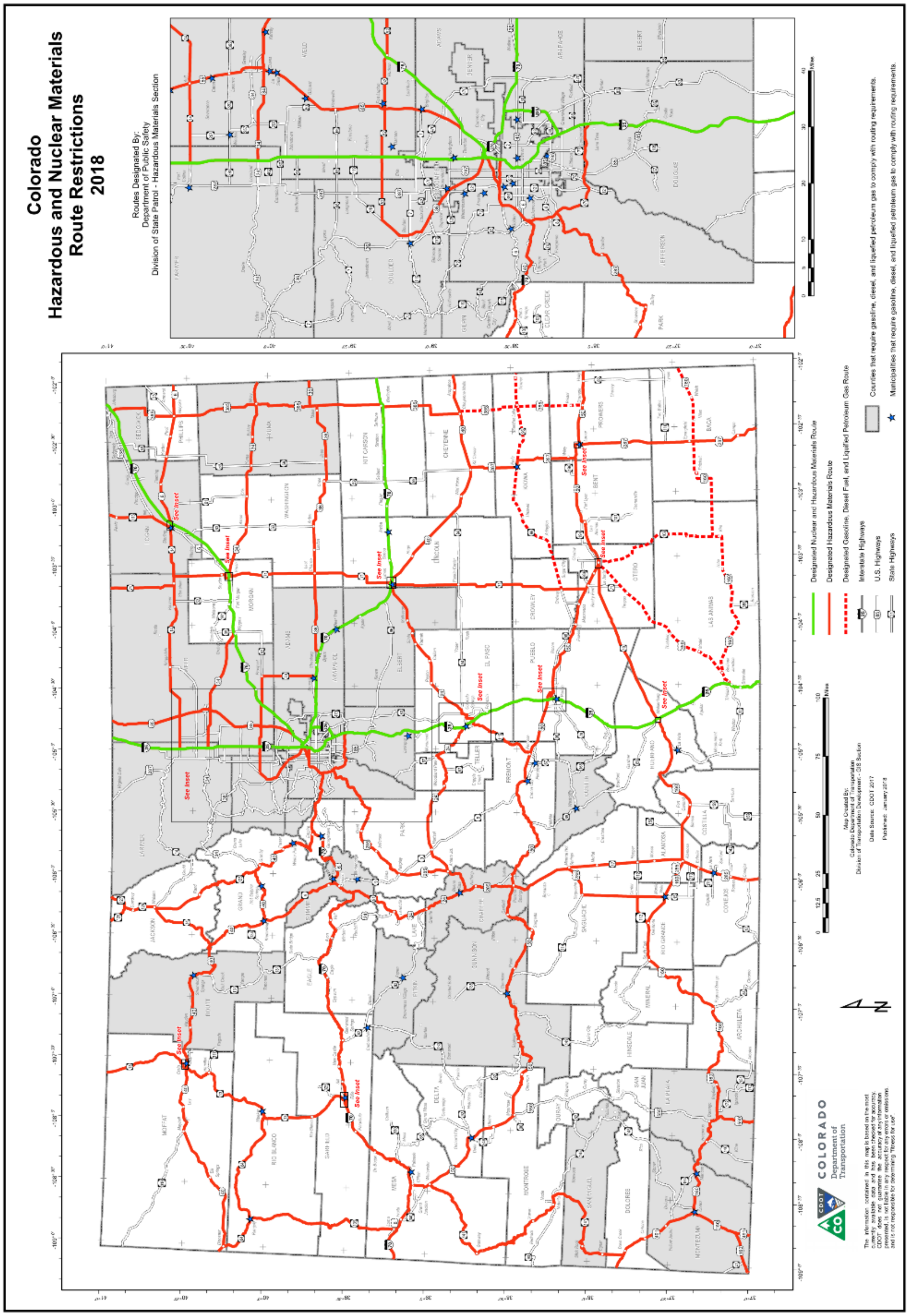


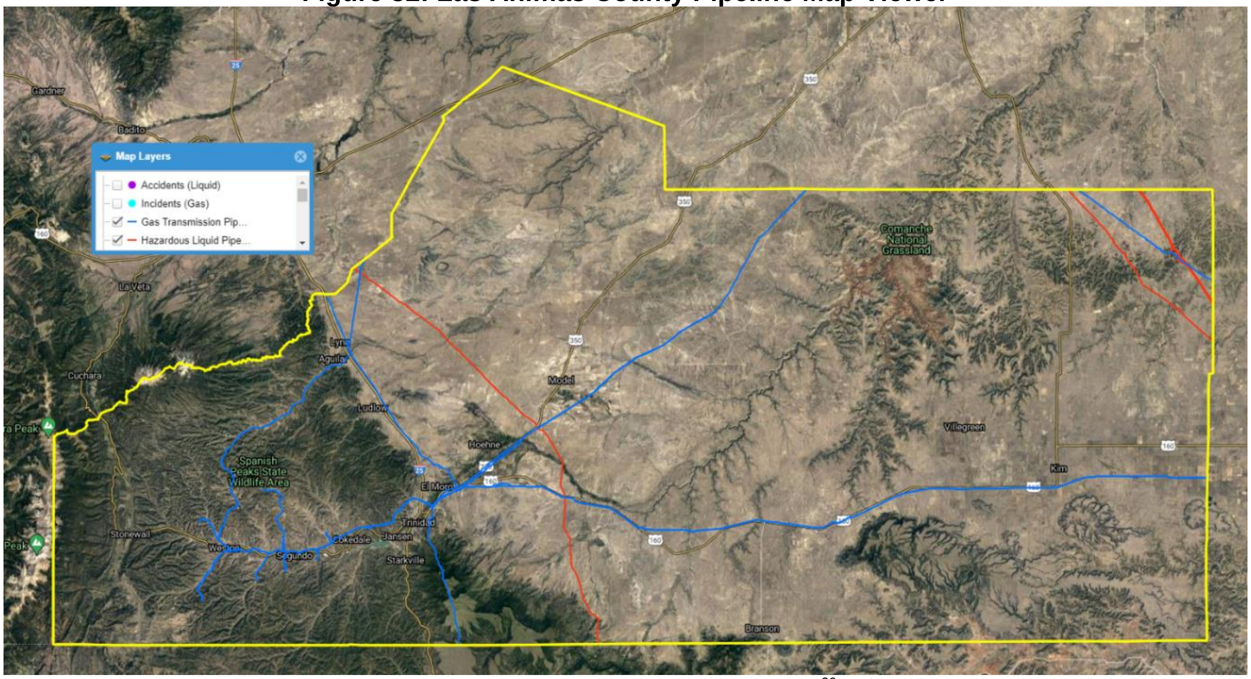
Figure 31: Colorado Hazardous and Nuclear Materials Route Restrictions



Source: Colorado Department of Public Safety, 2018[35]

35 Colorado Department of Public Safety. 2018. "Colorado Hazardous and Nuclear Materials Route Restrictions 2018". Access March 2022. https://dtdapps.coloradodot.info/staticdata/Downloads/StatewideMaps/HazMatMap.pdf.

Figure 32: Las Animas County Pipeline Map Viewer



Source: National Pipeline Mapping System[36]

Extent

The extent of chemical spills at fixed sites varies and depends on the type of chemical that is released with a majority of events localized to the facility. The probable extent of chemical spills during transportation is difficult to anticipate and depends on the type and quantity of chemical released. There were 12 fixed sites, 76 oil and gas, and 10 transportation chemical releases that have occurred in the county. Spills ranged from no material released to 500 gallons. Based on historic records, it is likely that any spill involving hazardous materials will not affect an area larger than a quarter mile from the spill location.

Radiation is the main danger during a nuclear materials spill. Gamma rays can result in acute and long-term illness, with significant enough doses leading to death. The Gray (Gy), which is the standard unit for measuring radiation, is equal to one joule of energy release per kilogram of matter. While any radiation absorption can be dangerous, any exposure of eight Gy or greater will result in certain death within a few days or weeks. Table 47 shows the effects of acute radiation illness. According to the US Nuclear Regulatory Commission, nuclear accidents and incidents are classified under three categories:

- **Criticality Incidents:** Involve nuclear assemblies, research, production or power reactors, and chemical operation. Worldwide, these incidents have resulted in fatalities, radiation exposure, and release of radioactivity into the environment.
- **Loss-of-Coolant:** Accidents result when a reactor coolant system experiences a breach large enough that coolant inventory can no longer be maintained by the norm operating makeup system.
- **Loss-of-Containment:** Accidents involve the release of radioactivity. Points of release for this type of incident can be containment vessels at power facilities or damaged packages during transportation. This is most likely to occur during transportation of nuclear materials.

36 National Pipeline Mapping System. 2022. "Public Viewer." Accessed January 2022. https://pvnpms.phmsa.dot.gov/PublicViewer/.

Table 47: Acute Radiation Illness Chart

Phase	Symptom	Whole-Body Absorbed Dose (Gy)				
		1-2 Gy	2-6 Gy	6-8 Gy	8-30 Gy	>30 Gy
Immediate Effects	Nausea and Vomiting	5-50%	50-100%	75-100%	90-100%	100%
	Time of Onset	2-6 hours	1-2 hours	10-60 min	<10 min	<5 min
	Duration	<24 hours	24-48 hours	<48 hours	<48 hours	Death within 48 hours
	Diarrhea	None	None to mild	Mild to severe	Severe	Severe
	Time of onset	-	3-8 hours	1-3 hours	<1 hour	<1 hour
	Headache	Slight	Mild to moderate	Moderate	Severe	Severe
	Time of onset	-	2-24 hours	3-4 hours	1-2 hours	<1 hour
	Fever	None	Moderate increase	Moderate to severe	Severe	Severe
	Time of onset	-	1-3 hours	<1 hour	<1 hour	<1 hour
	Central nervous system function	No impairment	Cognitive impairment 6-20 hours	Cognitive impairment >24 hours	Rapid incapacitation	Seizures, tremor, ataxia, lethargy
Latent Period		28-31 days	7-28 days	<7 days	None	None
Overt Illness	Clinical Manifestations	Mild to moderate leukopenia	Moderate to severe leukopenia	Severe leukopenia	Nausea	Patients die within 48 hours
		Fatigue	Purpura	High Fever	Vomiting	
		Weakness	Hemorrhage	Diarrhea	Severe diarrhea	
			Infections	Vomiting	High fever	
			Epilation after 3 Gy	Dizziness and disorientation	Electrolyte disturbance	
				Hypotension	Shock	
				Electrolyte disturbance		
Mortality	Without Care	0-5%	5-95%	95-100%	100%	100%
	With Care	0-5%	5-50%	50-100%	100%	100%
	Death	6-8 weeks	4-6 weeks	2-4 weeks	2 days – 2 weeks	1-2 days

Source: Merck Manuals Online, 2018

Historical Occurrences

Fixed Site Spills

According to the NRC database, there have been 12 fixed site chemical spills between January 1990 and September 2021 in the county. The following table lists those events. No injuries or fatalities occurred from these events.

In addition, the Colorado Oil and Gas conservation Commission reported 76 oil and gas well spills since 2018. Damages, injuries, and quantity spill was not given, however, nine of the events impacted the groundwater.[37]

37 Colorado Oil and Gas Conservation Commission. March 2022. "Daily Activity Dashboard". https://cogcc.state.co.us/dashboard.html#/dashboard.

Table 48: Chemical Fixed Site Incidents

Year	Location of Release	Quantity Spilled	Material Involved	Number Evacuated	Property Damage
1993	Trinidad	Unknown	Motor Oil	0	$0
1995	Trinidad	100 gallons	Mineral Oil	0	$0
1996	Trinidad	Unknown	PCB	0	$0
1999	Trinidad	500 gallons	Fuel Oil	0	$0
2000	Val Dez	5 gallons	Lubricating Oil	0	$0
2007	Trinidad	1	Hand Grenade	0	$0
2008	Aguilar	Unknown	Unknown	0	$0
2009	Weston	160 barrels 175 gallons	Produced Water Lubricating Oil	0	$0
2010	Aguilar	Unknown	Mercury	0	$0
2014	Las Animas County	Unknown	Produce Water	0	$0
2015	Ludlow	Unknown	Unknown	0	$0
2021	Trinidad	Unknown	Refrigerant Gas	0	$0

Source: National Response Center, 1990-Sept 2021[38]

Transportation Spills

According to the Pipeline and Hazardous Materials Safety Administration (PHMSA), 10 hazardous materials releases occurred during transportation in the county between 1971 and August 2021. None of the spills involved radioactive materials. During these events, there were no injuries, no fatalities, and $22,157 in damages. The following table provides a list of those events.

Table 49: Historical Chemical Spills 1990-2020

Date of Event	Location of Release	Failure Description	Material Involved	Method of Transportation	Quantity Spilled (LGA)	Total Damages
6/14/1990	Trinidad	Defective Device	Petroleum	Highway	0.0625	$0
9/2/1990	Trinidad	Improper Preparation	Cleaning Liquid	Highway	1	$270
5/22/1992	Aguilar	-	Petroleum	Highway	4	$6,548
3/24/1993	Trinidad	Defective Device	Anhydrous Ammonia	Rail	0	$0
8/27/1999	Trinidad	Overfilled	Gasoline	Highway	500	$0
9/27/1999	Trinidad	Defective Device	Hydrochloric Acid	Highway	0.5	$12,000
1/13/2004	Aguilar	-	Hydrogen Peroxide	Highway	25	$3,339
8/8/2006	Trinidad	Defective Device	Resin Solution	Highway	0.125	$0
4/8/2011	Trinidad	Human Error	Gasoline	Highway	5	$0
5/28/2017	Trinidad	Human Error	Gasoline	Highway	2	$0

Liquid Gallons (LGA)
Source: PHMSA, 1971-Aug 2021[39]

38 U.S. Coast Guard National Response Center. 2021. "Chemical Pollution and Railroad Incidents, 1990-2021." [datafile]. http://nrc.uscg.mil/.
39 Pipeline and Hazardous Materials Safety Administration. August 2021. "Incident Statistics: Colorado." https://www.phmsa.dot.gov/hazmat-program-management-data-and-statistics/data-operations/incident-statistics.

Average Annual Losses

There have been 12 chemical fixed site spills in the county reported from the NRC, 10 transportation spills as reported by PHMSA, and 76 oil and gas well spills reported by the Colorado Oil and Gas Conservation Commission. Neither the NRC nor PHMSA track crop losses from chemical spills. Transportation spill events reported $22,157 in property damages. This does not include losses from displacement, functional downtime, economic loss, injury, or loss of life.

Table 50: Hazardous Materials Release Losses

Hazard Type	Number of Events	Events per Year	Total Property Loss	Average Annual Property Loss
Fixed Site Spills - NRC	12	0.4	$0	$0
Oil and Gas Well Spills	76	19	$0	$0
Transportation Spills	10	0.2	$22,157	$426

Source: NRC, 1990-Sept 2021; PHMSA, 1971-Aug 2021; Colorado Oil and Gas Conservation Commission, 2018-March 2022

Probability

Given the historic record of occurrence for NRS fixed chemical spill events (12 out of 32 years with a reported event), for the purposes of this plan, the annual probability of a fixed chemical spill is 38 percent. The annual probability for an oil and gas well spill is 100%. Given the historic record of occurrence for chemical transportation spill events (8 out of 52 years with a reported event), for the purposes of this plan, the annual probability of chemical transportation occurrence is 15%.

Climate Change

Climate trends are not anticipated to have a direct impact on hazardous materials spills. However, as events continue to impact infrastructure used by and for hazardous materials, future spills will likely occur. For example, geohazards are likely to increase which may affect roadways causing more spills to occur.

Jurisdictional Top Hazard Status

The following table lists jurisdictions which identified hazardous materials release as a top hazard of concern.

Jurisdictions	
City of Trinidad	

Future Development

As population increases, the demand for hazardous materials may increase as well, creating increased production and transportation of hazardous materials. While Las Animas County may not be currently growing in population, other areas along the front range are growing. This could cause an increase in the amount of hazardous materials being transported through the county. Any new facilities which house vulnerable populations, ush as schools, nursing homes, hospitals, should be built in areas with adequate buffer space from major transportation routes and fixed chemical sites.

Oil and gas operations are projected to grow in the future. As of March 2022, there are four pending permits for oil and gas wells.[40] As the number of oil and gas wells grows, so does the risk for additional spills.

County Vulnerabilities

The following table provides information related to county vulnerabilities; for jurisdictional-specific vulnerabilities, refer to *Section Seven: Participant Profiles.*

Table 51: County Hazardous Materials Release Vulnerabilities

Sector	Vulnerability
People	-Those in close proximity could have minor to moderate health impacts -Possible evacuations -Hospitals, nursing homes, and the elderly at greater risk due to low mobility -Risk of health impacts to first responders
Economic	-A chemical plant shutdown in smaller communities would have significant impacts to the local economy -Evacuations and closed transportation routes could impact businesses near spill
Built Environment	-Risk of fire or explosion
Infrastructure	-Transportation routes can be closed during evacuations or cleanup -Potential contamination of drinking water supplies
Community Lifelines	-Risk of fire, explosion, or other damages to buildings -Risk of evacuation -Transportation routes can be closed during evacuation or cleanup -Potential contamination of drinking water supplies

40 Colorado Oil and Gas Conservation Commission. March 2022. "Daily Activity Dashboard". https://cogcc.state.co.us/dashboard.html#/dashboard.

Landslide, Mud/Debris Flow, Rockfall

Landslides are the downward and outward movement of slopes with debris. These events include names such as slumps, rockslides, debris slide, lateral spreading, debris avalanche, earth flow, and soil creep. The size of a landslide usually depends on the geology and landslide triggering mechanism. Landslides initiated by rainfall tend to be smaller, while those initiated by earthquakes may be very large. Slides associated with volcanic eruptions can include as much as one cubic mile of material.

Landslides are typically triggered by periods of heavy rainfall or rapid snowmelt. Earthquakes, changes to the hydrology, removal of vegetation, and excavations may also trigger landslides. Certain geologic formations are more susceptible to landslides than others. Human activities, including locating development near steep slopes, can increase susceptibility to landslide events as well. Landslides on steep slopes are more dangerous because movements can be rapid. Some characteristics that determine the type of landslide are slope of the hillside, moisture content, and the nature of the underlying materials.

Slow moving landslides can occur on relatively gentle slopes and can cause significant property damage. However, slow moving landslides are far less likely to result in serious injuries than rapidly moving landslides that can leave little time for evacuation.

Mud and debris flows are defined by the Colorado Geological Survey as a mass of water and fine-grained earth that flows down a stream, ravine, canyon, arroyo, or gulch and more than half of the solids in the mass are larger than sand grains. The volume of fine sediment (silt, clay and fine sands in the fluid matrix) controls the properties of the flow, including, viscosity, density, and yield stress. Due to their density and sediment, mudflows have significantly slower velocities compared to water floods on the same slope. The fine sediments increase the density of the fluid matrix, which increases the buoyancy of sediments thereby creating conditions that allow gravel to boulder-sized material to be transported near the flow surface by mudflows.[41] They can occur on gentle slopes, move rapidly for large distances, and increase in size as they move.

Rock falls occur when blocks of material come loose on steep slopes. Weathering, erosion, or excavations, such as those along highways, can cause falls where the road has been cut through bedrock. They are fast moving with the materials free falling or bouncing down the slope. The volume of material involved could be large or small, and the velocity of the fall may cause significant damage. Rockfalls can threaten human life, impact transportation corridors and communication systems, and result in other property damage. Spring is typically the rockfall season in Colorado as snow melts and saturates soils and temperatures enter into freeze/thaw cycles.

41 Mussetter Engineering Inc. May 2009. “Cornet Creek Watershed and Alluvial Fan Debris Flow Analysis.” https://www.sanmiguelcountyco.gov/DocumentCenter/View/273/Telluride-2009-Cornet-Creek-Debris-Flow-Report-PDF.

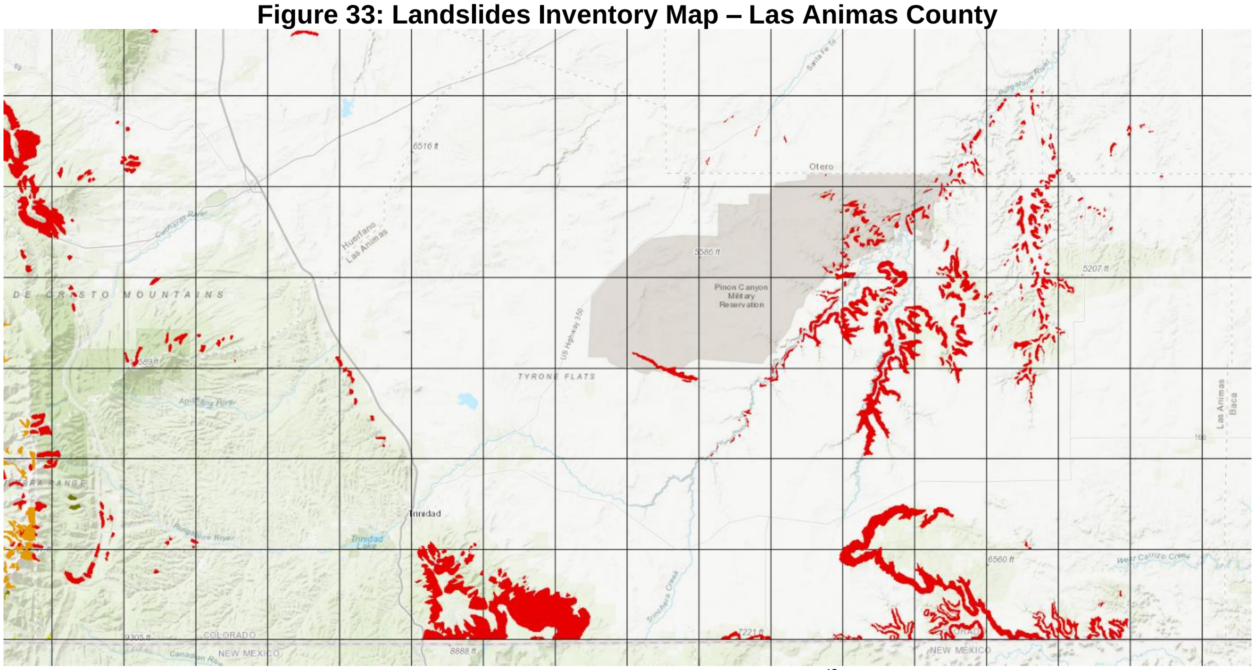
Location

This hazard is correlated with elevation change; thus, this hazard largely occurs in the slopped areas of the county. In 2002, the Colorado Geological Survey updated the Colorado Landslide Mitigation Plan.[42] The updated plan contains a ranked list of communities, areas, and facilities most at risk from landslides. Hazard areas are grouped by relative severity into three tiers:

- **Tier One** listings are serious cases needing immediate or ongoing action or attention because of the severity of potential impacts.
- **Tier Two** listing are very significant but less severe; or where adequate information and/or some mitigation is in place; or where current development pressure are less extreme.
- **Tier Three** listing are similar to Tier Two but with less severe consequences or primarily local impacts.

The plan did not identify any tiered areas in Las Animas County. The figure below shows mapped landslide deposits in Las Animas County based on a compendium of landslide GIS databases from the Colorado Geological Survey.

Figure 33: Landslides Inventory Map – Las Animas County



Source: Colorado Geological Survey, 2022[43]

In addition to areas that are mapped as prone to landslides, post-wildfire burn areas are highly susceptible to mud and debris flow events. After a wildfire, the probability of a mud and debris flow increases significantly. The loss of the vegetative cover in burn areas increases run-off rates. The burned and barren slopes are more prone to erosion, resulting in increased peak discharge and bulking rates.[44] Relatively frequent storm events of high intensity, and short durations, have the potential to cause unusually large mudflow events in post-wildfire conditions.[45] The burning of

---

42 Rogers, W.P. 2005. “Critical Landslides of Colorado.” Colorado Geological Survey. https://coloradogeologicalsurvey.org/hazards/landslides/.

43 Colorado Geological Survey. Access March 2022. “Colorado Landslide Inventory”. https://cologeosurvey.maps.arcgis.com/apps/webappviewer/index.html?id=9dd73db7fbc34139abe51599396e2648.

44 White, J. L., Wait, TC, and Morgan M.L. 2008. “Geologic Hazards Mapping Project for Montrose County, Colorado.” Colorado Geological Survey Department of Natural Resources.

45 Rosgen, D. and Rosgen, B. 2013. “Restoring Alluvial Fan Connectivity for Post-Fire Flood Alleviation and Sediment Reduction.”

organic material matter on the ground can: (1) create high temperatures on the ground causing hydrophobicity, which is the tendency of the soil to resist wetting or infiltration of moisture; (2) decrease the roughness of the ground; and (3) increase the erosive capacity of the soil.

Extent

Rapidly moving landslides (debris flows and earth flows) present the greatest risk to human life. Persons living in or traveling through areas prone to rapidly moving landslides should take caution. Slow moving landslides can cause significant property damage but are less likely to result in serious human injuries.

Landslides can be massive, or they may disturb only a few cubic feet of material. The majority of events in Las Animas County are likely to cause limited property damage; limited or no deaths and injuries; and little or no impacts to critical facilities and infrastructure. However, single events near populated areas or key infrastructure may have significant impacts.

In response to the increase of wildfires in the western United States, the United States Geological Survey (USGS) has developed equations for estimating the potential for post-wildfire debris flows, as well as estimating the potential volume of debris resulting from a debris flow event.[46] A statistical evaluation of data collected from recently burned basins in the western United States was used to develop the empirical equations.[47] The estimate of volume is a function of a drainage basin's soil properties, basin characteristics, burn severity, and rainfall conditions.

Therefore, should a basin in Las Animas County burn, the following regression equation could be used to estimate the volume of debris flow that could be produced:

$$Ln\,V = 7.2 + 0.6(\ln SG30) + 0.7(AB)^{0.5} + 0.2(T)^{0.5} + 0.3,$$

where, *V* is the debris-flow volume, including water, sediment, and debris (cubic meters); *SG30* is the area of drainage basin with slopes equal to or greater than 30 percent (square kilometers); *AB* is the drainage basin area burned at moderate to high severity (square kilometers); *T* is the total storm rainfall (millimeters); and 0.3 is a bias correction factor that changes the predicted estimate from a median to a mean value.[48]

The regression equation for debris flow volume is more accurate for smaller basins. Watershed size is an important factor in estimating mud and debris flow probability. Watersheds over 100 acres are more likely to produce flood events, with a significant amount of entrained sediment, while smaller watersheds are more likely to produce a mud and debris event.

Historical Occurrences

NCEI data since 1996 did not report any landslide, mud/debris flow, or rockfall events for Las Animas County. However, as Figure 33 showed, landslides have occurred in the past but were not reported.

---

46 Cannon, S.H., Gartner, J.E., Rupert, M.G., Michael, J.A., Rea, A.H., and Parrett, C. 2010. "Predicting the Probability and Volume of Postwildfire Debris Flows in the Intermountain Western United States." Geological Society of America Bulletin v. 122; no 1-2 pp. 127-144.

47 Stevens, M.R., Flynn, J.L., Stephens, V.C., and Verdin, K.L. 2011. "Estimated Probabilities, Volumes, and Inundation Areas Depths of Potential Postwildfire Debris Flows from Carbonate, Slate, Raspberry, and Milton Creeks, near Marble, Gunnison County, Colorado." U.S. Geological Survey: Scientific Investigations Report 2011–5047.

48 Helsel, D.R. and Hirsch, R.M. 1992. "Statistical Methods in Water Resources." Elsevier Science: Volume 49.

Average Annual Losses

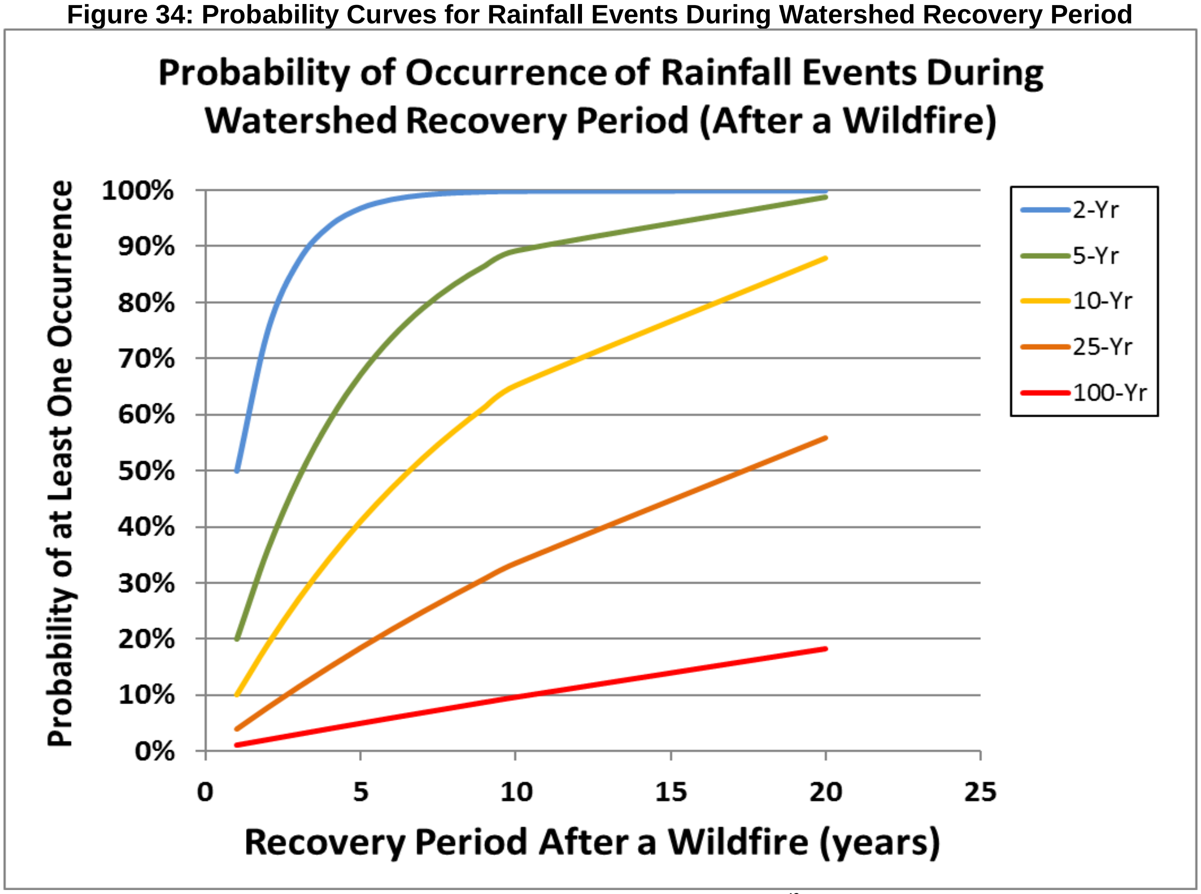
With no historical reported landslide, mud/debris flow, or rockfall events, the average annual losses for property and crops are $0. Any landslides that could occur are likely to have minimal impacts on the built environment.

Probability

Geologic hazards such as landslides, mud/debris flows, and rockfalls may be sporadic and somewhat unpredictable. These events are likely to occur in occasionally in the county, typically in areas where they won't get recorded. However, in the case of a post-wildfire condition and in combination of heavy precipitation, it is likely landslides, debris flows, and mudslides may occur more frequently.

Large mudflows can occur when a relatively common rainfall event happens over a watershed that has been exposed to wildfire. As the vegetation and soil in a burned area recover and the watershed returns to its pre-burn hydrologic condition, the depth and intensity of rainfall necessary to generate a mudflow will generally increase for a given location. Probability curves have been developed to understand the relationship between storm event return frequency and the probability that a given storm will occur at least once over a period of 20 years, as show in the following figure.

Figure 34: Probability Curves for Rainfall Events During Watershed Recovery Period



Source: Wright Water Engineering, 2003[49]

[49] Wright Water Engineering. 2003. "Compilation of Technical Research: Part 1: A Curve Number Approach to Evaluation of Post-Fire Subbasin Recovery Following the Cerro Grande Fire, Los Alamos, New Mexico. Part 2: Post-Burn Assessment of Hydrologic Conditions and Forest Recovery at the Three-Year Anniversary of the Cerro Grande Fire. Part 3: Summary of Mesa Verde 2000 Bircher Fire Basin Recovery in Morefield Canyon."

As show in the figure above, the probability of occurrence for a 2-year event within 10 years is virtually 100 percent, while the probability of a 25-year event and 100-year event are 34 percent and ten percent respectively, within ten years.

Climate Change

The Colorado Department of Transportation completed a climate study in 2021 specifically looking at how changing climate and extreme weather impacts various geohazards in Colorado. This study found that rockfalls will increase, debris flows will either increase or decrease depending on the climate variable, and landslides will either increase or decrease depending on the climate variable. The table below shows summary scenarios that could affect landslides, rockfalls, and debris flows.

Table 52: Summary of Scenarios that Could Affect Geohazards

Table 5-1. Summary of scenarios that could affect geohazard FM. Bold text identifies increases to geohazard FM.

Climate Variable Trend	Geophysical Process Trend	Geohazard FM
Number of Extreme Freeze Thaw Days Increases	Discontinuity Aperture Increases	**Rockfall Increase**
	Material Strength Decreases	**Debris Flow Increase**
Winter Precipitation Increases	Increasing Water in Discontinuities	**Rockfall Increase**
	Increasing Overland Flow	**Debris Flow Increase**
	Increasing Infiltration	**Shallow Landslide Increase**
	Increasing River Runoff	
	Increasing Groundwater Level	**Deep Landslide Increase**
Number of Extreme Heat Days Increases	Increasing Wildfire Frequency	**Debris Flow Increase**
Summer Precipitation Decreases		
Summer Precipitation Decreases	Decreasing Overland Flow	Debris Flow Decrease
	Decreasing Infiltration	Shallow Landslide Decrease
	Decreasing Groundwater Level	Deep Landslide Decrease

Source: Colorado Department of Transportation[50]

Jurisdictional Top Hazard Status

No jurisdictions identified landslides, mud/debris flow, rockfall events as a top hazard of concern.

Future Developments

Although landslides are a natural geologic process, the incidence of landslides and their impacts on people can be exacerbated by human activities. Grading for road construction and development can increase slope steepness and decrease the stability of a hillslope by adding weight to the top of the slope, removing support at the base of the slope, and increasing water content. Other human activities affecting landslides include: excavation, drainage and groundwater alterations, and changes in vegetation. Future development could be vulnerable to

[50] Colorado Department of Transportation. May 14, 2021. "Climate Study: Changing Climate and Extreme Weather Impacts on Geohazards in Colorado". https://www.codot.gov/programs/planning/data-studies/cdot-climate-resilience-study.pdf.

landslides, as well as the infrastructure required to support this growth, if not accounted for in siting and design.

According to the 2018-2023 Colorado Enhanced Hazard Mitigation Plan, Las Animas County's exposure rating incorporating growth (2010-2030) is negligible. This takes into account projected population change and local HMP categorization.

County Vulnerabilities

The following table provides information related to county vulnerabilities; for jurisdictional-specific vulnerabilities, refer to *Section Seven: Participant Profiles.*

Table 53: County Landslide, Mud/Debris Flow, and Rockfall Vulnerabilities

Sector	Vulnerability
People	-Exposure is more likely to occur driving on roadways and in sloped recreation areas -People living in homes located on steep slopes -First responders in areas that are still geologically unstable
Economic	-Limited loss of accessibility and potential damage to businesses
Built Environment	-Damage building foundations due to moving soil -General damage to buildings from rocks -Homes and other buildings located on slopes
Infrastructure	-Damage to roadways and bridges -Damage or breaking of underground utility lines -Power loss from downed lines and towers
Community Lifelines	-Damage to roadways and bridges -Damage or breaking of underground utility lines -Power loss from downed lines and poles

Lightning

Lightning is an electrical discharge between positive and negative regions of a thunderstorm. A lightning flash is composed of a series of strokes with an average of about four strokes per flash. The length and duration of each lightning stroke vary, but typically average about 30 microseconds.

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

Although not as common, cloud-to-ground lightning is the most damaging and dangerous form of lightning. Most flashes originate near the lower-negative charge center and deliver negative charge to earth. However, a minority of flashes carry positive charge to earth. These positive flashes often occur during the dissipating stage of a thunderstorm's life. Positive flashes are also more common as a percentage of total ground strikes during the winter months. This type of lightning is particularly dangerous for several reasons. It frequently strikes away from the rain core, either ahead or behind the thunderstorm. It can strike as far as five or ten miles from the storm in areas that most people do not consider to be a threat. Positive lightning also has a longer duration, so fires are more easily ignited. And, when positive lightning strikes, it usually carries a high peak electrical current, potentially resulting in greater damage.

The ratio of cloud-to-ground and intra-cloud lightning can vary significantly from storm to storm. Depending upon cloud height above ground and changes in electric field strength between cloud and earth, the discharge stays within the cloud or makes contact with the earth. Figure 35 shows the lightning flash density for the United States.

Location

The entire county is at risk to thunderstorms and associated damages. Common locations for lightning strikes include open fields, under trees, boats, golf courses, near heavy or large-scale equipment, telephone poles, or other raised platforms.

Extent

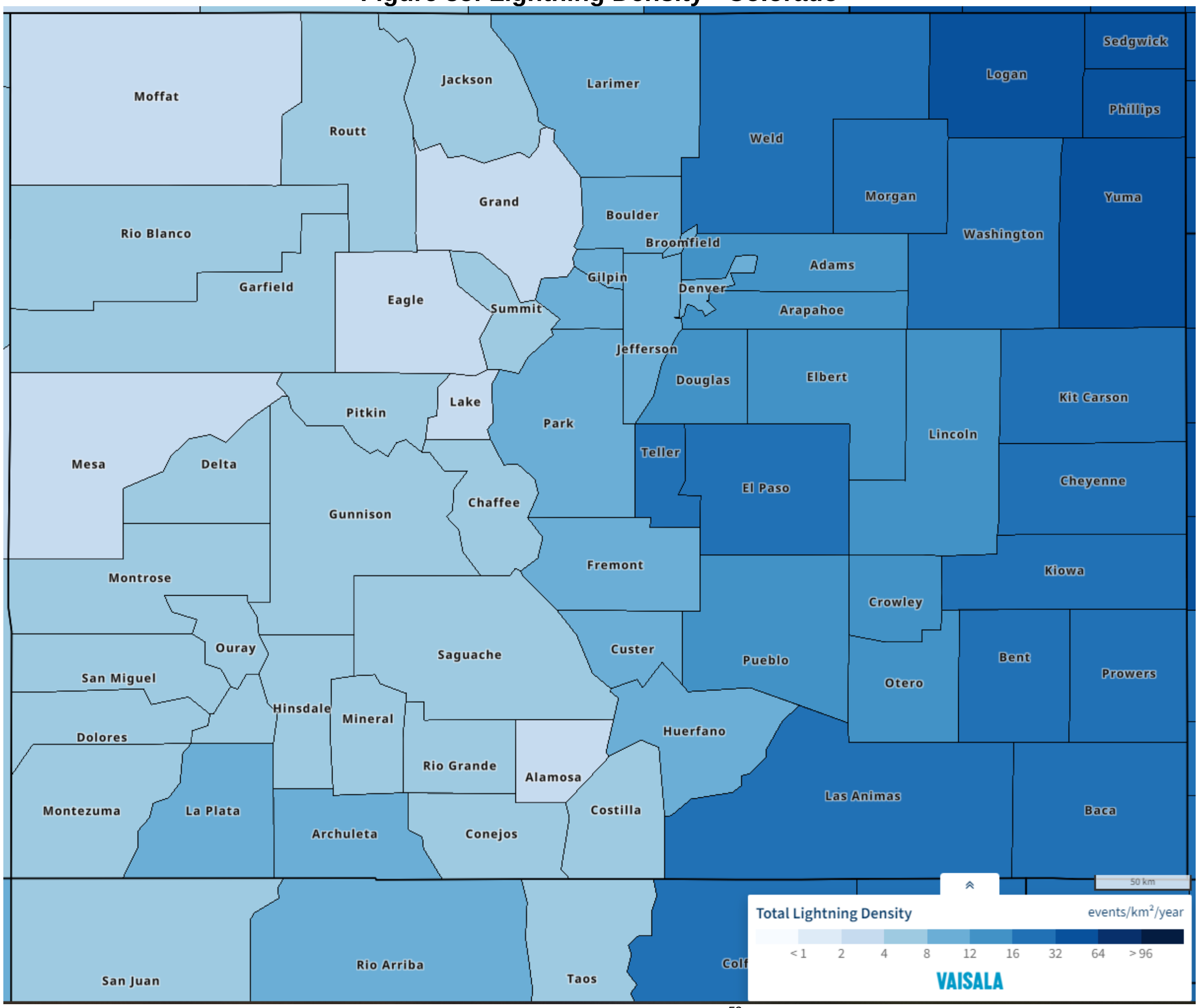
Cloud-to-ground lightning is the most threatening due to its ability to cause death, injury, wildfire, and damage to property. The extent of lightning is dependent on a multitude of factors, some of which explain the geographic extent of the most frequent lightning strikes in Colorado. Ground elevation, ground humidity, and wind currents are all ingredients that enhance the frequency of lightning.

Historical Occurrences

SHELDUS data from 1960 to 2018 reported six lightning events in the county. These events caused $895 in property damage and one fatality. However, SHELDUS data is likely under reported as VAISALA data shows that Las Animas County averages 17.1 events per square kilometer per year.[51]

51 VAISALA. 2016-2021. "Global Lightning Density Map". Accessed March 2022. https://interactive-lightning-map.vaisala.com/?_ga=2.241223942.528535091.1647036919-204568516.1647036919.

Figure 35: Lightning Density - Colorado



Source: VAISALA, 2016-2021[52]

Average Annual Losses

The average annual property and crop damage estimate was determined based upon recorded damages from SHELDUS data. This does not include losses from displacement, functional downtime, economic loss, injury, or loss of life. According to SHELDUS, lightning has causes $15 in property damage annually.

Table 54: Lightning Losses

Hazard Type	# of Events	Average # events per year	Total Property Loss	Average Annual Property Loss	Total Crop Loss	Average Annual Crop Loss
Lightning	6	0.1	$895	$15	$0	$0

Source: SHELDUS (1960-2018)

52 VAISALA. 2016-2021. "Global Lightning Density Map". Accessed March 2022. https://interactive-lightning-map.vaisala.com/?_ga=2.241223942.528535091.1647036919-204568516.1647036919.

Probability
While SHELDUS reported lightning events in only 6 out of 59 years in the period of record, lightning is likely to occur several times annually in Las Animas County. For the purposes of this plan the annual probability of lightning is 100 percent.

Climate Change
Currently, climate change impacts on lightning are still not fully understood. The 2018-2023 Colorado Enhanced Mitigation Plan anticipated little change in lightning events due to climate change.

Jurisdictional Top Hazard Status
The following table lists jurisdictions which identified lightning events as a top hazard of concern.

Jurisdictions	
Town of Cokedale	Hoehne Fire Protection District

Future Development
Lightning strikes will continue to pose a threat to future development throughout Las Animas County. For any future development that occurs, adequate protection from lightning strikes should be incorporated into building designs and plans. Lightning rods, protected rooftop utilities, surge protectors, and fuels reduction projects are possible steps new developments can take to reduce impacts from lightning.

According to the 2018-2023 Colorado Enhanced Hazard Mitigation Plan, Las Animas County's exposure rating incorporating growth (2010-2030) is negligible. This takes into account projected population change and combined risk (deaths/injuries and number of storm events).

County Vulnerabilities
In addition to direct damages from lightning strikes, the potential for lightning to start wildfires is of great concern to many communities. Lightning from one storm can start dozens of wildfires throughout the county. The following table provides information related to county vulnerabilities; for jurisdictional-specific vulnerabilities, refer to *Section Seven: Participant Profiles.*

Table 55: County Lightning Vulnerabilities

Sector	Vulnerability
People	-Injuries can occur from: not seeking shelter, standing near windows, and shattered windshields in vehicles -Those who work outside, and emergency responders are more vulnerable -Hikers and campers who may not have nearby sheltering locations
Economic	-Minimal loss of business from power outages -Damage to computers and other electronics due to power surges
Built Environment	-Damage to building and rooftop utilities
Infrastructure	-Power outages
Community Lifelines	-Power outages -Loss of information systems -Damage to critical buildings and rooftop utilities

Severe Wind

The National Weather Service (NWS) defines high winds as sustained wind speeds of 40 mph or greater lasting for 1 hour or longer, or winds of 58 mph or greater for any duration.[53] The NWS issues High Wind Advisories when there are sustained winds of 25 to 39 miles per hour and/or gusts to 57 mph. Severe winds typically accompany severe thunderstorms, severe winter storms, tornadoes, and other large low-pressure systems, which can cause significant crop damage, downed power lines, loss of electricity, traffic flow obstructions, and substantial property damage, including trees and center-pivot irrigation systems. There are several types of damaging winds:

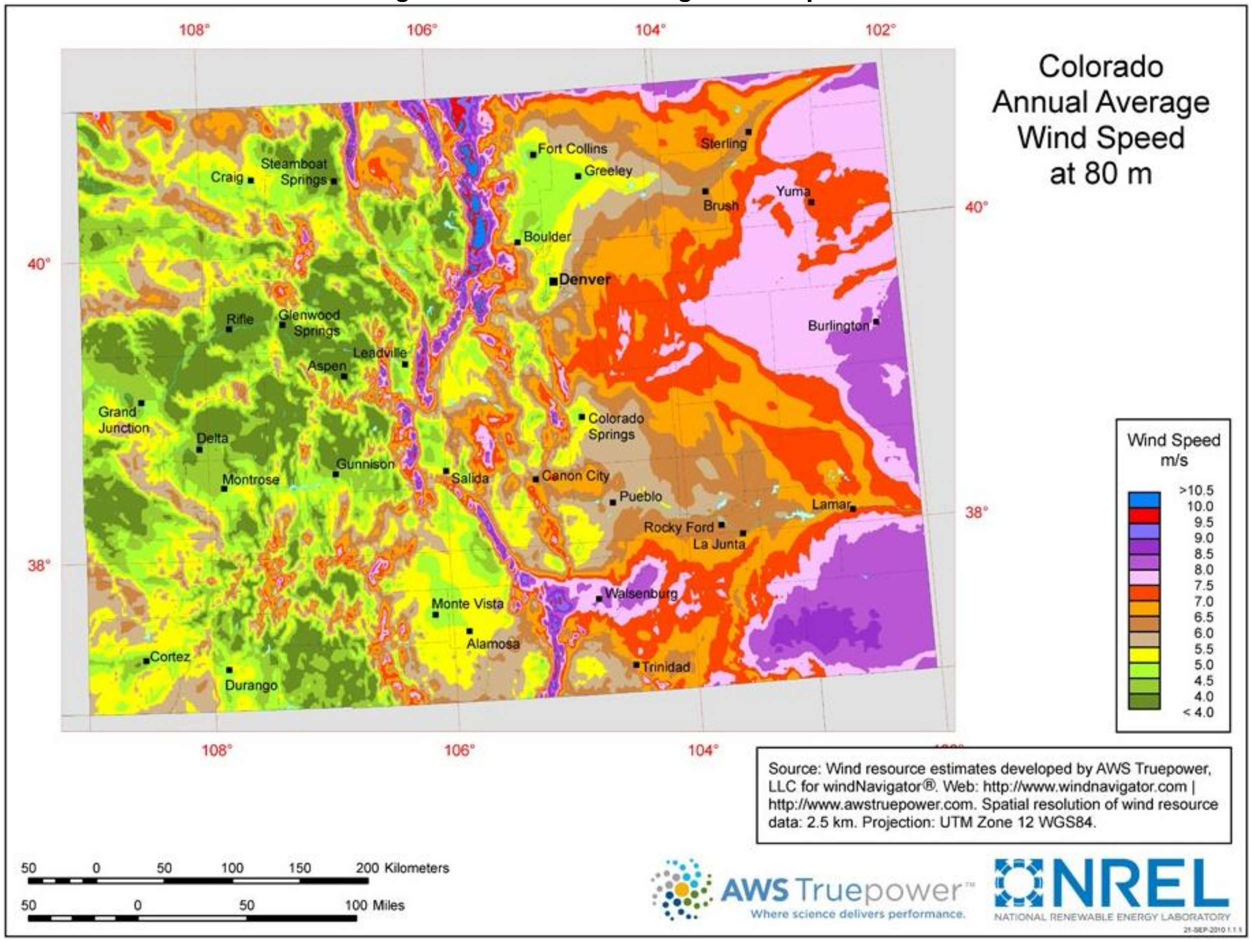
- **Straight-line winds:** Any thunderstorm wind that is not associated with rotation; this term is used mainly to differentiate from tornado winds. Most thunderstorms produce some straight-line winds generated by the thunderstorm downdraft.
- **Down Drafts:** A small-scale column of air that rapidly sinks toward the ground.
- **Downbursts:** A strong downdraft with horizontal dimension larger than 2.5 miles resulting in an outward burst or damaging winds on or near the ground. Although usually associated with thunderstorms, downbursts can occur with showers too weak to produce thunder.
- **Microbursts:** A small, concentrated downburst that produces an outward burst of damaging winds at the surface. Microbursts are generally less than 2.5 miles across and short-lived, lasting only five to ten minutes, with maximum wind speeds up to 168 mph.
- **Gust front:** a gust front is the leading edge of rain-cooled air that clashes with warmer thunderstorms inflow. Gust fronts are characterized by a wind shift, temperature drop, and gusty winds out ahead of a thunderstorm. Sometimes the winds push up air above them, forming a shelf cloud or detached roll cloud.
- **Derecho:** A derecho is a widespread thunderstorm wind caused when new thunderstorms form along the leading edge of an outflow boundary. The word “derecho” is Spanish origin and means “straight ahead”. Thunderstorms feed on the boundary and continue to reproduce. Derechos typically occur in the summer when complexes of thunderstorms form over plains, producing heavy rain and severe wind. The damaging winds can last a long time and cover a large area.
- **Bow Echo:** A bow echo is a linear wind front bent outward in a bow shape. Damaging straight-line winds often occur near the center of a bow echo. Bow echoes can be 200 miles long, last for several hours, and produce extensive wind damage at the ground.
- **Chinook/Bora Winds:** Unique wintertime wind conditions typically felt in Colorado. These winds occur seasonally due to convective air movements where the Rocky Mountains meet the Great Plains. Warm, dry winds descend from the eastern slopes of the mountains, causing a rapid rise in temperature, snowmelt, and sometimes flooding.

Location

Severe winds can occur throughout the county. Wind speed in Colorado is correlated with elevation. Figure 36 show the annual average wind speed in Colorado (at 80 meters height above ground level). As seen in Figure 37, the majority of severe wind events occur in the early spring and winter months.

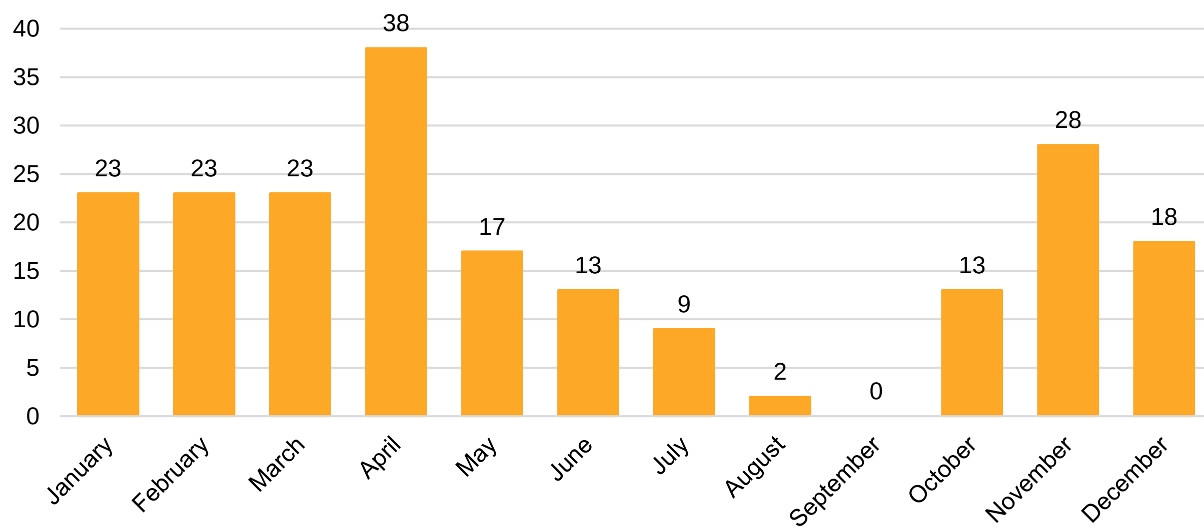
53 National Weather Service. 2017. “Glossary.” http://w1.weather.gov/glossary/index.php?letter=h.

Figure 36: Annual Average Wind Speeds



Source: National Renewable Energy Laboratory, 2021[54]

Figure 37: Severe Wind Events by Month



Source: NCEI, 1996-June 2021

54 National Renewable Energy Laboratory. 2021. "Wind Energy in Colorado: Colorado Annual Average Wind Speed at 80m." https://windexchange.energy.gov/states/co.

Extent

The Beaufort Wind Scale can be used to classify wind strength. The following table outlines the Beaufort scale including wind speed ranking, range of wind speeds per ranking, and a brief description of conditions for each ranking.

Table 56: Beaufort Wind Ranking

Beaufort Wind Force Ranking	Range of Wind	Conditions
0	<1 mph	Smoke rises vertically
1	1-3 mph	Direction shown by smoke but not wind vanes
2	4-7 mph	Wind felt on face; leaves rustle; wind vanes move
3	8-12 mph	Leaves and small twigs in constant motion
4	13-18 mph	Raises dust and loose paper; small branches move
5	19-24 mph	Small trees in leaf begin to move
6	25-31 mph	Large branches in motion; umbrellas used with difficulty
7	32-38 mph	Whole trees in motion; inconvenience felt when walking against the wind
8	39-46 mph	Breaks twigs off tree; generally, impedes progress
9	47-54 mph	Slight structural damage: chimneypots and slates removed
10	55-63 mph	Trees uprooted; considerable structural damages; improperly or mobiles homes with no anchors overturned
11	64-72 mph	Widespread damages; very rarely experienced
12 - 17	72 - > 200 mph	Hurricane; devastation

Source: Storm Prediction Center[55]

Using the NCEI reported events, the average wind event in the Las Animas County is a level 11 on the Beaufort Wind Ranking scale. The reported severe wind events ranged from 49 mph to 98 mph, with an average speed of 68 mph. Table 57 shows the number of events by wind speed.

Table 57: Severe Wind Events by Magnitude

Miles Per Hour	Number of Events	Miles Per Hour	Number of Events
49	1	72	2
58	17	73	2
59	10	75	41
60	44	76	4
61	7	77	4
62	9	78	1
63	4	79	1
64	12	81	7
66	4	83	1
67	3	85	2
68	2	86	1
69	7	89	3
70	10	98	1
71	7		

Source: NCEI, 1996-June 2021

55 Storm Prediction Center: National Oceanic and Atmospheric Administration. 1805. "Beaufort Wind Scale." http://www.spc.noaa.gov/faq/tornado/beaufort.html.

Historical Occurrences

According to the NCEI, there were 207 high wind and thunderstorm wind events that occurred between January 1996 and June 2021. These events were responsible for $561,000 in property damages (NCEI) and $1,209,643 in crop damages (SHELDUS). One fatality and 103 injuries have been reported from severe wind events. Significant hazard events with direct impacts to communities are discussed in more detail in the applicable *Community Profiles.*

<u>July 14, 1989 – High Wind Event</u>

Although this even occurred outside NCEI's period of record, this event should be discussed. A thunderstorm with 60 mph winds struck an encampment at Pinyon Canyon near Trinidad. The winds brought down 12 to 15 large tents, including a field hospital, and sent debris flying. About 100 National Guard troops were injured, including 20 who were hospitalized.

<u>November 12, 2011 - High Wind Event</u>

A high wind event caused a reported $500,000 in property damage in Las Animas County. A strong storm system centered over northern Colorado produced widespread damaging winds over south central and southeast Colorado. There were widespread power outages and damage, especially over sections of Custer and Las Animas Counties. Numerous trees and power lines were blown down. In addition, sheds and barns were destroyed, a few cars were damaged or destroyed when large tree limbs came crashing down on them, a few homes also had tree damage, trailers were knocked over, and some roofs were damaged and/or blown off. Winds were reported at 66 mph with gusts up to 91 mph.

Average Annual Losses

The average annual damage estimate was determined based upon NCEI Storm Events Database since 1996 and the annual crop damage estimate was based on SHELDUS data from 1960-2018. This does not include losses from displacement, functional downtime, economic loss, injury or loss of life. It is estimated that severe wind events can cause an average of $21,576 per year in property damages and $20,502 per year in crop damages.

Table 58: Severe Wind Losses

Hazard Type	# of Events[1]	Average # events per year	Total Property Loss[1]	Average Annual Property Loss	Total Crop Loss[2]	Average Annual Crop Loss
High Winds	183	7.0	$560,000	$21,538	$1,209,643	$20,502
Thunderstorm Wind	24	0.9	$1,000	$38		
Total	**207**	**7.9**	**$561,000**	**$21,576**	**$1,209,643**	**$20,502**

Source: 1 NCEI (1996-June 2021), 2 SHELDUS (1960-2018)

Probability

Given the historic record of occurrence for severe wind events (26 out of 26 years with reported events), for the purposes of this plan, the annual probability of severe wind occurrence is 100 percent.

Climate Change

Studies have indicated that the frequency and magnitude of high wind events may increase in Colorado due to climate trends. However, currently there is no known direct relationship between climate trends and severe wind.

Jurisdictional Top Hazard Status

The following table lists jurisdictions which identified severe wind events as a top hazard of concern.

Jurisdictions	
Town of Aguilar	Town of Branson
Kim Reorganized 88	Trinidad School District #1

Future Development

Any future development and population growth elevates exposure of property and people to the impacts of severe wind. Future development should take steps to reduce potential damages from high winds. Building codes for new structures can be strengthened, requiring increased rebar in foundations, enhanced nailing patterns for wall sheathing, the use of Simpson Strong Ties and Straps, and require the use of anchors and tie-downs of mobile homes. Additionally, individuals can choose to build to an option Code Plus Standard, such as Fortified for Safer Living. The installation of public shelters to protect residents caught outside or in vulnerable areas, such as mobile home parks, can increase safety of residents in those areas.

According to the 2018-2023 Colorado Enhanced Hazard Mitigation Plan, Las Animas County's exposure rating incorporating growth (2010-2030) is slight. This takes into account projected population change and combined risk (deaths/injuries and number of wind events).

County Vulnerabilities

In addition to damages from severe winds, wildfire conditions are exacerbated by high winds. In an area experiencing long-term drought, windstorms can become dust storms, leading to massive erosion. The following table provides information related to county vulnerabilities; for jurisdictional-specific vulnerabilities, refer to *Section Seven: Participant Profiles.*

Table 59: County Severe Wind Vulnerabilities

Sector	Vulnerability
People	-Vulnerable populations include those living in mobile homes (especially if improperly anchored), nursing homes, schools, or in substandard housing -People outside during events -People living at higher elevations and hikers/climbers -Elderly with decreased mobility or poor hearing may be at higher risk -Lack of multiple ways to receive weather warnings, especially at night
Economic	-Agricultural losses to crops -Damages to businesses and prolonged power outages can cause impacts to the local economy -Delay flight schedules for airlines
Built Environment	-All building stock is at risk of damages. Roof and siding damage is most likely to occur
Infrastructure	-Downed power lines and power outages -Impassable roads due to debris blocking roadways
Community Lifelines	-Damage to critical buildings -Many critical buildings like fire stations, police stations, and governmental buildings are housed in older buildings that were not built to current codes and could see increased damages -Downed power lines and power outages -Loss of information systems -Impassable roads

Subsidence

Ground subsidence is the sinking of the land over human caused or natural underground voids and the settlement of native low-density soils. Natural causes of subsidence include the development of sinkholes, rock sliding downward along faults, natural sediment compaction, and melting of permafrost. Subsidence can occur gradually over time or virtually instantaneously. There are many different types of subsidence; however, in Colorado, there are three types of subsidence that warrant the most concern: settlement related to collapsing soils, sinkholes in karst areas, and ground subsidence over abandoned mines.

Collapsible soils are a group of soils that can rapidly settle or collapse the ground. The most common type of collapsible soil is hydrocompactive soil. These soils are low in density and in moisture content and are loosely packed together. Agents that bind these loosely packed particles together, such as clay and silk buttresses, are water sensitive. When water is introduced to these soils, the binding agents may quickly break down, soften, disperse, or dissolve. This results in a reorganization of the soil particles in a denser arrangement, which results in a net volume loss indicated by subsidence at the surface. Volume loss can by anywhere between 10%-15%, which can result in several feet of surface-level displacement.

Sinkholes in karst areas are related to the dissolution of evaporite minerals or limestone. Evaporite minerals dissolve in water and include gypsum and halite. Rocks containing limestone also form sinkholes based on dissolution by water. This dissolution of the rock creates caverns, open fissures, streams from bedrock, breccia pipes, subsidence sags, depressions, and sinkholes. Factors leading to the formation of sinkholes in these landscapes may be natural or may be induced by human activities. Natural factors include downward percolation of surface water or lateral movement of water within the water table. Human activities that may contribute include stream channel changes, irrigation ditches, land irrigation leaking, ponding of surface water, and mining of soluble materials by the forced circulation of water.

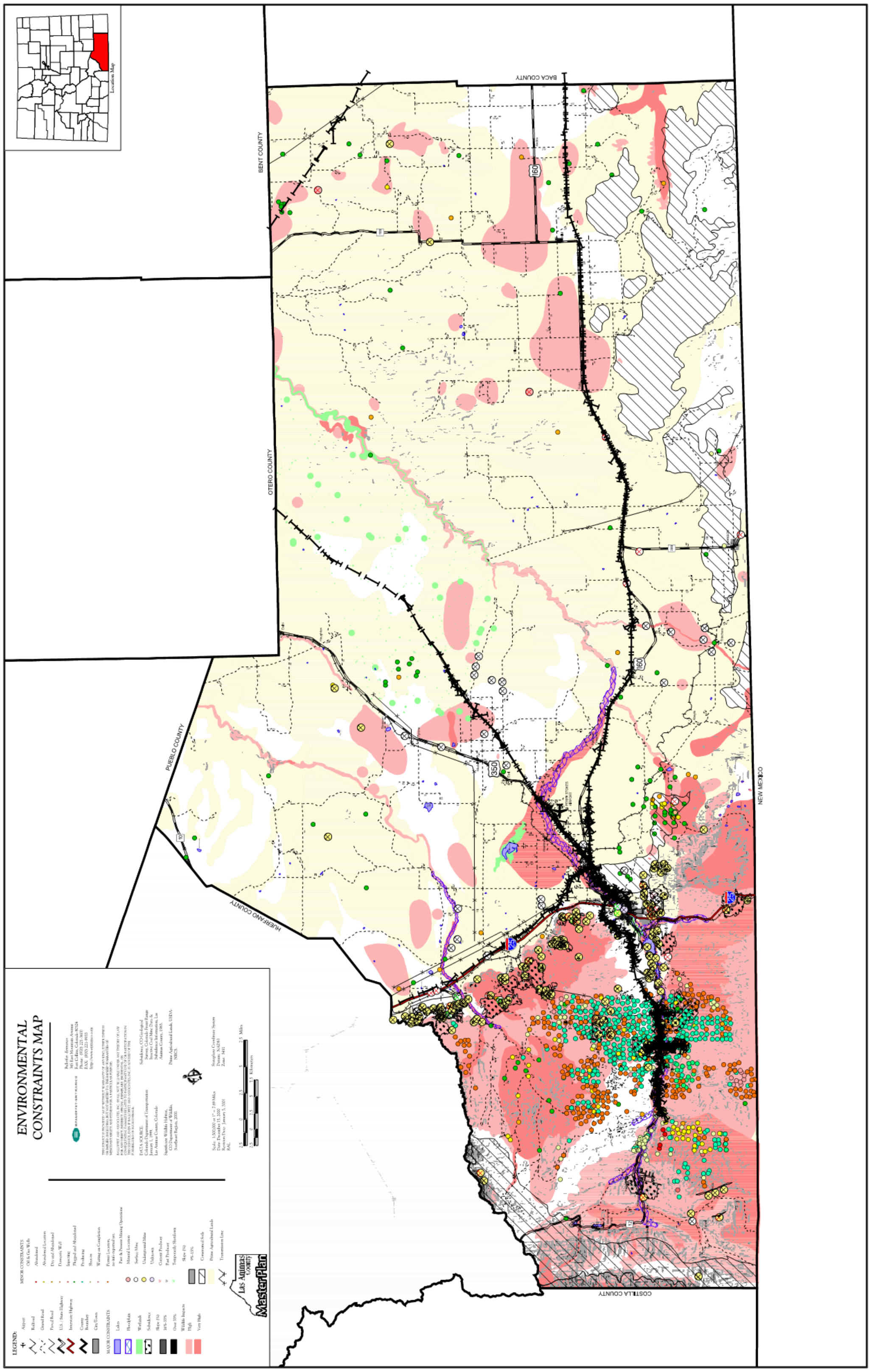
Abandoned mines subsidence are caused by the removal of minerals and rock that undermine underground support systems and lead to void spaces. These voids can then be affected by natural and man-made processes such as caving, changes in flowage, or changes in overlying rock and soil material resulting in collapse. Hazards from these abandoned sites are complicated by the fact that many “final mine maps” are inaccurate or incomplete. There are some mapped, known mine hazard areas in Las Animas County; however, it is likely that there are additional hazard areas for which no records exist.

Location

Las Animas County has put together an Environmental Constraints Map (Figure 38), in which the county has identified known subsidence areas (black dotted areas) and the location of underground mines (yellow circles with an “x”). Identified subsidence areas are located west of Interstate-25, around the Town of Starkville, and various locations in the western portion of the county. Underground mines are primarily located west of Interstate-25 and south of the City of Trinidad.

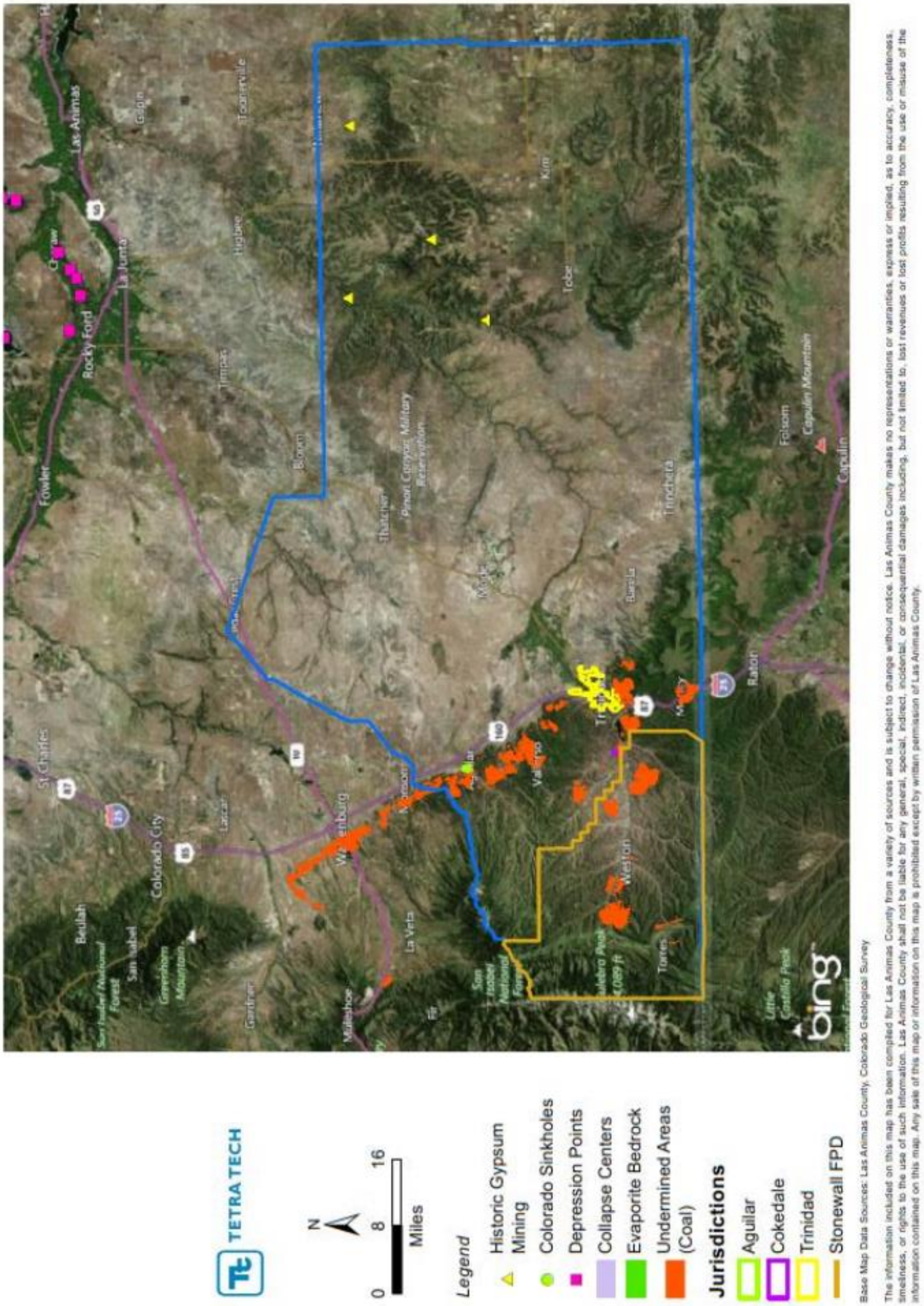
In the northeast corner of Las Animas County, there are areas of gypsum mining. Along the Interstate-25 corridor and locations west of Trinidad have undermined coal areas. Figure 39 shows the evaporative bedrock, historic gypsum mining, and undermined coal areas for the county.

Figure 38: Environmental Constraints Map



Source: Las Animas County

Figure 39: Evaporative Bedrock, Historic Gypsum Mining, and Undermined Coal Area



Source: 2017 Las Animas County Hazard Mitigation Plan

Extent
Although infrequent, subsidence may occur abruptly as dangerous ground openings that could swallow any part of a structure that happens to lie at that location or leave a dangerous steep-sided hole. According to the Colorado Geological Survey, merely an inch of differential subsidence beneath a residential structure can cause several thousand dollars of damage. There are many factors that affect the extent of a subsidence hazard. These may include the size of the mine, the susceptibility of the soil to collapse, and composition of the soil. Areas may appear to be free of subsidence for many years, and then undergo renewed gradual or even drastic subsidence.

Historical Occurrences
The Colorado Geological Survey did not identify any historical sinkhole or subsidence events in Las Animas. However, the local planning team from The Town of Cokedale identified several past sinkholes that have opened up in the Town's ballpark and on roadways. These sinkholes resulted in limited damages.

Average Annual Losses
With no historical reported subsidence events from the Colorado Geological Survey, the average annual losses for property and crops is $0.

Probability
Subsidence is a naturally occurring process that has occurred historically and will continue to do so across the county. Due to the lack of available historical occurrences, it is not currently possible to estimate annual probability.

Climate Change
It is likely that continued changes to the regional climate will lead to an increase in frequency and intensity of drought or rainfall/flash flooding events across the state. There are periods of heavy rain or prolonged dryness can impact the frequency of subsidence.[56] For the purposes of this plan, it is assumed that if current climate trends continue, it is probable that subsidence events will increase in frequency for Las Animas County.

Jurisdictional Top Hazard Status
The following table lists jurisdictions which identified subsidence as a top hazard of concern.

Jurisdictions	
Town of Cokedale	

Future Developments
Any future development will potentially intersect subsidence hazard areas. Avoidance is generally the best mitigation solution where subsidence areas are identified. Many older sinkholes may be hidden. Only subsurface inspections, either by investigative trenching, borings, and observation made during lot grading or utility installation, can ascertain whether sinkholes exist within a development area. Ground-modification and structural solutions can help mitigate the threat of localized subsidence. Drainage issues and proper water management are also important.

56 USGS. December 21, 2016. "Drought Impacts." Accessed November 2021. https://ca.water.usgs.gov/data/drought/drought-impact.html.

County Vulnerabilities

The following table provides information related to county vulnerabilities; for jurisdictional-specific vulnerabilities, refer to *Section Seven: Participant Profiles.*

Table 60: County Subsidence Vulnerabilities

Sector	Vulnerability
People	-Residents living or traveling in areas prone to subsidence are at risk of injury -First responders performing duties after a site is impacted and unstable
Economic	-Limited due to losses of facilities or infrastructure function
Built Environment	-Localized damage to building foundations -Condemnation of damaged structures
Infrastructure	-Settling and damage to roadways -Structural damage to underground utilities and pipelines
Community Lifelines	-Damage to critical buildings -Damage to roadways -Structural damage to underground utilities and pipelines

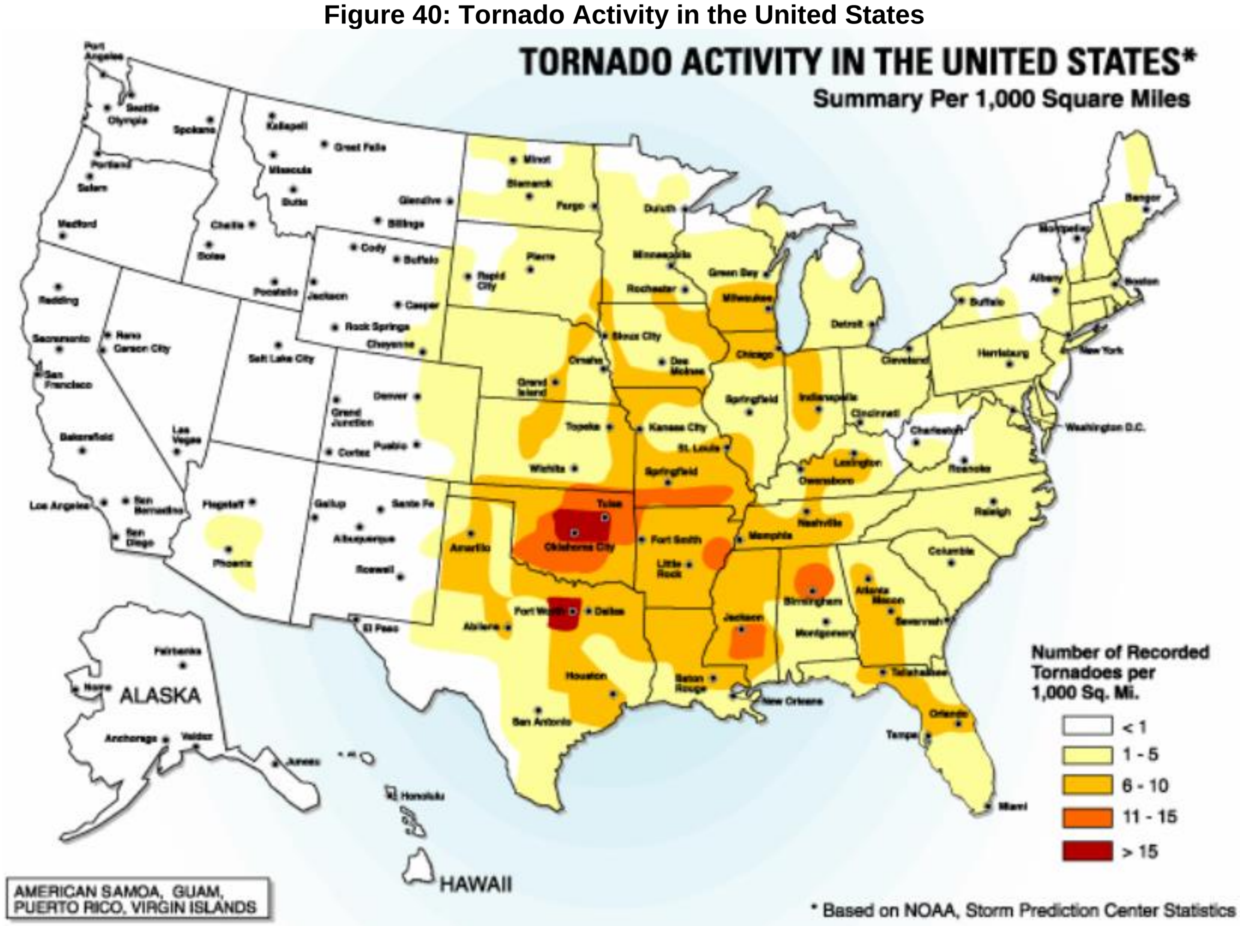
Tornadoes

A tornado is a narrow, violently rotating column of air that extends from the base of a cumulonimbus cloud to the ground. The visible sign of a tornado is the dust and debris that is caught in the rotating column made up of water droplets. For a rotation to be classified as a tornado, three characteristics must be met:

- There must be a microscale rotating area of wind, ranging in size from a few feet to a few miles wide;
- The rotating wind, or vortex, must be attached to a convective cloud base and must be in contact with the ground; and,
- The spinning vortex of air must have caused enough damage to be classified by the Fujita Scale as a tornado.

Once tornadoes are formed, they can be extremely violent and destructive. They have been recorded all over the world but are most prevalent in the American Midwest and South, in an area known as “Tornado Alley.” Tornadoes can travel distances over 100 miles and reach over 11 miles above ground. Tornadoes usually stay on the ground no more than 20 minutes.

Figure 40: Tornado Activity in the United States

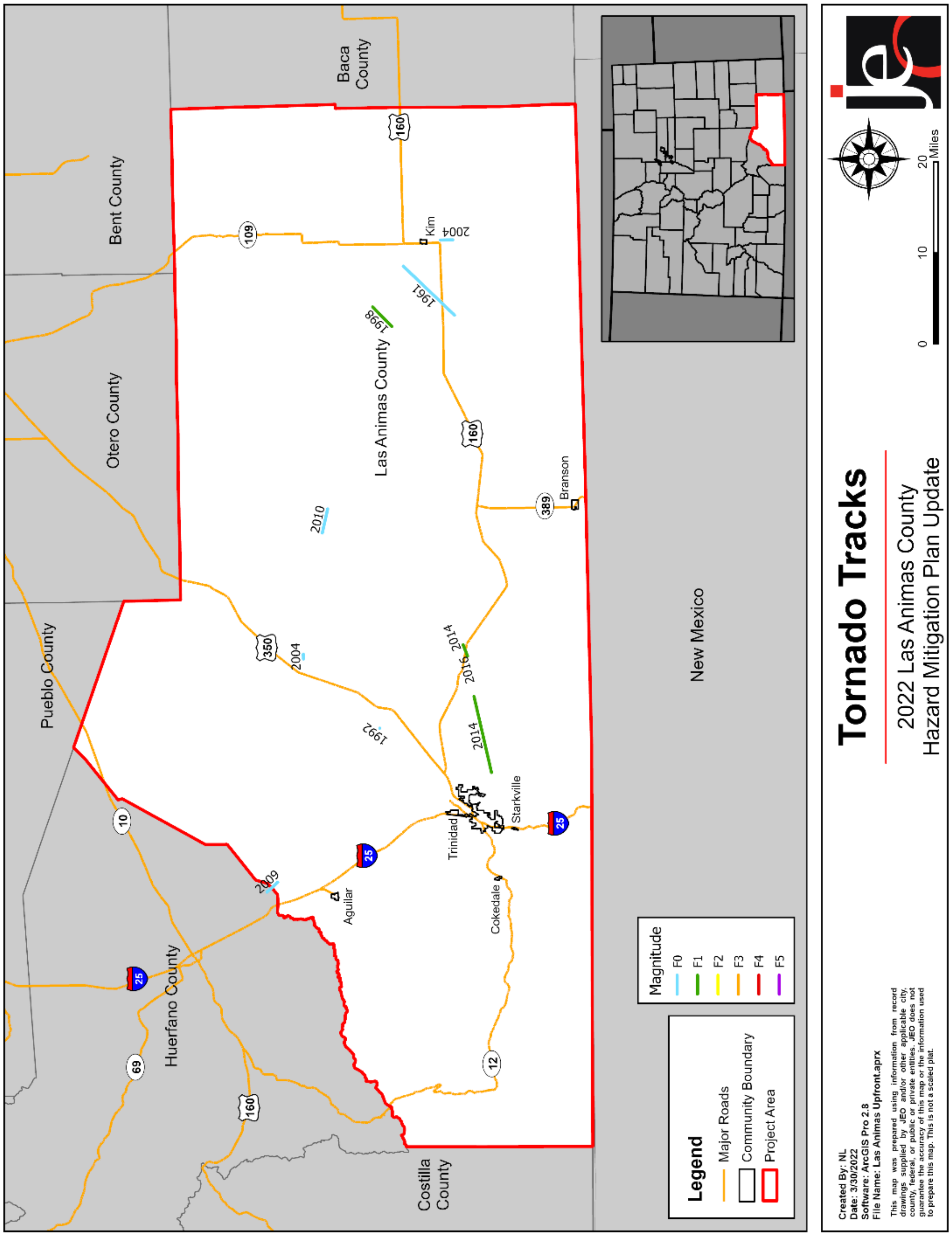


Source: FEMA

Location

The following map shows the historical track locations across the region according to the Midwestern Regional Climate Center. Tornadoes are more likely to occur at lower elevations in the eastern portion of the county. The impacts would be greater in more densely populated areas, such as in the City of Trinidad.

Figure 41: Tornado Tracks in the County



Extent

The Enhanced Fujita Scale replaced the Fujita Scale in 2007. The Enhanced Fujita Scale does not measure tornadoes by their size or width, but rather the amount of damage caused to human-built structures and trees after the event. The official rating category provides a common benchmark that allows comparisons to be made between different tornadoes. The enhanced scale classifies EF0-EF5 damage as determined by engineers and meteorologists across 28 different types of damage indicators, including different types of building and tree damage. To establish a rating, engineers and meteorologists examine the damage, analyze the ground-swirl patterns, review damage imagery, collect media reports, and sometimes utilize photogrammetry and videogrammetry. Based on the most severe damage to any well-built frame house, or any comparable damage as determined by an engineer, an EF-Scale number is assigned to the tornado. The following tables summarize the Enhanced Fujita Scale and damage indicators.

Table 61: Enhanced Fujita Scale

Storm Category	3 Second Gust (mph)	Damage Level	Damage Description
EF0	65-85	Gale	Some damages to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages to sign board
EF1	86-110	Weak	The lower limit is the beginning of hurricane wind speed; peels surface off rooms; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages might be destroyed
EF2	110-135	Strong	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.
EF3	136-165	Severe	Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted.
EF4	166-200	Devastating	Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown, and large missiles generated.
EF5	200+	Incredible	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 re-enforced concrete structures badly damaged.
EF No Rating	--	Inconceivable	Should a tornado with the maximum wind speed in excess of EF5 occur, the extent and types of damage may not be conceived. A number of missiles such as iceboxes, water heaters, storage tanks, automobiles, etc. will create serious secondary damage on structures.

Source: NOAA; FEMA

Table 62: Enhanced Fujita Scale Damage Indicator

Number	Damage Indicator	Number	Damage Indicator
1	Small barns, farm outbuildings	**15**	School – 1 story elementary (interior or exterior halls)
2	One- or two-family residences	**16**	School – Junior or Senior high school
3	Single-wide mobile homes (MHSW)	**17**	Low-rise (1-4 story) buildings
4	Double-wide mobile homes (MHDW)	**18**	Mid-rise (5-20 story) buildings
5	Apartment, condo, townhouse (3 stories or less)	**19**	High-rise (over 20 stories)
6	Motel	**20**	Institutional buildings (hospital, government, or university)
7	Masonry apartment or motel	**21**	Metal building systems
8	Small retail buildings (fast food)	**22**	Service station canopy
9	Small professional (doctor office, branch bank)	**23**	Warehouse (tilt-up walls or heavy timber)
10	Strip mall	**24**	Transmission line tower
11	Large shopping mall	**25**	Free-standing tower
12	Large, isolated (“big box”) retail building	**26**	Free standing pole (light, flag, luminary)
13	Automobile showroom	**27**	Tree- hardwood
14	Automotive service building	**28**	Tree -softwood

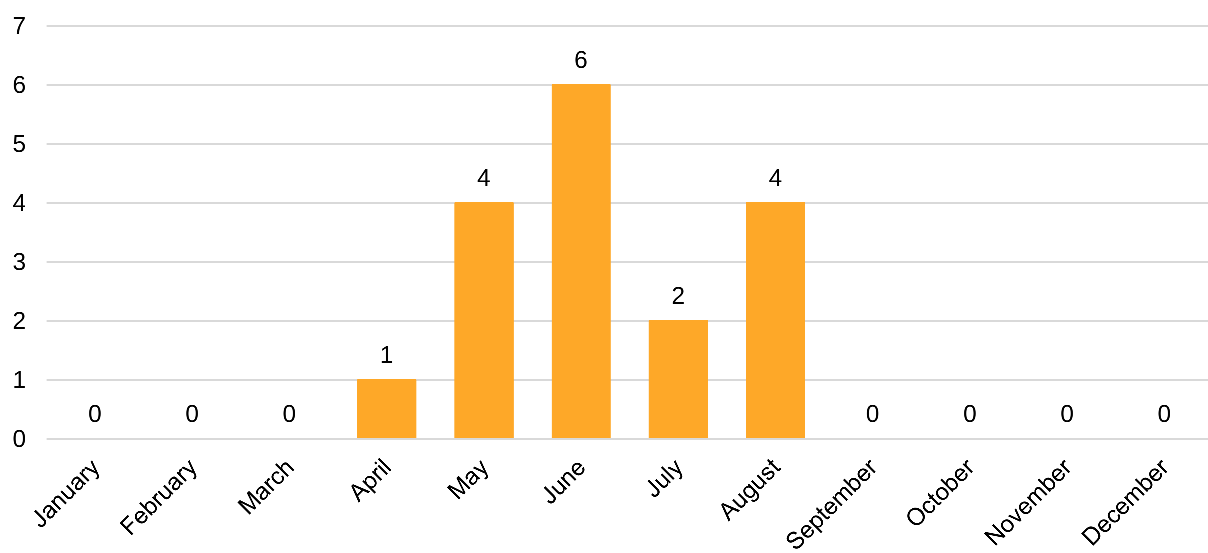
Source: NOAA; FEMA

Based on the historical record, it is most likely that tornadoes that occur within the county will be of EF0 strength. Of the 17 reported tornado events, 14 were EF/F0 and three were EF/F1.

Historical Occurrences

NCEI data between January 1996 and June 2021 show 17 tornadic events ranging in magnitude from EF/F0 to EF/F1. These events were responsible for $43,000 in property damages (NCEI), $0 in crop damages (SHELDUS) and one injury. As seen in the following figures, most tornado events occur in the late spring and summer. Significant hazard events with direct impacts to communities are discussed in more detail in the applicable *Community Profiles.*

Figure 42: Tornadoes by Month in Las Animas County



Source: NCEI, 1996-June 2021

Average Annual Losses

The annual average property loss estimate was determined based upon NCEI Storm Events Database since 1996 and the annual average crop damage was determined based upon SHELDUS data between 1960 and 2018. This does not include losses from displacement, functional downtime, economic loss, injury or loss of life. It is estimated that tornado events can cause an average of $1,654 per year in property damages.

Table 63: Tornado Losses

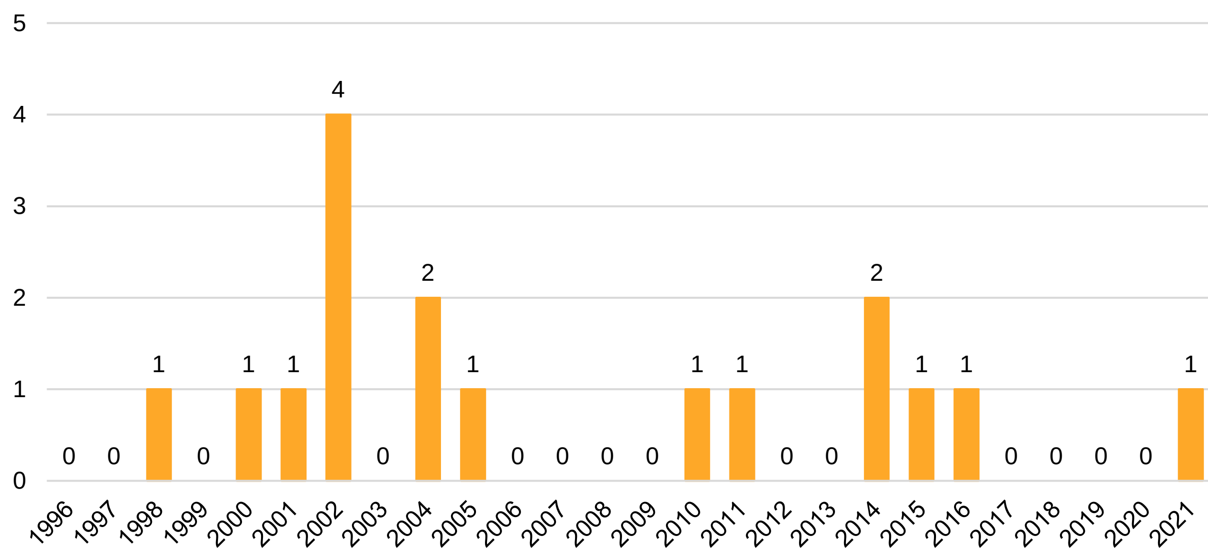
Hazard Type	# of Events[1]	Average # events per year	Total Property Loss[1]	Average Annual Property Loss	Total Crop Loss[2]	Average Annual Crop Loss
Tornadoes	17	0.7	$43,000	$1,654	$0	$0

Source: 1 NCEI (1996-June 2021), 2 SHELDUS (1960-2018)

Probability

Given the historic record of occurrence for tornado events (12 out of 26 years with reported events), for the purposes of this plan, the annual probability of tornado occurrence is 46%. Figure 43 shows tornado events broken down by year.

Figure 43: Tornado Events by Year



Source: NCEI, 1996-June 2021

Climate Change

Climate change impacts on the frequency and severity of tornadoes are unclear. It is likely that a warmer climate with moisture changes could allow for more frequent instability and an increase in severe weather events.

Jurisdictional Top Hazard Status

The following table lists jurisdictions which identified tornadoes as a top hazard of concern.

Jurisdictions	
Town of Kim	Kim Reorganized 88

Future Development

Development at lower elevations will be particularly vulnerable to tornadoes. Development regulations that require safe rooms, basements, warning sirens, or other structures that reduce risk to people would decrease vulnerability. Tornadoes that cause a lot of damage are uncommon in the county, so mandatory regulations may not be cost-effective.

According to the 2018-2023 Colorado Enhanced Hazard Mitigation Plan, Las Animas County's exposure rating incorporating growth (2010-2030) is slight. This takes into account projected population change and combined risk (deaths/injuries and number of tornado events).

County Vulnerabilities

Prior notification is vital the safety and response of individuals. As there are no tornado sirens in the county, many people will have to rely on text notifications, phone applications, radio, and television for prior notification. The following table provides information related to county vulnerabilities; for jurisdictional-specific vulnerabilities, refer to *Section Seven: Participant Profiles.*

Table 64: County Tornadoes Vulnerabilities

Sector	Vulnerability
People	-Vulnerable populations include those living in mobile homes (especially if improperly anchored), nursing homes, schools, or in substandard housing -People outside during events -Residents living in areas that isolated from major roads -Citizens without access to shelter below ground or in reinforced rooms -Elderly with decreased mobility or poor hearing may be at higher risk -Lack of multiple ways to receive weather warnings or those that speak a different language
Economic	-Agricultural losses to both crops and livestock -Damages to businesses and prolonged power outages can cause significant impacts to the local economy
Built Environment	-All building stock is at risk of significant damages
Infrastructure	-Downed power lines and power outages -All above ground infrastructure at risk to damages -Impassable roads due to debris blocking roadways
Community Lifelines	-Risk of significant damages to critical buildings -Downed power lines and power outages -Loss of information systems -All above ground infrastructure at risk to damages -Impassible roads due to debris blocking roadways

Wildfires

Wildfires, also known as grassfires, brushfires, forest fires, or wildland fires, are any fires occurring on wildlands that require response. Wildfires range in size from a few acres to thousands of acres in some cases. Fire events can rapidly spread from their original source, change direction quickly, and jump gaps (such as roads, rivers, and fire breaks). Wildfire events are particularly dependent on the local conditions including temperature, humidity, wind speed, wind direction, slope, and available fuel load. While some wildfires burn in remote forested regions, others can cause extensive destruction of homes and other property located in the wildland-urban interface (WUI), the zone of transition between developed areas and undeveloped wilderness. The wildfire hazard is often characterized by an increased fire risk in the WUI where homes and other structures are built into a densely forested or natural landscape. Figure 44 shows the WUI map for the county.

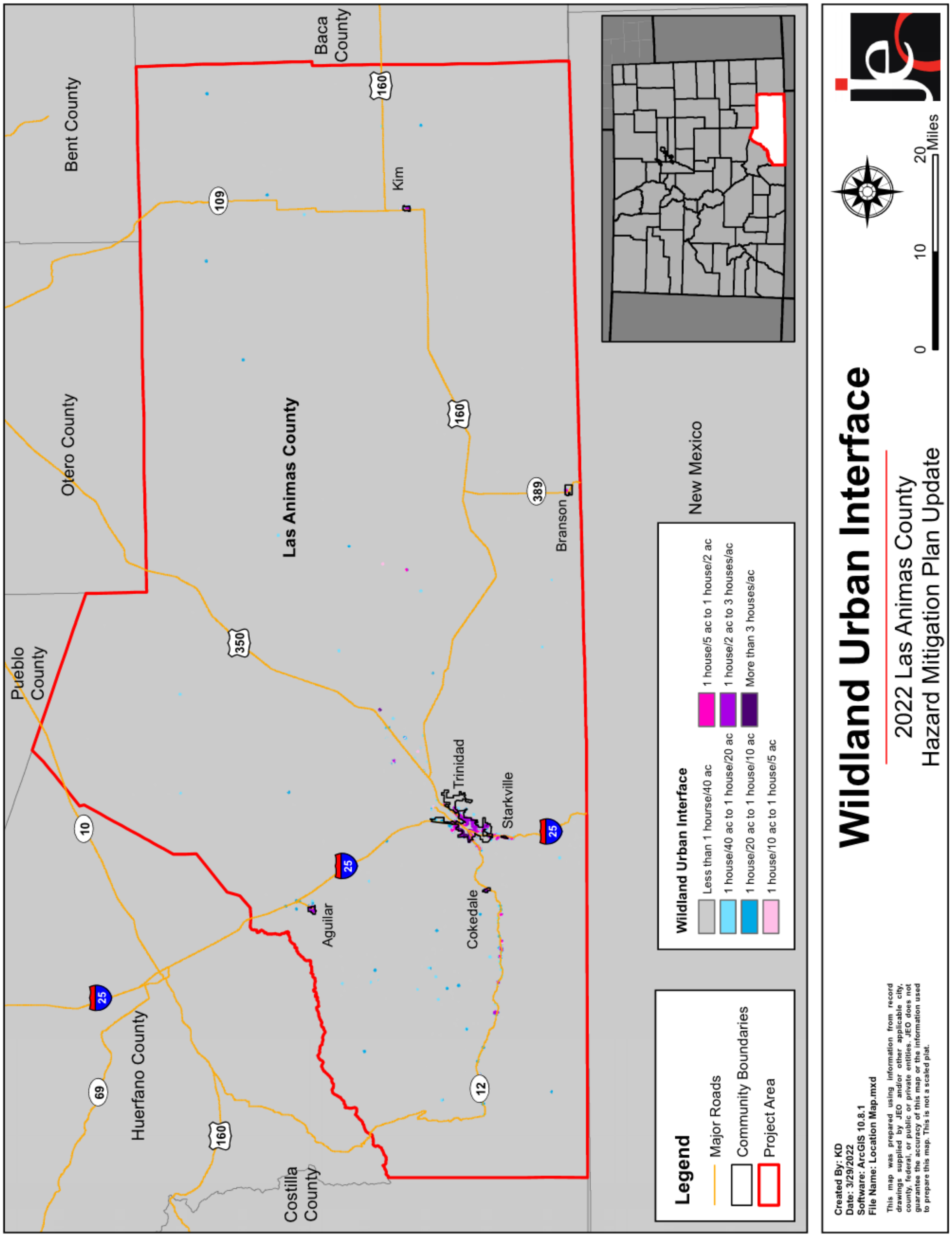
There are three categories of interface fire:

- The classic wildland-urban interface exists where well-defined urban and suburban development presses up against open expanses of wildland areas;
- The mixed wildland-urban interface is characterized by isolated homes, subdivisions, small communities situated predominantly in wildland settings; and
- The occluded wildland-urban interface exists where islands of wildland vegetation occur inside a largely urbanized area.

Certain conditions must be present for significant interface fires to occur. The most common are: hot, dry, and windy weather; the inability of fire protection forces to contain or suppress the fire; the occurrence of multiple fires that overwhelm committed resources; and a large fuel load (dense vegetation). Once a fire has started, other conditions influence its behavior, including fuel, topography, weather, drought, and development. Although wildfire is a natural and often beneficial process, long-term fire suppression can also lead to more severe fires due to the buildup of vegetation, which creates more fuel and increases the intensity and devastation of future fires.

Las Animas County experiences an increased fire risk seasonally, typically April through October. Lightning is the primary source of ignition; secondary causes include human caused ignitions. County-wide, primary fuel sources are ponderosa pine, spruce-fir, pinyon-juniper, grassland, and dead trees from insect infestation. Fuel and structure location are the primary factors people can control and are the target of most mitigation efforts.

Figure 44: Wildland Urban Interface



Fire Protection

There are nine fire protection districts located in Las Animas County. These include the following list.

- Bon Carbo Spanish Peaks Fire Protection District
- Branson Fire Protection District
- City of Trinidad Fire Protection District
- Cokedale Fire Department
- Fishers Peak Fire Protection District
- Hoehne Fire Protection District
- Kim Fire Protection District
- Pinon Fire Protection District
- Stonewall Fire Protection District

Firewise USA

Firewise USA is a national recognition program that provides resources to inform communities how to adapt to living with wildfire and encourages neighbors to take action together to reduce their wildfire risk. Colorado communities that take the following five steps can be recognized as Firewise.

1. Form a Firewise board or committee.
2. Obtain a wildfire risk assessment from Colorado State Forest Service or local fire department and create an action plan.
3. Hold a Firewise event once per year.
4. Invest a minimum of $24.14 per dwelling unit in local Firewise actions annually.
5. Create a National Fire Prevention Association profile.

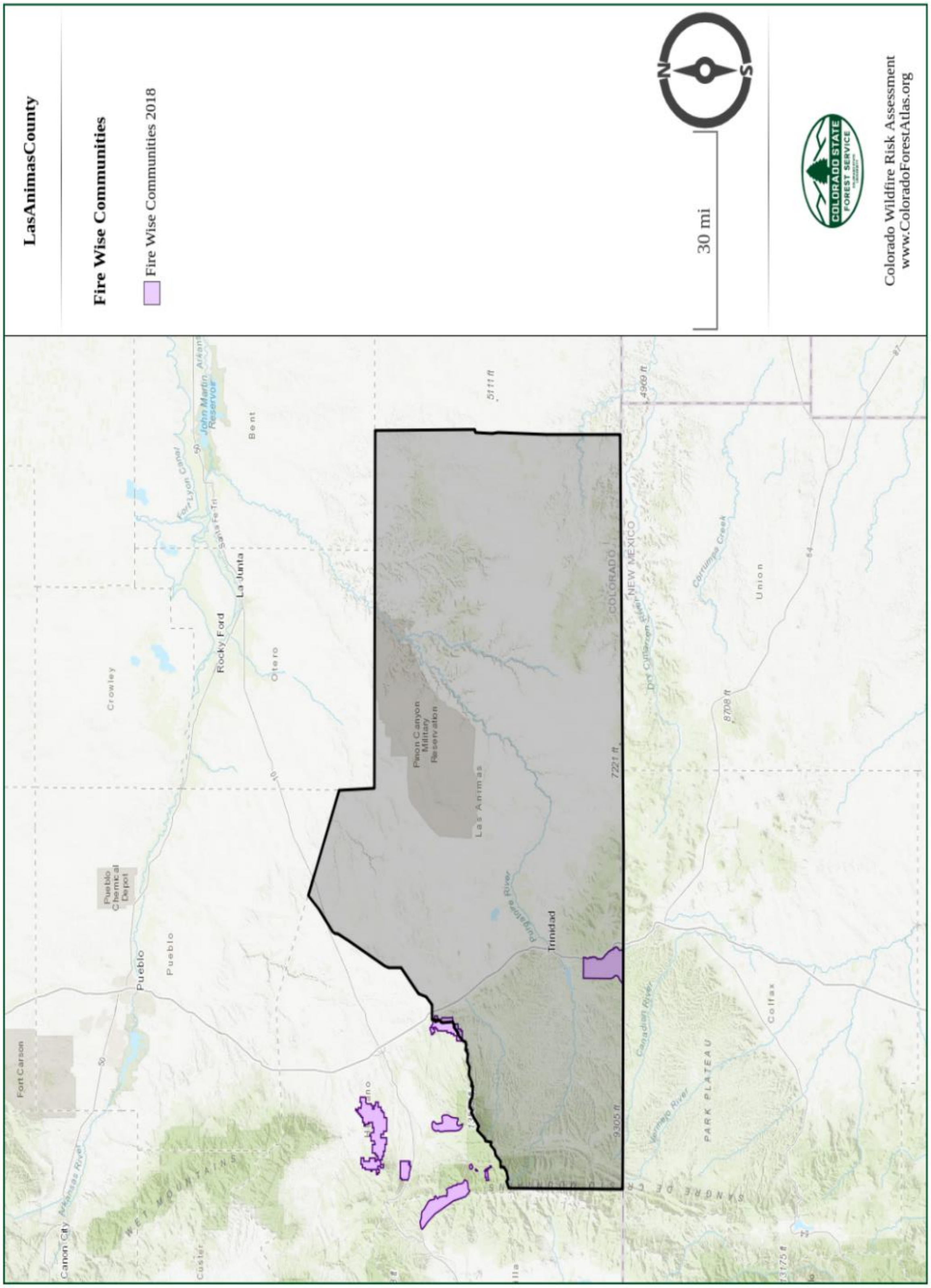
Two areas in Las Animas County have been recognized as Firewise: Santa Fe Trails Ranch and Blackhawk Ranch.[57] Figure 45 shows the locations of these areas.

Community Wildfire Protection Plans

Even though wildfires are a natural part of the ecosystem, they can present a substantial hazard to life and property, especially along the WUI. Las Animas County has three Community Wildfire Protection Plans (CWPPs): Santa Fe Trail CWPP, Spirit Mountain Ranch CWPP, and Stonewall Fire Protection District CWPP. The CWPPs summarize the current state of fire prevention, preparedness, and suppression in the plan areas; identify and prioritize areas most at risk of WUI fires; present strategies for appropriate fire response; and identify mitigation actions.

57 Colorado State Forest Service. 2017. “2017 Colorado Wildfire Risk Assessment Summary Report”.

Figure 45: Firewise Communities



Source: Colorado State Forest Service[58]

58 Colorado State Forest Service. 2017. "2017 Colorado Wildfire Risk Assessment Summary Report".

Location

Wildfires can occur throughout the county. GIS data and wildfire occurrence data was collected from the Colorado State Forest Service's (CSFS) Wildfire Risk Assessment Summary Report. Included the report is wildfire risk for Las Animas County shown in Table 65 and Figure 46. Most of the county's wildfire risk is located in the western portion of the county.

Table 65: Las Animas County Wildfire Risk

Wildfire Risk Class	Acres	Percent of Land Area
Non-Burnable	62,790	2.1%
Lowest Risk	2,577,361	84.4%
Low Risk	353,868	11.6%
Moderate Risk	60,477	2.0%
High Risk	24	0.1%
Highest Risk	0	0.0%

Source: Colorado State Forest Service[59]

Table 66 and Figure 47 show the difficulty or relative cost to suppress a fire given the terrain and vegetation conditions that may impact machine operability. Suppression difficulty in the county is highest in the western portion and along rivers and creeks.

Table 66: Las Animas County Wildfire Suppression Difficulty Rating

Suppression Difficulty Rating Class	Acres	Percent of Land Area
No Limitations	1,924,805	63.1%
Slight	254,495	8.3%
Slight to Moderate	269,118	8.8%
Moderate	192,563	6.3%
Moderate to Significant	137,812	4.5%
Significant	62,649	2.1%
Significant to Severe	102,268	3.4%
Severe	61,407	2.0%
Inoperable	46,755	1.5%

Source: Colorado State Forest Service[60]

59 Colorado State Forest Service. 2017. "2017 Colorado Wildfire Risk Assessment Summary Report".
60 Colorado State Forest Service. 2017. "2017 Colorado Wildfire Risk Assessment Summary Report".

Figure 46: Las Animas County Wildfire Risk

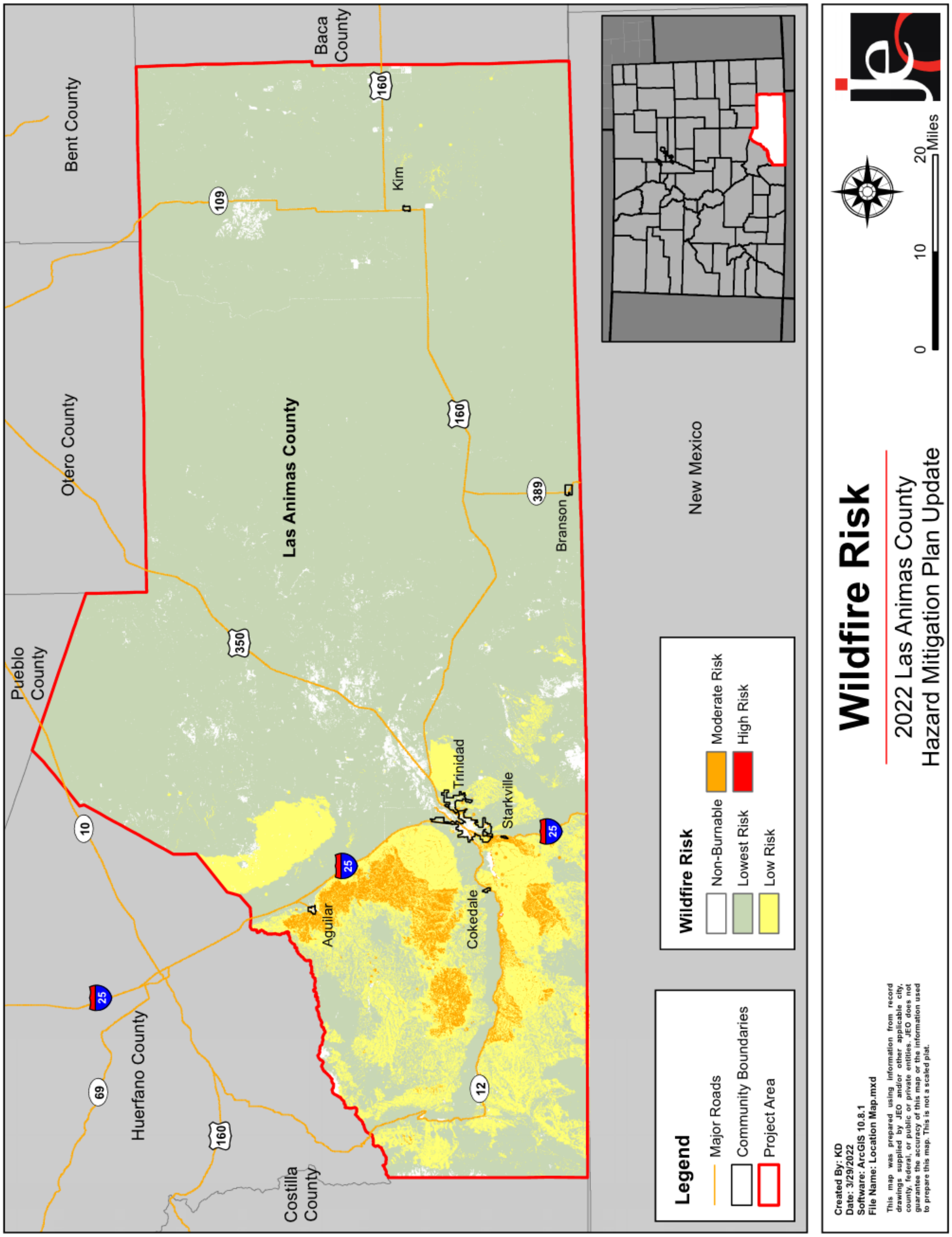
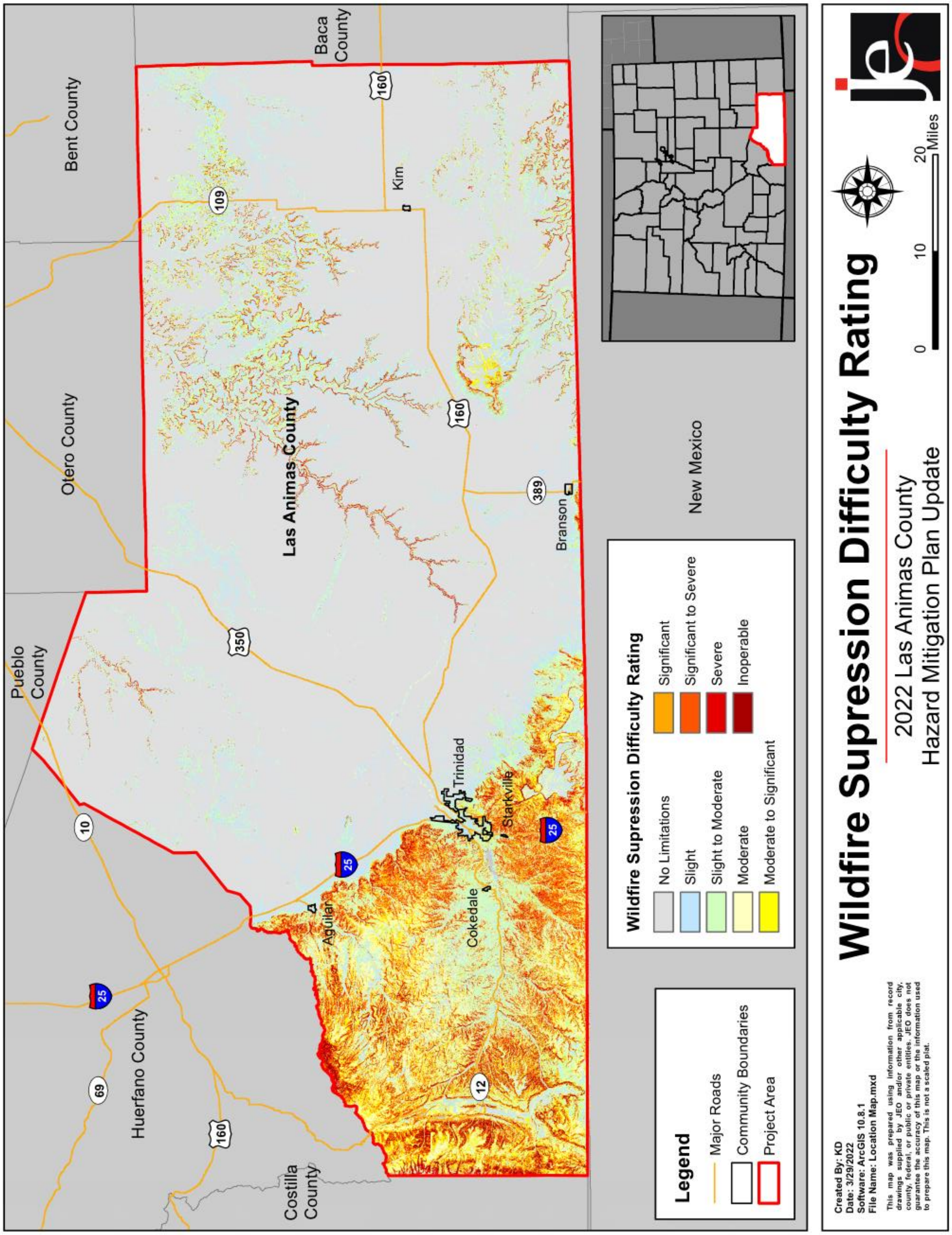


Figure 47: Las Animas County Wildfire Suppression Difficulty Rating



Extent

The Fire Intensity Scale (FIS) identifies areas where significant fuel hazard and associated dangerous fire behavior potential exist. FIS consist of five classes where the order of magnitude between classes is ten-fold. The five different classes are shown below.

Table 67: Fire Intensity Scale

Class	Intensity	Description
Class 1	Lowest Intensity	Very small, discontinuous flames, usually less than 1 foot in length; very low rate of spread; no spotting. Fires are typically easy to suppress by firefighters with basic training and non-specialized equipment.
Class 2	Low Intensity	Small flames, usually less than 2 feet long; small amount of very short-range spotting possible. Fires are easy to suppress by trained firefighters with protective equipment and specialized tools.
Class 3	Moderate Intensity	Flames up to 8 feet in length; short-range spotting is possible. Trained firefighters will find these fires difficult to suppress without support from aircraft or engines, but dozer and plows are generally effective. Increasing potential for harm or damage to life and property.
Class 4	High Intensity	Large flames; up to 30 feet in length; short-range spotting common; medium range spotting possible. Direct attack by trained firefighters, engines, and dozers is generally ineffective, indirect attack may be effective.
Class 5	Highest Intensity	Very large flames up to 150 feet in length; profuse short-range spotting, frequent long-range spotting; strong fire-induced winds. Indirect attack marginally effective at the head of the fire. Great potential for harm or damage to life and property.

Source: Colorado State Forest Service

The average wildfire in Las Animas County burned 454 acres. Of the reported, over 61 percent burned less than one acre. Less than nine percent of recorded fires burned more than 100 acres.

Wildfire also contributes to an increased risk from other hazard events, compounding damages and straining resources. FEMA has provided additional information in recent years detailing the relationship between wildfire and flooding (Figure 49). Wildfire events remove vegetation and harden soil, reducing infiltration capabilities during heavy rain events. Subsequent severe storms that bring heavy precipitation can then escalate into flash flooding, dealing additional damage to jurisdictions.

Figure 48: Las Animas County Fire Intensity Scale

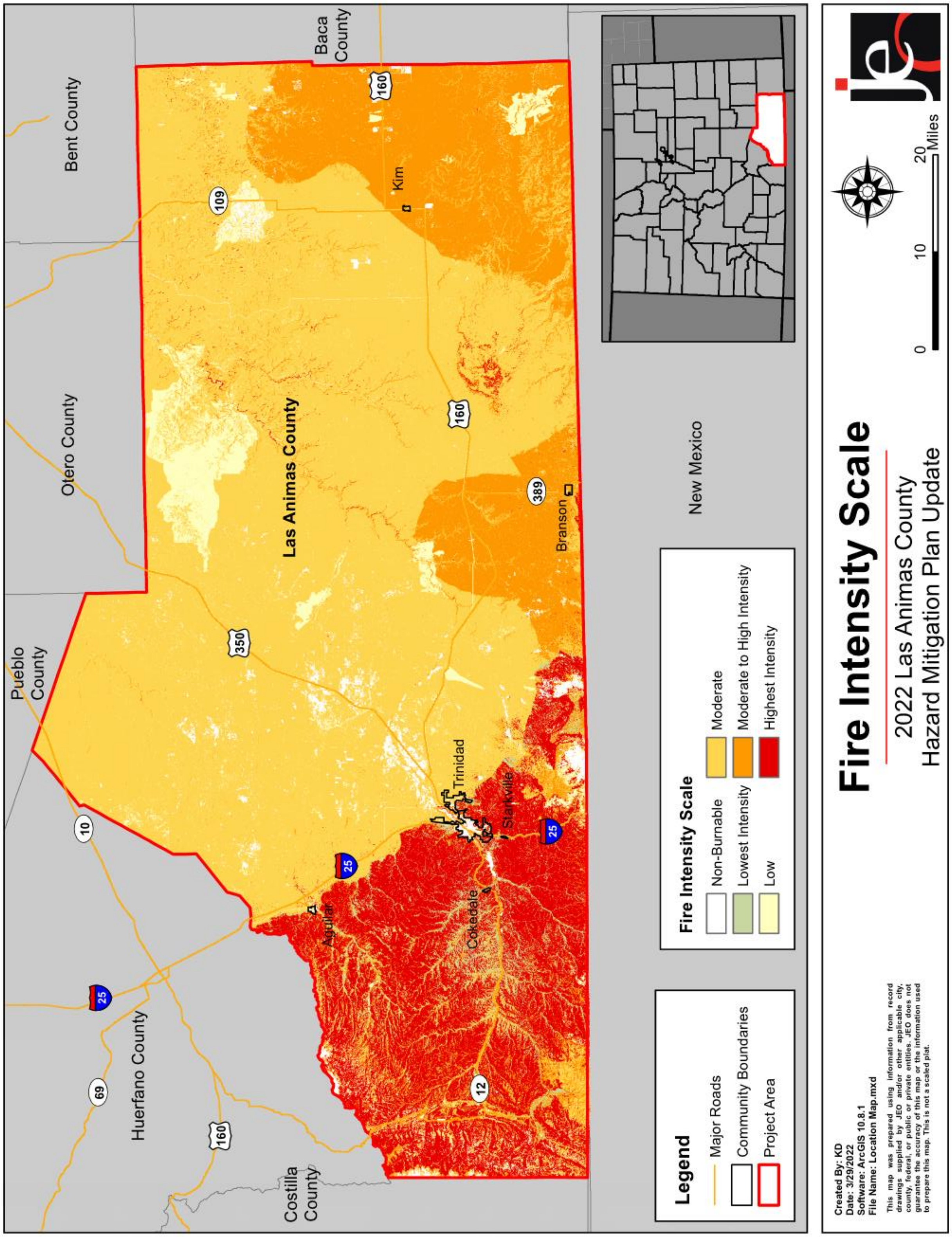
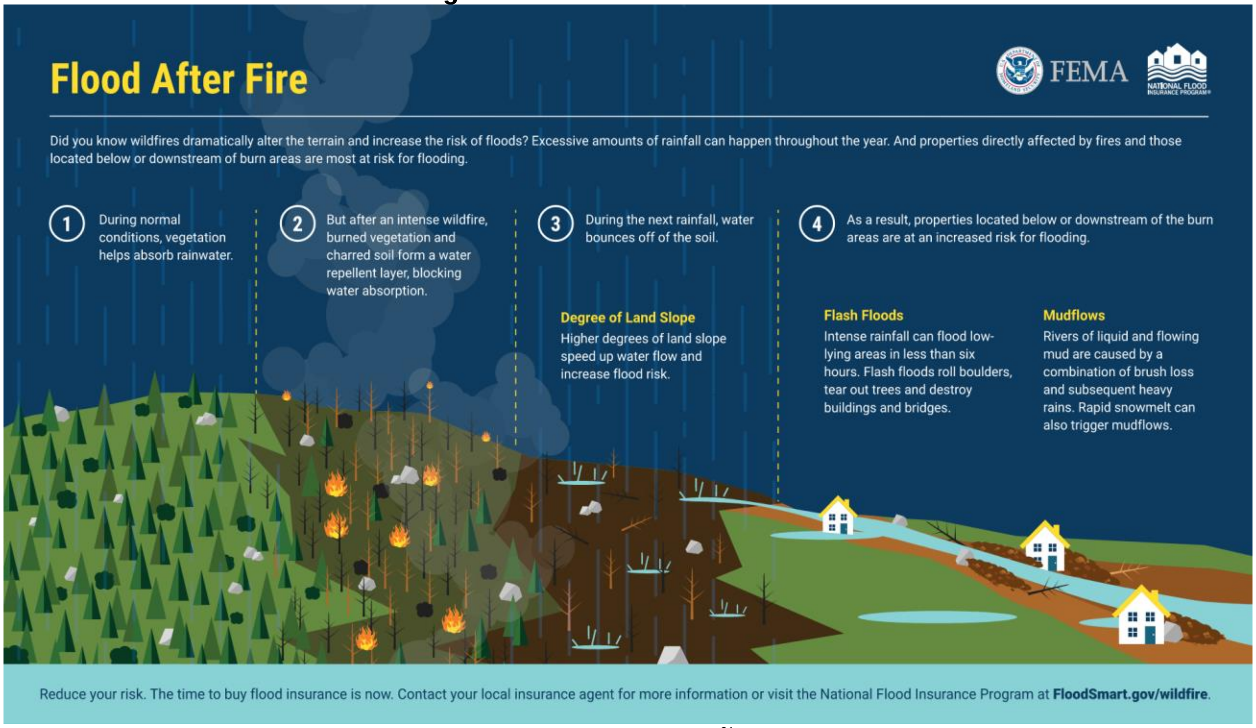


Figure 49: FEMA Flood After Fire

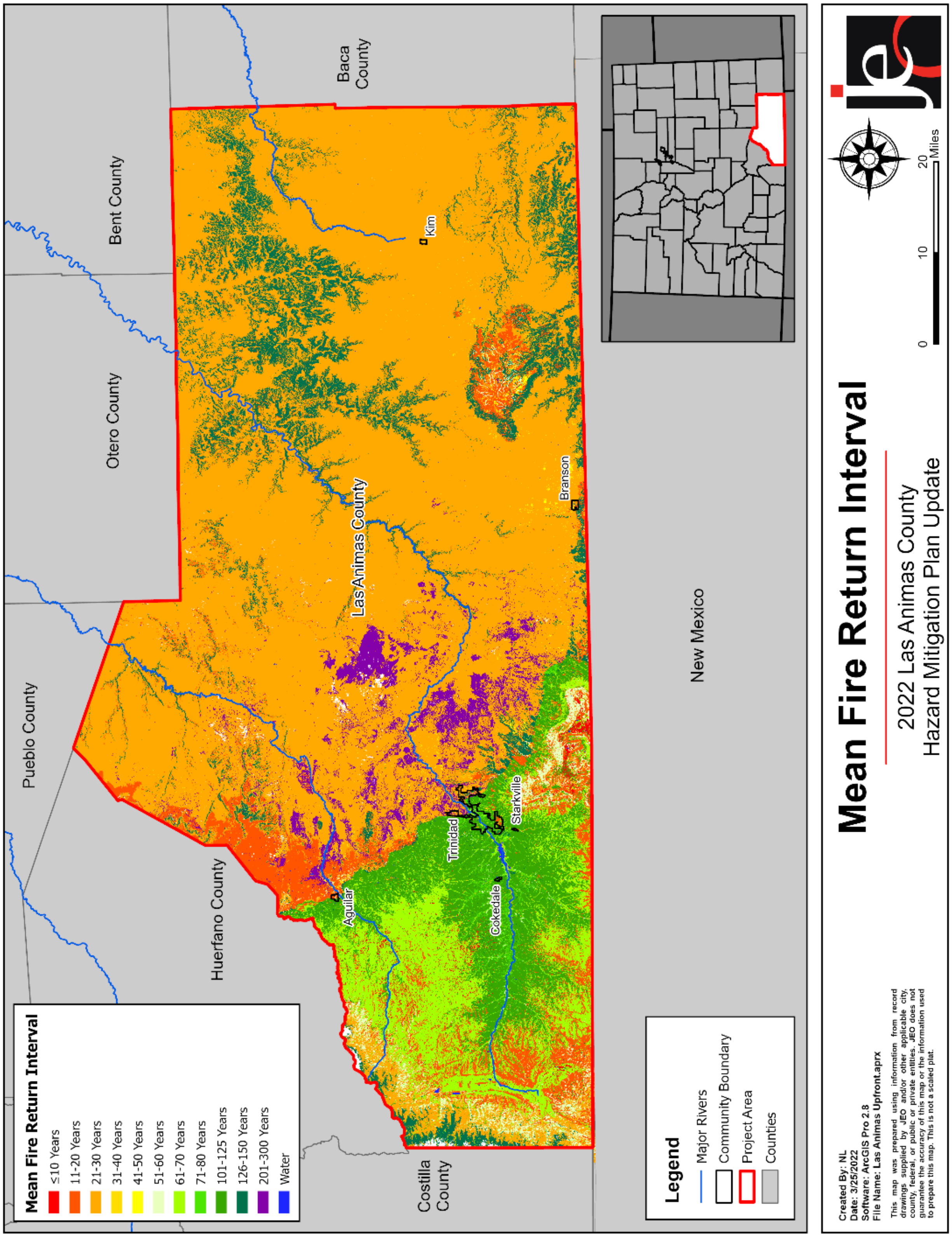


Source: FEMA, 2020[61]

Figure 50 shows the USGS' Mean Fire Return Interval. This model considers a variety of factors, including landscape, fire dynamics, fire spread, fire effects, and spatial context. These values show how often fires occur under natural conditions.

61 FEMA and NFIP. 2020. "Flood After Fire." Accessed September 2020. https://www.fema.gov/media-library-data/1573670012259-3908ab0344ff8fbf5d537ee0c6fb531d/101844-019_FEMA_FAF_Infographic-ENG-web_v8_508.pdf.

Figure 50: Mean Fire Return Interval



Historical Occurrences

Las Animas County is a fire-prone area with many fire events occurring annually; however, it is important to note that there is no comprehensive fire event database. Fire events, magnitude, and local responses were reported voluntarily by local fire departments and local reporting standards can vary between departments. Actual fire events and their impacts are likely underreported in the available data.

According to data available from the Colorado State Forest Service, 759 wildfire events have been reported in Las Animas County between 1992 and 2017 (Figure 51). In this time frame, Las Animas County averaged approximately 29 fires per year. The average fire size was 454 acres with events ranging from less than one acre to 45,000 acres. Six injuries were reported from these events. While most fires are relatively insignificant in terms of size and fire intensity, several high-intensity fires have not only burned thousands of acres but also posed significant threats to structures or other human developments.

<u>June 2-14, 2002: Trinidad Complex Fire</u>
This fire was caused by lightning and burned 17,295 acres resulting in six injuries.

<u>January 2006: Mauricio Canyon Fire</u>
Burned 3,825 acres and destroyed five homes southwest of Aguilar. This wind-driven fire made a five-mile run in two hours during extremely windy conditions.

<u>June 8 – July 9, 2008: Bridger Fire</u>
A lightning caused fire burned 45,800 acres at the Pinon Canyon Maneuver Site. Three structures were lost.

<u>June 5-21, 2011: Bear Springs/Callie Marie Fires</u>
Burned 44,662 acres at the Pinon Canyon Maneuver Site and five structures were lost. Lightning caused the fire.

<u>June 7-17, 2011: Shell Complex Fire</u>
Burned 13,312 acres 15 miles north of the Town of Kim and seven structures were lost. Lightning caused the fire.

<u>June 12-18, 2011: Track Fire</u>
Burned 27,792 acres and destroyed 11 structures along the New Mexico/Colorado border. This was a human caused fire.

<u>May 9-17, 2018: Stateline Fire</u>
This fire started in New Mexico and burned into the southwest corner of Las Animas County. Over 28,000 acres were burned with an estimated 10,750 acers in Colorado.

<u>May 20-25, 2020: Cherry Canyon Fire</u>
Burned 11,818 acres near the Purgatoire River about 10 miles west of Kim.

Figure 51: Wildfire Occurrences in the County

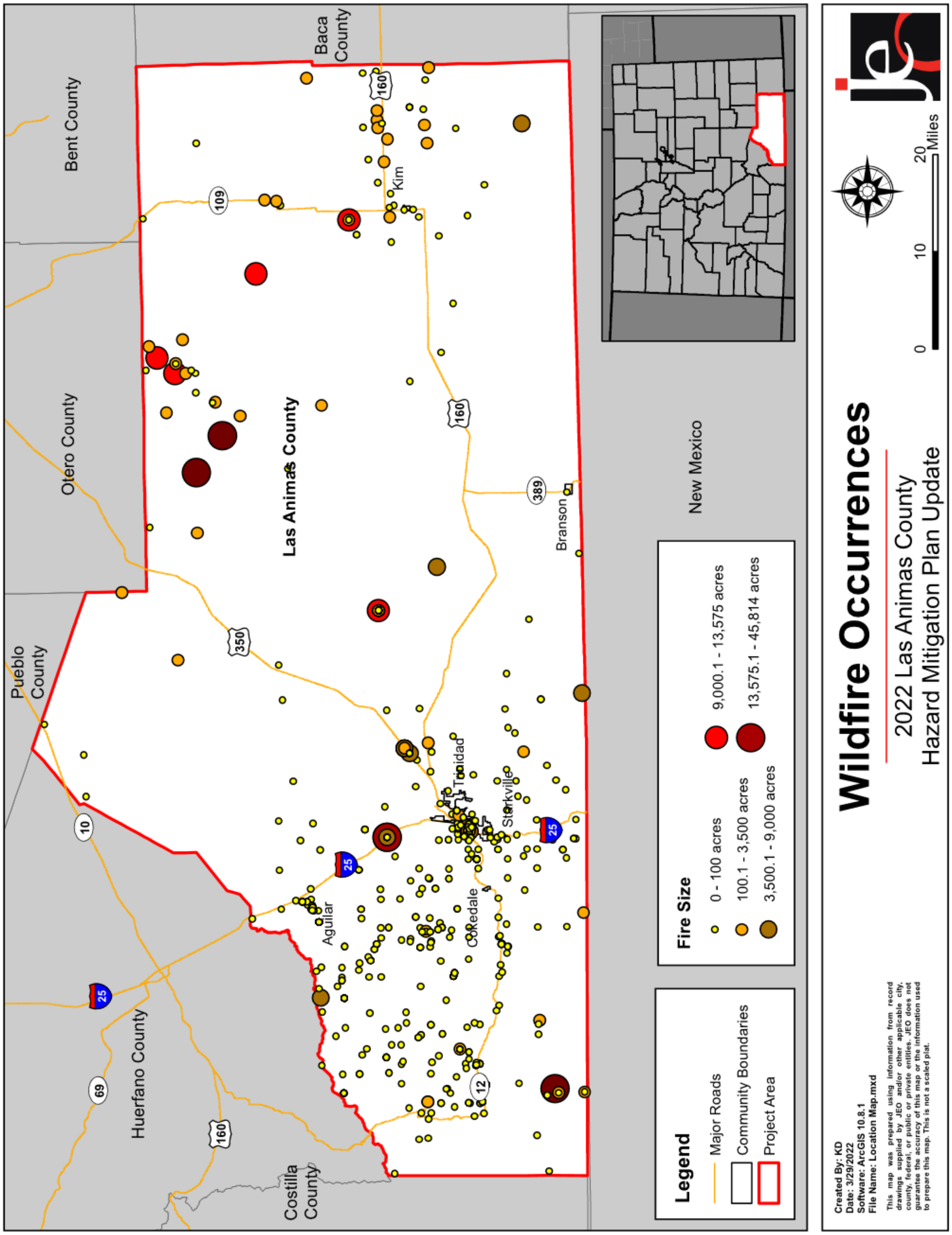


Figure 52: Shell Complex Fire

Source: Las Animas County Emergency Management

Figure 53: Area After the Track Fire

Source: Las Animas County Emergency Management

Average Annual Losses

The annual average property loss estimate was determined based upon NCEI Storm Events Database since 1996. This does not include losses from displacement, functional downtime, economic loss, injury, or loss of life. Average annual crop loss data is based on SHELDUS information from 1960-2018. NCEI reported a total of $32,0808,000 in property damage from wildfires. However, further research of the wildfire events showed that most of the damages came from two wildfires where all of the damages and most of the burned acres occurred in a neighboring county. When those two events are taken out, total property loss is $1,080,000 for Las Animas County.

Damages caused by wildfires extend past the loss of building stock, recreation areas, timber, forage, wildlife habitat, and scenic views. Secondary effects of wildfires, including erosion, landslides, introduction of invasive species, and changes in water quality, all increase due to the exposure of bare ground and loss of vegetative cover following a wildfire, and can often be more disastrous than the fire itself in long-term recovery efforts.

Table 68: Wildfire Loss Estimation

Hazard Type	Total Property Loss[1]	Average Property Loss[1]	Total Crop Loss[2]	Average Annual Crop Loss[2]
Wildfire	$1,080,000	$41,538	$0	$0

Source: 1 NCEI (1996-June 2021), 2 SHELDUS (1960-2018)

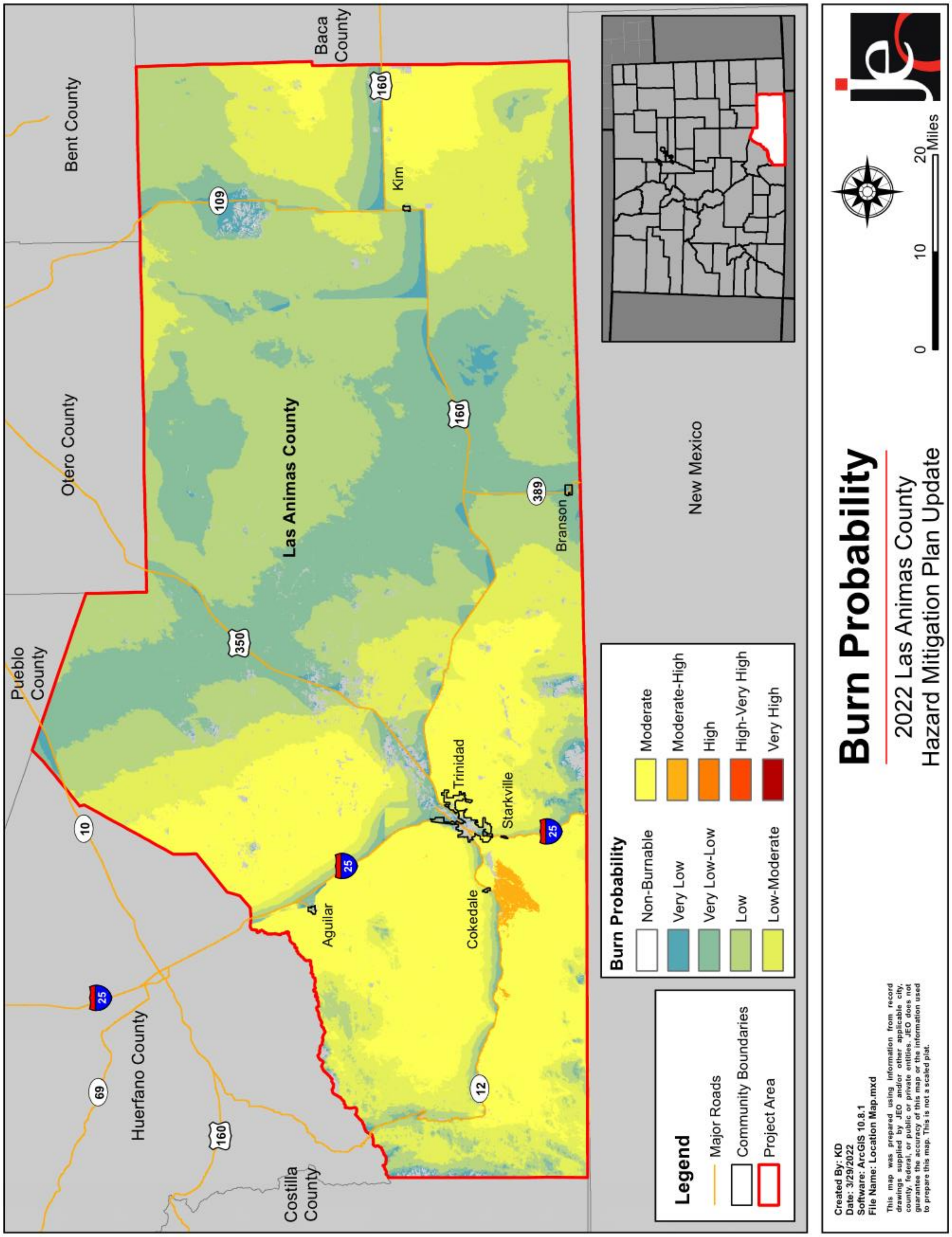
Probability

Given the historic record of occurrence for wildfire events (at least one fire event reported in each year on record) for the purposes of this plan, the annual probability of wildfire occurrence is 100 percent.

The figure below shows the burn probability for Las Animas County. Burn probability is the annual probability of any location to burn due to a wildfire. Areas with the highest probability to burn include the western portion and eastern edge of the county.[62]

62 Colorado State Forest Service. 2017. “2017 Colorado Wildfire Risk Assessment Summary Report”.

Figure 54: Las Animas County Burn Probability



Climate Change

Current climate trends are expected to result in an increase in frequency and severity of wildfires throughout the state of Colorado. Periods of drought can occur throughout the year while extreme heat conditions during summer months greatly increase the potential for and magnitude of wildfires. During a severe drought, dry conditions, and/or wind conditions, large wildfires can more easily spread.

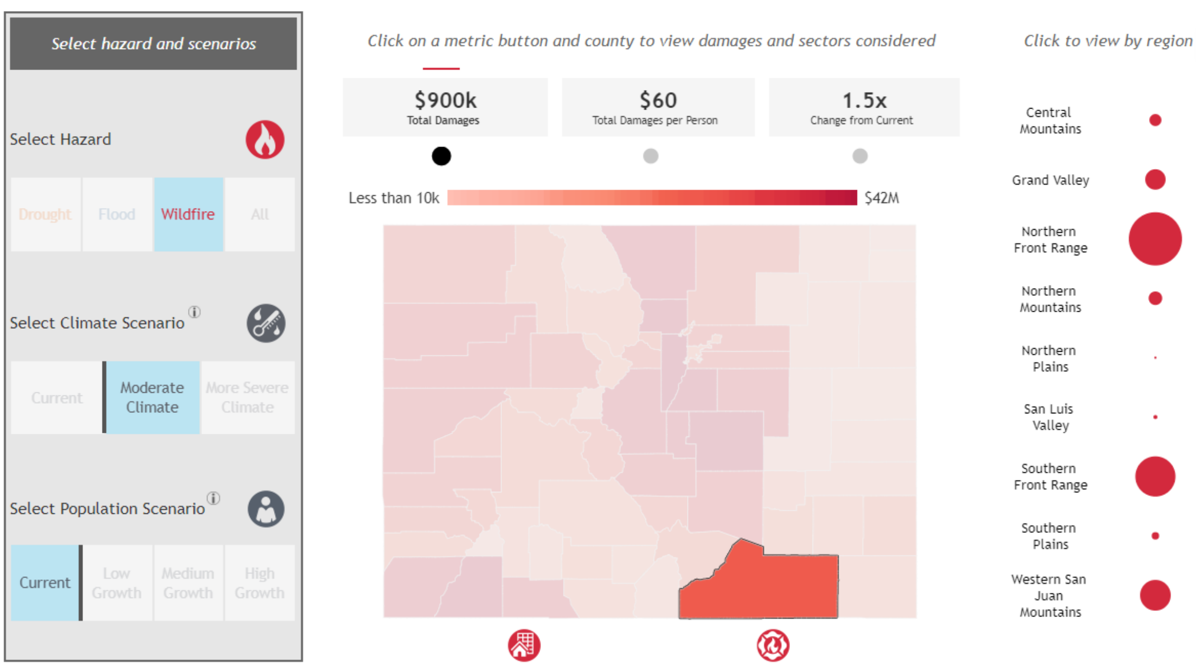
A specific tool developed and utilized in the State of Colorado include FACE[63] for wildfire. This tool presents an in-depth look at potential future economic impacts of wildfire on specific sectors of the Colorado economy. Based on the FACE assessments, it is likely that Las Animas County will experience worsening impacts from climate change regarding wildfire. At the current growth rate and only moderate climate impacts, the county may experience up to $900,000 in total damages annually from wildfire. Damages may vary across sectors and regions such as bridges, building, cattle, crops, and fire suppression activities.

Table 69: FACE Anticipated Damages for Wildfire Matrix

Population Scenario	Climate Scenario		
	Current Climate	Moderate Climate	More Severe Climate
Current Growth Rate	$600,000 $40 per person	$900,000 $60 per person	$900,000 $60 per person
Low Growth Rate	$600,000 $50 per person	$900,000 $70 per person	$900,000 $70 per person
Medium Growth Rate	$600,000 $50 per person	$900,000 $70 per person	$900,000 $70 per person
High Growth Rate	$600,000 $40 per person	$900,000 $70 per person	$900,000 $70 per person

Source: CWCB FACE, 2020

Figure 55: FACE Wildfire Analysis Example



Source: CWCB FACE, 2020

63 Colorado Water Conservation Board. 2020. "Future Avoided Cost Explorer: Colorado Hazards." https://storymaps.arcgis.com/stories/4e653ffb2b654ebe95848c9ba8ff316e.

Suggested actions to improve resilience to wildfire from FACE are shown in the graphic below.

Figure 56: Exploring Resilience Actions for Wildfire

Source: CWCB FACE, 2020

Jurisdictional Top Hazard Status

The following table lists jurisdictions which identified wildfire as a top hazard of concern.

Jurisdictions	
City of Trinidad	Town of Branson
Town of Kim	Town of Starkville
Hoehne Fire Protection District	Kim Reorganized 88

Future Development

People living in or near wildland settings in Las Animas County are vulnerable to the threat of wildfire. Any development of homes and other structures encroaching into the forest wildland and natural areas would expand the WUI. Interface neighborhoods are characterized by a diverse mixture of varying housing structures, development patterns, ornamental and natural vegetation, and natural fuels. Problems can arise if new development increases the amount of fuel without coordinated thinning of the forests and the creation of defensible space around homes.

Local officials can adopt codes and ordinances that can guide growth in ways to mitigate potential losses from wildfires. These may include more stringent building code standards, setback requirements, or zoning regulations. The development of additional CWPPs or a county wide CWPP can assist the county with wildfire preparation. Other notable vulnerabilities exist for fire departments which service both urban and rural areas as many fire districts lack adequate resources and staff to respond to multi-fire complexes or events in separate areas. The utilization and development of mutual aid agreements or memorandum of understandings are an important tool for districts to share resources and coverage.

According to the 2018-2023 Colorado Enhanced Hazard Mitigation Plan, Las Animas County's exposure rating incorporating growth (2010-2030) is negligible. This takes into account projected population change and wildfire risk ratio.

County Vulnerabilities

Wildfire poses a threat to a range of demographic groups. Wildfire, wildfire within the WUI, and urban fire could result in major evacuations of residents in impacted and threatened areas. Groups and individuals lacking reliable transportation could be trapped in dangerous locations. Lack of transportation is common among the elderly, low-income individuals, and racial minorities.

Smoke and air pollution from wildfires can be a severe health hazard, especially for sensitive populations, including children, the elderly, and those with respiratory and cardiovascular diseases. Smoke generated by wildfire consists of visible and invisible emissions that contain particulate matter, gases, and toxics. Public health impacts associated with wildfire include difficulty in breathing, odor, and reduction in visibility.

In the event of a wildfire, vegetation, structures, and other flammables can combine to create unwieldy and unpredictable events. Factors relevant to the fighting of such fires include access, firebreaks, proximity of water sources, distance from fire stations, and available firefighting personnel and equipment. The vulnerability of structures and homes in the interface area is increased by: combustible roofing and construction material; no/insufficient defensible space; poor access to structures; heavy natural fuel types; steep slopes; limited water supply; and winds over 30 miles per hour.

The following table provides information related to county vulnerabilities; for jurisdictional-specific vulnerabilities, refer to *Section Seven: Participant Profiles.*

Table 70: County Wildfire Vulnerabilities

Sector	Vulnerability
People	-Risk of injury or death for residents and firefighting personnel -Displacement of people and loss of homes -Lack of transportation poses risk to low-income individuals, families, and elderly -Increased health impacts to people with breathing difficulties -Hikers and other recreationalists in remote areas -Transportation routes may be blocked by fire, preventing evacuation efforts
Economic	-Damages to buildings and property can cause significant losses to business owners -Loss of businesses
Built Environment	-Building and property damages
Infrastructure	-Damage to power lines and utility structures -Contamination of water supplies
Community Lifelines	-Risk of damages to critical buildings -Damage to powerlines and utility structures -Contamination of water supplies
Other	-Increase chance of landslides, erosion, and land subsidence -May lead to poor water quality -Post fire, flash flooding events may be exacerbated

Winter Storms

Winter storms are an annual occurrence in Colorado. Winter storms can bring extreme cold, ice, heavy or drifting snow, and blizzards. Generally, winter storms occur between the months of October and April but may occur as early as September and as late as May. Heavy snow is usually the most defining element of a winter storm. Large snow events can cripple an entire area by hindering transportation, knocking down tree limbs and utility lines, and structurally damaging buildings. Extreme cold, freezing rain, and blizzards also occur alongside many winter storms.

Extreme Cold

Along with snow and ice storm events, extreme cold is dangerous to the well-being of people and animals. What constitutes as extreme cold varies from region to region but is generally accepted as temperatures that are significantly lower than the average low temperature. For the county, the coldest months of the year are December, January, and February. The average low temperature for these months is all below freezing (average low for the three months in the county is 18.2°F). The average high temperatures for the months of January, February, and December are near 32.4°F in the county.[64] A wind chill watch is issued by the National Weather Service when wind chill warning criteria are possible in the next 12 to 36 hours. A wind chill warning is issued for wind chills of at least -25°F the plains and -35°F in the mountains and foothills. Common impacts include pipes freezing and cars not starting.

Freezing Rain

Along with snow events winter storms also have the potential to deposit significant amounts of ice. Ice buildup on tree limbs and power lines can cause them to collapse. This is most likely to occur when rain falls and freezes upon contact, especially in the presence of wind. Freezing rain is the name given to rain that falls when surface temperatures are below freezing. Unlike a mixture of rain and snow, ice pellets or hail, freezing rain is made entirely of liquid droplets. Freezing rain can also lead to many problems on the roads, as it makes them slick, causing automobile accidents, and making vehicle travel difficult at best.

Blizzards

Blizzards are particularly dangerous due to drifting snow and the potential for rapidly occurring whiteout conditions, which greatly inhibits vehicular traffic. Defined by the National Weather Service as a combination of sustained winds or frequent gusts of 35 mph or greater, and visibilities of less than a quarter mile from falling or blowing snow for three hours or more. The reduced visibilities make travel of any kind, particularly treacherous and can disrupt key local transportation nodes including emergency response efforts.

Location

The entire county is at risk of severe winter storms. Resources that exist at higher elevations or at greater slopes will experience more risk of snow and ice.

Extent

The Sperry-Piltz Ice Accumulation Index (SPIA) was developed by the NWS to predict the accumulation of ice and resulting damages. The SPIA assesses total precipitation, wind, and temperatures to predict the intensity of ice storms. The following figure shows the SPIA index.

64 National Centers for Environmental Information. 2021. “Climate at a Glance 1895-2021.” https://www.ncdc.noaa.gov/cag/.

Figure 57: SPIA Index

The Sperry-Piltz Ice Accumulation Index, or "SPIA Index"

Copyright, February, 2009

ICE DAMAGE INDEX	*AVERAGE ICE AMOUNT (in inches) *Revised: Oct. 2011*	WIND (mph)	DAMAGE AND IMPACT DESCRIPTIONS
0	<0.25	<15	Minimal risk of damage to exposed utility systems; no alerts or advisories needed for crews, few outages.
1	0.10 – 0.25	15 – 25	Some isolated or localized utility interruptions are possible, typically lasting only a few hours. Roads and bridges may become slick and hazardous.
	0.25 – 0.50	>15	
2	0.10 – 0.25	25 – 35	Scattered utility interruptions expected, typically lasting 12 to 24 hours. Roads and travel conditions may be extremely hazardous due to ice accumulation.
	0.25 – 0.50	15 – 25	
	0.50 – 0.75	>15	
3	0.10 – 0.25	> – 35	Numerous utility interruptions with some damage to main feeder lines and equipment expected. Tree limb damage is excessive. Outages lasting 1 – 5 days.
	0.25 – 0.50	25 – 35	
	0.50 – 0.75	15 – 25	
	0.75 –1.00	>15	
4	0.25 – 0.50	> – 35	Prolonged and widespread utility interruptions with extensive damage to main distribution feeder lines and some high voltage transmission lines/structures. Outages lasting 5 – 10 days.
	0.50 – 0.75	25 – 35	
	0.75 –1.00	15 – 25	
	1.00 –1.50	>15	
5	0.50 – 0.75	> – 35	Catastrophic damage to entire exposed utility systems, including both distribution and transmission networks. Outages could last several weeeks in some areas. Shelters needed.
	0.75 –1.00	> – 25	
	1.00 –1.50	> – 15	
	> 1.50	Any	

(Categories of damage are based upon combinations of precipitation totals, temperatures and wind speeds/directions.)

Source: SPIA-Index[65]

The wind chill index was developed by the NWS to determine the decrease in air temperature felt by the body on exposed skin due to wind. The wind chill is always lower than the air temperature and can quicken the effects of hypothermia or frost bite as it gets lower. The following figure shows the Wind Chill Index used by the NWS.

65 SPIA-Index. 2009. "Sperry-Piltz Ice Accumulation Index." https://www.spia-index.com/.

Figure 58: Wind Chill Index Chart

NWS Windchill Chart

Temperature (°F)

Wind (mph)	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	-82	-89	-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

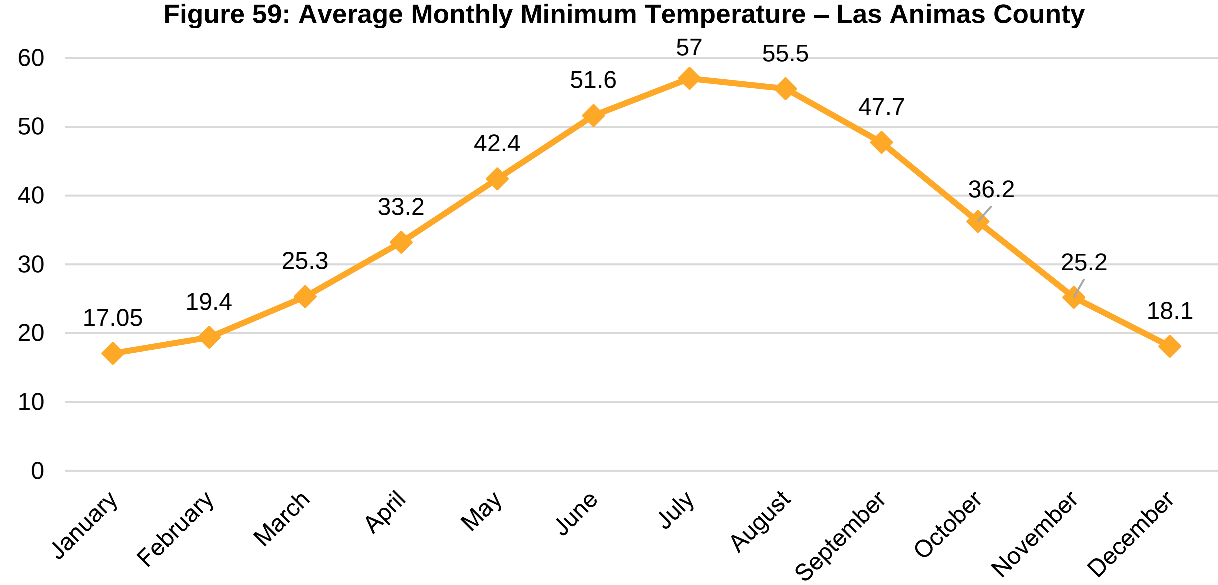
Frostbite Times 30 Minutes 10 Minutes 5 Minutes

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

T = Air Tempurature (°F) **V** = Wind Speed (mph)

Source: NWS

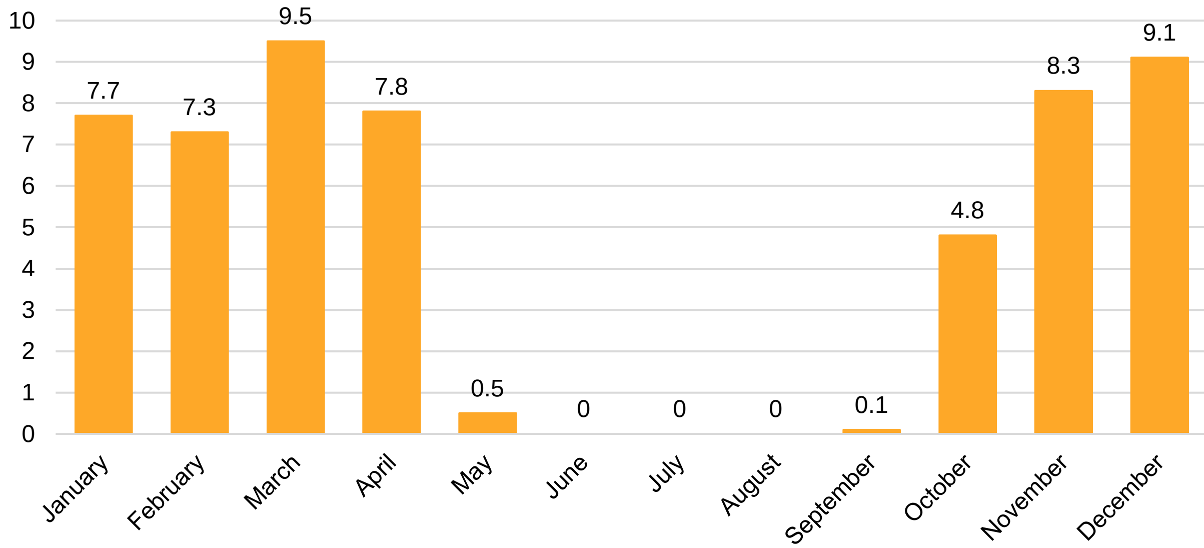
Figure 59: Average Monthly Minimum Temperature – Las Animas County



Source: NCEI, 1895-2021

Average monthly snowfall for the county is shown in Figure 60, which shows the snowiest months are December, March, and April. Past winter storms have resulted in anywhere from one inch to one foot of snow in a 24-hour period. Often these snow events are accompanied by high winds causing blizzard conditions. It is reasonable to expect wind speeds of 35 to 40 mph with gusts reaching 50 mph or higher. Strong winds and low temperatures can combine to produce extreme wind chills of 20°F to 40°F below zero.

Figure 60: Monthly Normal Snowfall in Inches – Las Animas County



Source: Western Regional Climate Center, 1981-2010

Historical Occurrences

According to the NCEI, there were a combined 399 winter storm events for the county from January 1996 to June 2021. These recorded events caused a total of $550,000 in property damages and $98,069 in crop damages. No fatalities or injuries were reported from these events.

<u>October 24, 1997 – Blizzard</u>

Blizzard conditions across the county resulted in $300,000 in property damage. High snow totals and poor road conditions also closed several roads.

<u>April 10, 2005 – Blizzard</u>

Blizzard conditions caused by a strong surface low pressure system over southeast Colorado and southwest Kansas impacted southeast Colorado causing snow drifts several feet in depth in some areas as well as closed roads. Snow totals for Las Animas County were up to 12 inches. There was a reported $250,000 in property damages from the event.

Average Annual Losses

The annual average property loss estimate was determined based upon NCEI Storm Events Database since 1996 and includes calculations for each of the six types of winter weather as provided in the database. This does not include losses from displacement, functional downtime, economic loss, injury, or loss of life. Average annual crop loss data is based on SHELDUS information from 1960-2018. Severe winter storms have caused an average of $21,154 per year in property damage and $1,662 per year in crop damage for the county.

Table 71: Severe Winter Storms Losses

Hazard Type	# of Events[1]	Average # events per year	Total Property Loss[1]	Average Annual Property Loss	Total Crop Loss[2]	Average Annual Crop Loss
Blizzard	16	0.6	$550,000	$21,154	$98,069	$1,662
Extreme Cold / Wind Chill	2	0.1	$0	$0		
Heavy Snow	97	3.7	$0	$0		
Ice Storm	1	0.04	$0	$0		
Winter Storms	258	9.9	$0	$0		
Winter Weather	25	1	$0	$0		
Totals	**399**	**15.3**	**$550,000**	**$21,154**	**$98,069**	**$1,662**

Source: 1 NCEI (1996-June 2021), 2 SHELDUS (1960-2018)

Probability

Based on historical records, winter storm events are likely to occur on an annual basis. The NCEI reported a severe winter storm event in every year, resulting in 100 percent chance annually for thunderstorms.

Climate Change

Winter conditions including extreme temperatures and precipitation are projected to change in the future. The number of extreme freeze thaw days is likely to increase. Colorado is expected to receive more rain in the fall and spring months as well as more snow during mid-winter months.[66] However, as increasing temperatures persist over time, an earlier snowmelt may occur that changes the timing and efficiency of runoff.

Jurisdictional Top Hazard Status

The following table lists jurisdictions which identified winter storms as a top hazard of concern.

Jurisdictions	
City of Trinidad	Town of Cokedale
Trinidad School District #1	

Future Development

All future development will be affected by winter storms. New infrastructure in the county creates a higher probability of damage to occur from winter weather as more property is exposed to risk. The ability to withstand impacts lies on sound land use practices and consistent enforcement of codes and regulations for new construction.

According to the 2018-2023 Colorado Enhanced Hazard Mitigation Plan, Las Animas County's exposure rating incorporating growth (2010-2030) is moderate. This takes into account housing percent change and historical severe winter weather.

County Vulnerabilities

Winter storms that bring snow, ice, and high winds can cause significant impacts on life and property. Many severe winter storm deaths occur as a result of traffic accidents on icy roads, heart

66 Colorado Department of Transportation. May 14, 2021. "Climate Study: Changing Climate and Extreme Weather Impacts on Geohazards in Colorado". https://www.codot.gov/programs/planning/data-studies/cdot-climate-resilience-study.pdf.

attacks when shoveling snow, and hypothermia from prolonged exposure to the cold. The temporary loss of home heating can be particularly hard on the elderly, young children, and other vulnerable individuals.
Property is at risk due to flooding and landslides that may result if there is a heavy snowmelt. Additionally, ice, wind, and snow can affect the stability of trees, power and telephone lines, and TV and radio antennas. Downed trees and limbs can become major hazards for houses, cars, utilities and other property. Below freezing temperatures can also lead to breaks in uninsulated water lines serving schools, businesses and industry, and individual homes. Such damage in turn can become major obstacles to providing critical emergency response, police, fire, and other disaster response and recovery services.

Severe winter weather also can cause the temporary closure of key roads and highways, air and train operations, businesses, schools, government offices, and other important community services. These effects, if lasting more than several days, can create significant economic impacts for the communities affected as well for the surrounding region.

The following table provides information related to county vulnerabilities; for jurisdictional-specific vulnerabilities, refer to *Section Seven: Participant Profiles.*

Table 72: County Winter Storm Vulnerabilities

Sector	Vulnerability
People	-Elderly citizens are at higher risk to injury or death, especially during extreme cold and heavy snow accumulations -Citizens without adequate heat and shelter at higher risk of injury or death -Exposure or injury to first responders during working conditions -Exposure for motorists, hikers, or other people outdoors -Those living in rural isolated areas of the county
Economic	-Closed roads and power outages can cripple an area for days, leading to significant revenue loss and loss of income for workers
Built Environment	-Heavy snow loads can cause roofs to collapse -Significant tree damage possible, downing power lines and blocking roads
Infrastructure	-Heavy snow and ice accumulation can lead to downed power lines and prolonged power outages -Transportation may be difficult or impossible during blizzards, heavy snow, and ice events -Damage to underground utility lines -Airport closures
Community Lifelines	-Power outages from downed power lines -Loss of access to vital records and information -Damage to critical building roofs -Transportation difficulties and road closers -Damage to underground utility lines -Airport closures