SECTION FOUR

RISK ASSESSMENT

Introduction

The ultimate purpose of this hazard mitigation plan is to minimize the loss of life and property across the planning area. This section contains a regional and local risk assessment including descriptions of potential hazards, regional vulnerabilities and exposures, probability of future occurrences, and potential impacts and losses. By conducting a regional 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 planning area; 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 planning area, *Section Seven* will discuss community-specific assets at risk for relevant hazards. Analysis for regional 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 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 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 April 2020. 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 is 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 tornado can have a widespread effect on a city.

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 included, while those which have caused significant damages or occurred in significant numbers are discussed in 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 planning area, crop loss information provided by the Risk Management Agency (RMA) of the USDA was also utilized for this update of the plan for counties with available data. The collected data were from 2000 to August 2020. 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 planning area began with a review of the 2019 State of Nebraska Hazard Mitigation Plan. The Regional Planning Team reviewed, discussed, and determined the list of hazards to be profiled in this HMP update at the Kick-off meeting. 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 2021 LBNRD and LBBNRD HMP		
Agricultural Plant and Animal Disease	Grass/Wildfire	Severe Winter Storms
Dam Failure	Hazardous Materials	Terrorism
Drought and Extreme Heat	Levee Failure	Tornadoes and High Winds
Earthquakes	Public Health Emergency	
Flooding	Severe Thunderstorms	

Hazard Changes and/or Elimination

Due to the development of new events, impacts to the planning area, and overall response capabilities associated per hazard, several changes were made to the hazards profiled for the 2021 HMP. These hazards are listed below with a brief explanation or description of the change.

Additions

- Public Health Emergency - Due to the Covid-19 pandemic, the Hazard Mitigation Planning Team determined that Public Health Emergency should be addressed in this HMP.

Although local health departments have plans in place and will lead many of the mitigation efforts, many communities were not prepared for the impacts and response for this hazard. Therefore, public health emergencies will be further analyzed in this planning effort.

Eliminated

- Transportation Incidents

Changes

Additionally, several hazards from the 2016 Little Blue NRD and Lower Big Blue HMP have been modified and combined to provide a more robust and interconnected discussion. The following hazards from the previous HMP have combined hazard profiles:

- Drought and Extreme Heat
- Severe Thunderstorms and Hail
- Tornadoes and High Winds

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: Regional Risk Assessment

Hazard	Previous Occurrences (events/year)	Approximate Annual Probability	Likely Extent
Agricultural Animal Disease	125/7	100%	Mean ~214 animal per event; Median ~1 animal per event
Agricultural Plant Disease	258/21	90%	Unavailable
Dam Failure	18/129	10%	Varies by structure
Drought	493/1,504 months	>32.8%	Mild Drought
Earthquakes	2/121	2%	~2.0 – 4.0 magnitude
Extreme Heat	Avg. 6 days per year	98%	>100°F
Flooding	234/25	98%-100%	Some inundation of structures and roads near streams. Some evacuations of people may be necessary.
Grass/wildfire	2,059/20	100%	<21 acres; Some homes and structures threatened or at risk
Hazardous Materials - Fixed Sites	368/30	100%	Localize to the facilities and adjacent surroundings.

Hazard	Previous Occurrences (events/year)	Approximate Annual Probability	Likely Extent
Hazardous Materials - Transportation	72/50	81%	<50 gallons, Limited (<0.5 mile) from release site
High Winds	183/25	84%	9 BWF (47-54mph)
Levee Failure	0	<1%	Total of 649 people and 585 structures in leveed areas
Public Health Emergency	3/12	>1%	Varies by event; >1 fatality
Severe Thunderstorms (includes hail)	2,755/25	100%	>1" rainfall Avg 1.16 hail; 35-58 mph
Severe Winter Storms	766/25	100%	0.25-0.5" ice 20°-40° below zero (wind chill) 4-8" snow 35-45 mph winds
Terrorism	2/48	<1%	Isolated to a single building; damages <$1M; varies by event
Tornadoes	148/25	96%	EF0-EF4

Table 4: Hazard Loss Estimates for the Planning Area

HAZARD		COUNT	PROPERTY	CROP
AGRICULTURAL DISEASE	Animal Disease	125	26,789 animals	N/A
	Plant Disease	258	N/A	$3,156,617
DAM FAILURE		18	$0	N/A
DROUGHT & EXTREME HEAT	Drought	493/1,504 months	$70,000,000	$246,935,998
	Extreme Heat	Avg. 6 days per year	$400,000	$22,026,050
EARTHQUAKES		2	$0	$0
FLOODING *1 FATALITY*	Flash Flood	112	$21,010,000	$2,408,030
	Flood	122	$117,270,900	
GRASS/WILDFIRE *15 INJURIES, 3 FATALITIES*		2,059	41,288 acres and $613,319	$1,361,497
HAZARDOUS MATERIALS *1 INJURY*	Fixed Sites	368	$0	N/A
	Transportation	72	$1,206,459	N/A
HIGH WINDS & TORNADOES *35 INJURIES, 1 FATALITY*	High Winds	183	$2,284,580	$10,526,687
	Tornadoes	148	$124,804,000	$388,802
LEVEE FAILURE		0	N/A	N/A
PUBLIC HEALTH EMERGENCY		3 outbreak events	>9,825 infections; >91 fatalities	N/A
	Hail	1,712	$83,647,000	$134,205,021

HAZARD		COUNT	PROPERTY	CROP
SEVERE THUNDERSTORMS *2 FATALITIES, 9 INJURIES*	Heavy Rain	196	$1,097,000	
	Lightning	25	$20,335,000	
	Thunderstorm Wind	822	$53,817,200	
SEVERE WINTER STORMS *1 INJURY*	Blizzards	79	$105,000	$12,156,696
	Extreme Cold	25	$0	
	Heavy Snow	41	$5,500,000	
	Ice Storms	51	$12,464,000	
	Winter Storms	379	$16,382,000	
	Winter Weather	191	$95,000	
TERRORISM		2	$0	N/A
TOTAL		**6,990**	**$531,031,458**	**$433,165,398**

N/A – indicates data not available

Historical Disaster Declarations

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

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 planning area in the last decade.

Table 5: SBA Declarations

Disaster Declaration Number	Declaration Year	Description	Primary Counties	Contiguous Counties
NE-00002	2005	Severe Storms and Flooding.	Adams, Fillmore	
NE-00011	2007	Severe Winter Storms.	Adams, Clay, Fillmore, Nuckolls, Webster	
NE-00013	2007	Severe Storms, Flooding, and Tornadoes	Gage, Jefferson, Saline	
NE-00018	2008	Severe Winter Storm	Gage, Jefferson	
NE-00019	2008	Severe Storms, Tornadoes, and Flooding	Gage, Johnson	
NE-00020	2008	Severe Storms, Tornadoes, and Flooding	Gage, Jefferson	Adams, Clay, Fillmore, Saline, Webster
NE-00021	2008	Severe Storms, Tornadoes, and Flooding	Adams, Fillmore, Gage, Jefferson, Saline, Thayer, Webster	
NE-00032	2009	Severe Winter Storm	Gage, Jefferson	

Disaster Declaration Number	Declaration Year	Description	Primary Counties	Contiguous Counties
NE-00033	2010	Severe Winter Storms and Snowstorm	Adams, Clay, Gage, Jefferson, Saline, Thayer	
NE-00035	2010	Severe Storms, Ice Jams, and Flooding.	Gage, Jefferson, Nuckolls, Saline	
NE-00038	2013	Severe Storms, Flooding, and Tornadoes	Nuckolls, Webster	
NE-00042	2011	Flooding		Gage
NE-00049	2013	Drought		Adams, Clay, Webster
NE-00050	2013	Drought	Adams, Clay, Webster	Fillmore, Nuckolls, Saline
NE-00051	2013	Drought	Fillmore, Saline	Clay, Gage, Jefferson, Nuckolls, Thayer
NE-00052	2013	Drought	Gage, Jefferson, Nuckolls, Thayer	Adams, Clay, Fillmore, Saline, Webster
NE-00053	2013	Drought	Adams, Clay, Fillmore, Gage, Jefferson, Saline, Thayer, Webster	
NE-00054	2014	Drought	Nuckolls	Adams, Clay, Fillmore, Thayer, Webster
NE-00055	2013	Severe Storms, Winter Storms, Tornadoes, and Flooding	Adams	
NE-00060	2014	Severe Storms, Tornadoes, Straight-line Winds, and Flooding	Clay, Fillmore, Saline	
NE-00064	2015	Severe Storms, Tornadoes, High Winds and Flooding	Saline, Thayer	Fillmore, Gage, Jefferson, Nuckolls
NE-00065	2015	Severe Storms, Tornadoes, Straight-line Winds, and Flooding.	Gage, Jefferson, Nuckolls, Saline, Thayer	

Source: Small Business Administration, 2001-2018[1]

Presidential Disaster Declarations

The presidential disaster declarations involving the planning area from 1953 to April 2020 are summarized in the following table. Declarations prior to 1962 are not designated by county and are not included.

[1] Small Business Administration. 2001-2018. "SBA Disaster Loan Data." Accessed December 2019. https://www.sba.gov/loans-grants/see-what-sba-offers/sba-loan-programs/disaster-loans/disaster-loan-data.

Table 6: Presidential Disaster Declarations

Disaster Declaration Number	Declaration Date	Title	Affected Counties
228	7/18/1967	Severe Storms & Flooding	Adams, Clay, Fillmore, Gage, Jefferson, Saline, Thayer
406	10/20/1973	Severe Storms & Flooding	Clay, Gage, Jefferson, Nuckolls, Saline, Thayer, Webster
500	4/8/1976	Ice Storms & High Winds	Adams, Clay, Fillmore, Gage, Jefferson, Nuckolls, Saline, Thayer, Webster
552	3/24/1978	Storms, Ice Jams, Snowmelt & Flooding	Jefferson, Nuckolls, Thayer
716	7/3/1984	Tornadoes & Flooding	Fillmore, Gage, Jefferson, Saline, Thayer
873	7/4/1990	Severe Storms, Tornadoes & Flooding	Clay, Gage, Thayer
954	8/19/1992	Severe Storms & Flooding	Jefferson, Nuckolls, Thayer
983	4/2/1993	Ice Jams & Flooding	Adams
998	7/19/1993	Severe Storms and Flooding	Adams, Clay, Fillmore, Gage, Jefferson, Nuckolls, Saline, Thayer, Webster
1123	6/25/1996	Severe Storms and Tornadoes	Gage
1190	11/1/1997	Severe Snow Storms, Rain, And Strong Winds	Adams, Clay, Fillmore, Nuckolls, Saline, Thayer, Webster
1373	5/16/2001	Severe Winter Storms, Flooding And Tornadoes	Gage, Nuckolls, Saline
1480	7/21/2003	Severe Storms And Tornadoes	Jefferson, Thayer
1517	5/25/2004	Severe Storms And Tornadoes	Adams, Clay, Fillmore, Gage, Jefferson, Nuckolls, Saline, Thayer, Webster
1590	6/23/2005	Severe Storms And Flooding	Adams, Fillmore
1674	1/7/2007	Severe Winter Storms	Adams, Clay, Fillmore, Nuckolls, Webster
1706	6/6/2007	Severe Storms, Flooding, And Tornadoes	Gage, Jefferson, Saline
1739	1/11/2008	Severe Winter Storm	Gage, Jefferson, Thayer
1765	5/30/2008	Severe Storms, Tornadoes, And Flooding	Gage
1770	6/20/2008	Severe Storms, Tornadoes, And Flooding	Adams, Fillmore, Gage, Jefferson, Saline, Thayer, Webster
1864	12/16/2009	Severe Winter Storm	Gage, Jefferson, Thayer
1878	2/25/2010	Severe Winter Storms And Snowstorm	Adams, Clay, Fillmore, Gage, Jefferson, Nuckolls, Saline, Thayer
1902	4/21/2010	Severe Storms, Ice Jams, And Flooding	Gage, Jefferson, Nuckolls, Saline
1924	7/15/2010	Severe Storms And Flooding	Adams, Jefferson, Nuckolls, Webster
3245	9/13/2005	Hurricane Katrina Evacuees	Adams, Clay, Fillmore, Gage, Jefferson, Nuckolls, Saline, Thayer, Webster

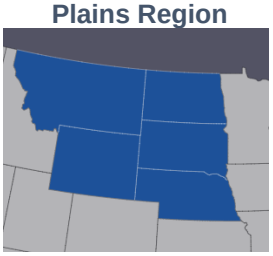
Disaster Declaration Number	Declaration Date	Title	Affected Counties
4156	11/26/2013	Severe Storms, Winter Storms, Tornadoes And Flooding	Adams
4179	6/17/2014	Severe Storms, Tornadoes, Straight-Line Winds, And Flooding	Clay, Fillmore, Saline
4225	6/25/2015	Severe Storms, Tornadoes, Straight-Line Winds, And Flooding	Adams, Clay, Fillmore, Gage, Jefferson, Nuckolls, Saline, Thayer
4325	8/1/2017	Severe Storms, Tornadoes, And Straight-Line Winds	Fillmore, Gage, Jefferson
4375	6/29/2018	Severe Winter Storm And Straight-Line Winds	Clay, Fillmore, Nuckolls, Webster
4420	3/21/2019	Severe Winter Storm, Straight-Line Winds, And Flooding	Adams, Clay, Fillmore, Gage, Jefferson, Nuckolls, Saline, Thayer, Webster
3483	3/13/2020	Covid-19	Adams, Clay, Fillmore, Gage, Jefferson, Nuckolls, Saline, Thayer, Webster
4521	4/4/2020	Covid-19 Pandemic	Adams, Clay, Fillmore, Gage, Jefferson, Nuckolls, Saline, Thayer, Webster

Source: FEMA, 1953-2020[2]

Climate Adaptation

Long-term climate trends have shifted throughout the 21st century and have created significant changes in precipitation and temperature which have altered the severity and subsequent impacts from severe weather events. The Regional and Local Planning Teams identified changes in the regional climate as a top concern impacting communities, Indian tribes, residents, local economies, and infrastructure throughout the planning area. Discussions on temperature, precipitation, and climate impacts are included below.

Figure 1: Great Plains Region



The planning area is located in the Northern Great Plains region of the United States, which stretches from Montana and North Dakota southward to Wyoming and Nebraska A large elevation change across the region contributes to high geographical, ecological, and climatological variability, including a strong gradient of decreasing precipitation moving from east to west across the region. Significant weather extremes impact this area, including winter storms, extreme heat and cold, severe thunderstorms, drought, and flood producing rainfall.

The Fourth National Climate Assessment has provided an overview of potential impacts within the planning area.

- **Water**: Water is the lifeblood of the Northern Great Plains, and effective water management is critical to the region's people, crops and livestock, ecosystems, and energy industry. Even small changes in annual precipitation can have large effects

[2] Federal Emergency Management Agency. 2020. "Disaster Declarations." Accessed March 2021. https://www.fema.gov/openfema-data-page/disaster-declarations-summaries-v2.

downstream; when coupled with the variability from extreme events, these changes make managing these resources a challenge. Future changes in precipitation patterns, warmer temperatures, and the potential for more extreme rainfall events are very likely to exacerbate these challenges.

- **Agriculture:** Agriculture is an integral component of the economy, the history, and the culture of the Northern Great Plains. Recently, agriculture has benefited from longer growing seasons and other recent climatic changes. Some additional production and conservation benefits are expected in the next two to three decades as land managers employ innovative adaptation strategies, but rising temperatures and changes in extreme weather events are very likely to have negative impacts on parts of the region. Adaptation to extremes and to longer-term, persistent climate changes will likely require transformative changes in agricultural management, including regional shifts of agricultural practices and enterprises.
- **Recreation and Tourism:** Ecosystems across the Northern Great Plains provide recreational opportunities and other valuable goods and services that are at risk in a changing climate. Rising temperatures have already resulted in shorter snow seasons, lower summer streamflows and higher stream temperatures. These changes have important consequences for local economies that depend on winter or river-based recreational activities. Climate-induced land-use changes in agriculture can have cascading effects on closely entwined natural ecosystems, such as wetlands, and the diverse species and recreational amenities they support.
- **Energy:** Fossil fuel and renewable energy production and distribution infrastructure is expanding within the Northern Great Plains. Climate change and extreme weather events put this infrastructure at risk, as well as the supply of energy it contributes to support individuals, communities, and the U.S. economy as a whole. The energy sector is also a significant source of greenhouse gases and volatile organic compounds that contribute to climate change and ground-level ozone pollution.

Nebraska's Changing Climate

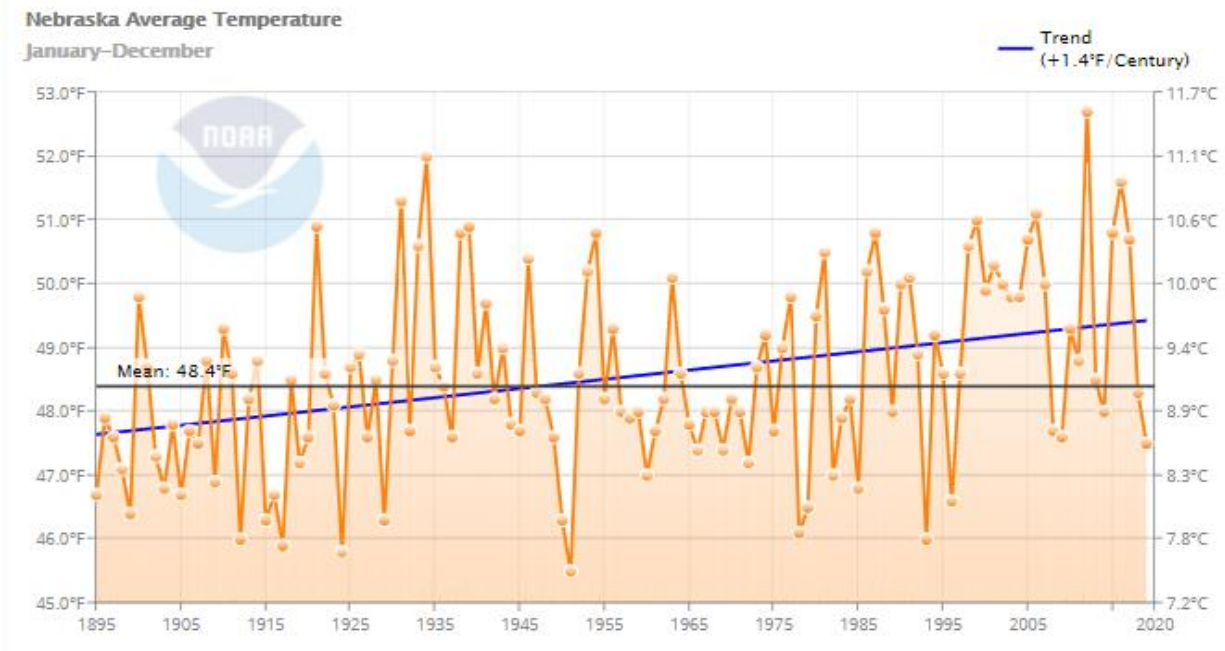
The United States as a whole is experiencing significant changes in temperature, precipitation, and severe weather events resulting from climate change. According to a University of Nebraska report (Understanding and Assessing Climate Change: Implications for Nebraska, 2014), the following changes can be expected for Nebraska's future climate:

- Increase in extreme heat events (days over 100°F)
- Decrease in soil moisture by 5-10%
- Increase in drought frequency and severity
- Increase in heavy rainfall events
- Increase in flood magnitude
- Decrease in water flow in the Missouri River and Platte River from reduced snowpack in the Rocky Mountains
- Additional 30-40 days in the frost-free season

Changes in Temperature

Since 1895 Nebraska's overall average temperature has increased by almost 1.5°F (Figure 2). The Great Plains region has additionally seen the greatest increase in overall temperature in the past two decades. While overall temperature shifts have not been consistent, the trend for increasing temperatures is apparent. Climate modeling suggests warmer temperature conditions will continue in the coming decades and rise steadily into mid-century. This trend will likely contribute to an increase in the frequency and intensity of hazardous events, which will cause significant economic, social, and environmental impacts on Nebraskans.

Figure 2: Nebraska Average Temperature (1895-2020)



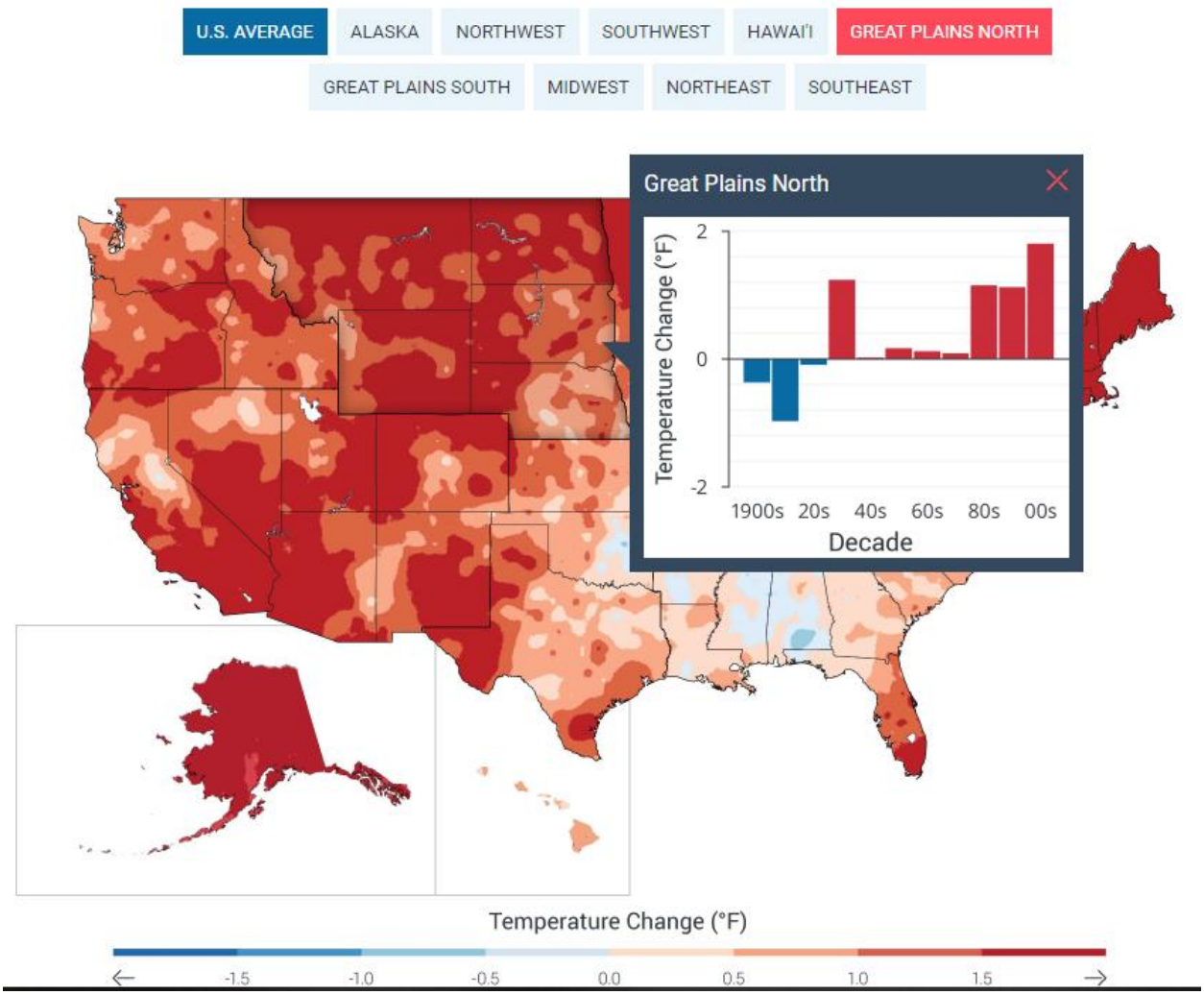
Source: NOAA, 2020[3]

Additionally, the length of the frost-free season (i.e. growing season) has been increasing nationally since the 1980s. While a longer growing season may provide some benefit for heavily agricultural areas, concurrent changes in temperature, water availability, and pest pressures may cause additional impacts. For instance, longer growing seasons coinciding with periods of drought and extreme heat can indicate lower production from increased plant mortality and increased risk to wildfire ignition probability and fuel load potentials. On average, the Great Plains has seen an increase of ten days to the annual growing season.[4]

[3] NOAA. 2020. "Climate at a Glance: Statewide Time Series.". Accessed September 2020. https://www.ncdc.noaa.gov/cag/statewide/time-series/25/tavg/12/12/1895-2020?base_prd=true&begbaseyear=1901&endbaseyear=2000&trend=true&trend_base=100&begtrendyear=1895&endtrendyear=2020

[4] U.S. Global Change Research Program. "2014 National Climate Assessment: Frost-free Season." Accessed 2020. https://nca2014.globalchange.gov/report/our-changing-climate/frost-free-season#tab2-images

Figure 3: Observed U.S. Temperature Change



Source: National Climate Assessment, 2014[5]

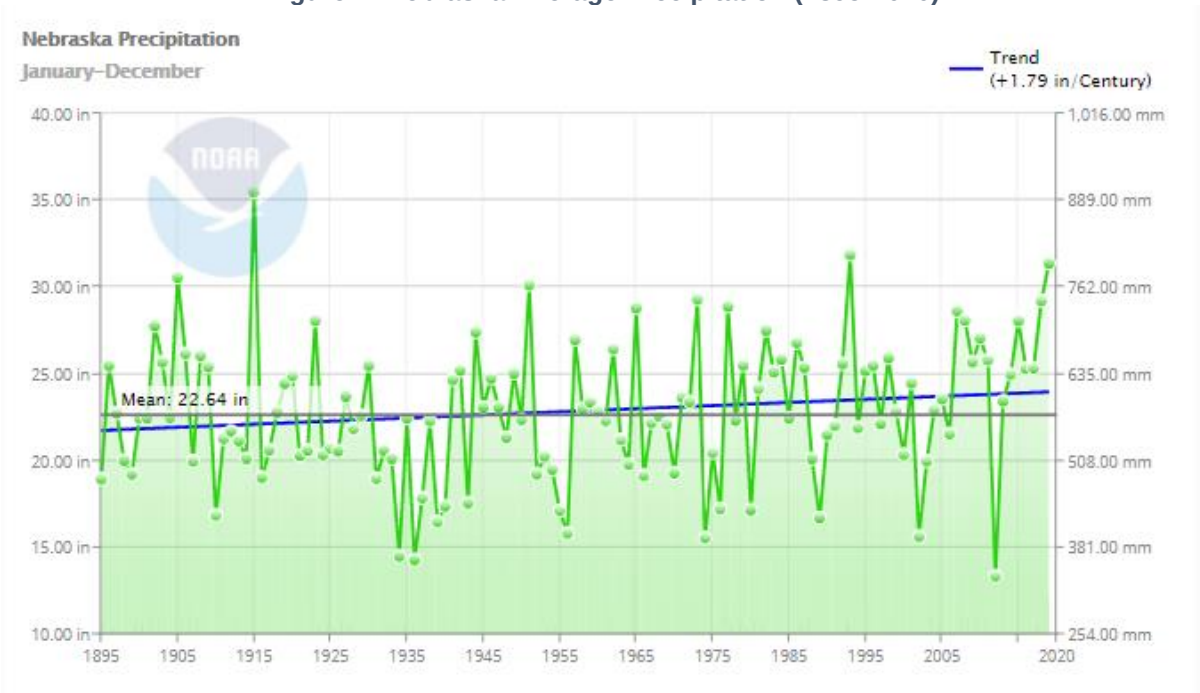
Changes in Precipitation

Changing extremes in precipitation are anticipated in the coming decades, with more significant rain and snowfall events and more intense drought periods. Seasonal variations will be heightened, with more frequent and more significant rainfall expected in the spring and winter and hotter, drier periods in the summer. Since 1895, yearly annual precipitation for Nebraska has increased slightly. This trend is expected to continue as the impacts of climate change continue to be felt. Climate modeling may show only moderate precipitation and streamflow changes; however, most of the Northern Great Plains region is already at risk to large annual and seasonable variability as seen by flooding and drought events occurring in concurrent years. There will likely be more days with a heavy precipitation event (rainfall of greater than one inch per day) across the region and subsequent impacts to riverine flooding events or overwhelmed

[5] U.S. Global Change Research Program. "2014 National Climate Assessment." Accessed 2020. https://nca2014.globalchange.gov/

local stormwater management systems. Groundwater and reservoir water sources are increasingly important to communities and residents in the planning area to meet water needs during periods of shortage. Precipitation varies significantly across the state (**Error! Reference source not found.**) and moves in a longitudinal gradient. The east receives twice as much precipitation (35 inches annually) as the Nebraska Panhandle (15 inches) on average.[6]

Figure 4: Nebraska Average Precipitation (1895-2020)

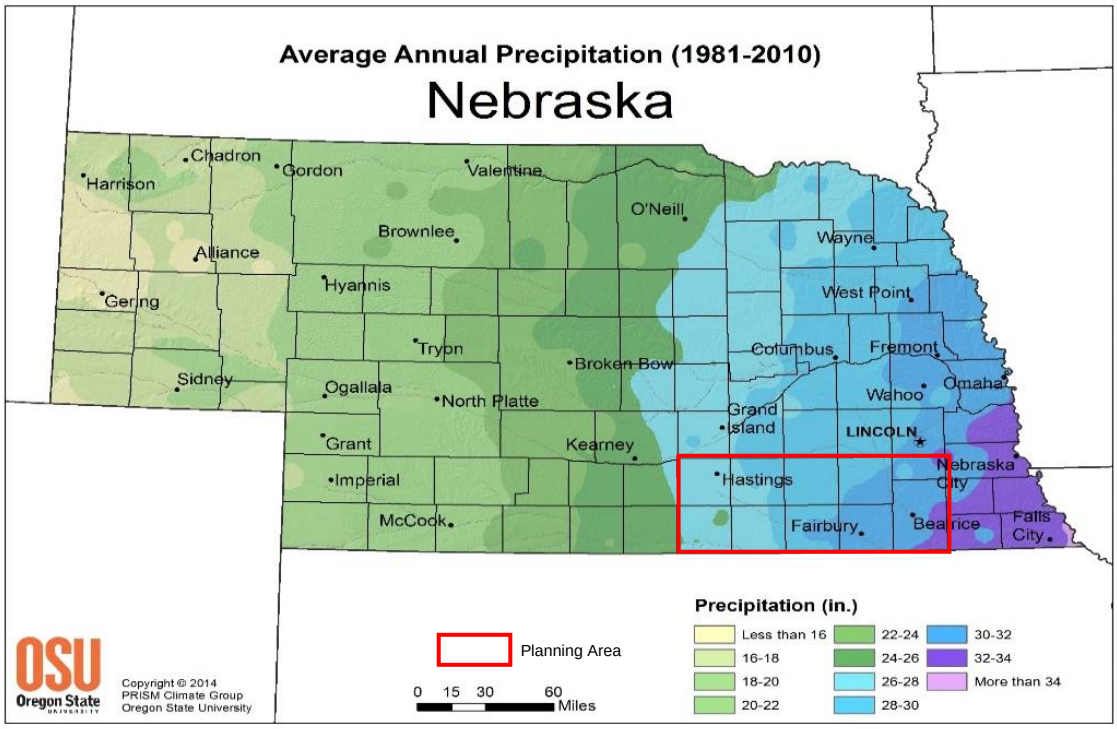


Source: NOAA, 2020[7]

[6] North Central Climate Collaborative. January 2020. "NC3 Nebraska Climate Summary." Accessed April 2021. https://northcentralclimate.org/files/2020/01/nc3-Nebraska-Climate-Summary-FINAL_2.12.pdf?x24082

[7] NOAA. 2020. "Climate at a Glance: Statewide Time Series.". Accessed September 2020. https://www.ncdc.noaa.gov/cag/statewide/time-series/25/pcp/12/12/1895-2020?base_prd=true&begbaseyear=1901&endbaseyear=2000&trend=true&trend_base=100&begtrendyear=1895&endtrendyear=2020

Figure 5: Average Annual Precipitation for Nebraska (1981-2010)



Source: Oregon State University PRISM Climate Group, 2014

Impacts from Climate Change

Observed changes in the intensity and frequency of extreme events are a significant concern now and in the future because of the social, environmental, and economic costs associated with their impacts. Challenges that are expected to affect communities, environments, and residents as a result of climate change include:

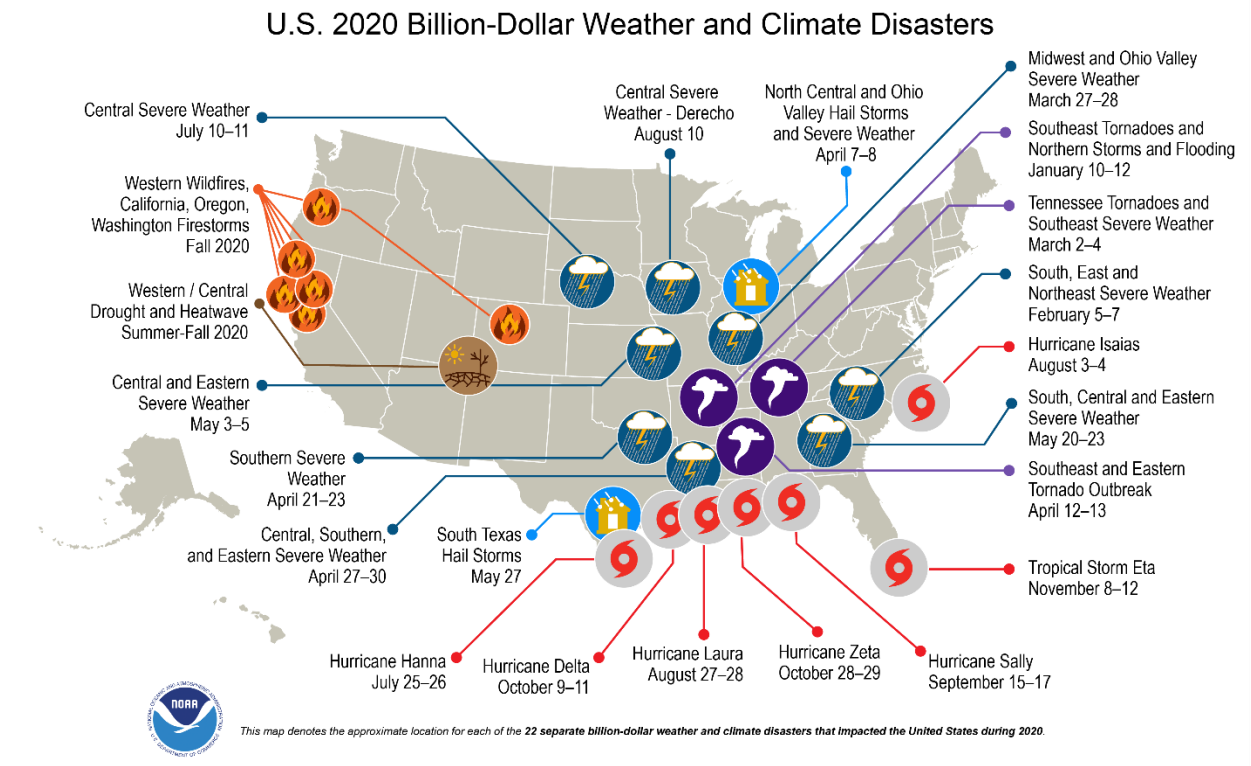
- Developing and maintaining sustainable agricultural systems
- Resolving increasing competition among land, water, and energy resources
- Conserving vibrant and diverse ecological systems
- Enhancing the resilience of the region's people to the impacts of climatic extremes

Certain groups of people may face greater difficulty when dealing with the impacts of a changing climate. Older adults, immigrant communities, and those living in poverty are particularly susceptible. Additionally, specific industries and professions tied to weather and climate, like outdoor tourism, commerce, and agriculture, are especially vulnerable.[8]

As seen in the figure below, the United States is experiencing an increase in the number of billion-dollar natural disasters.

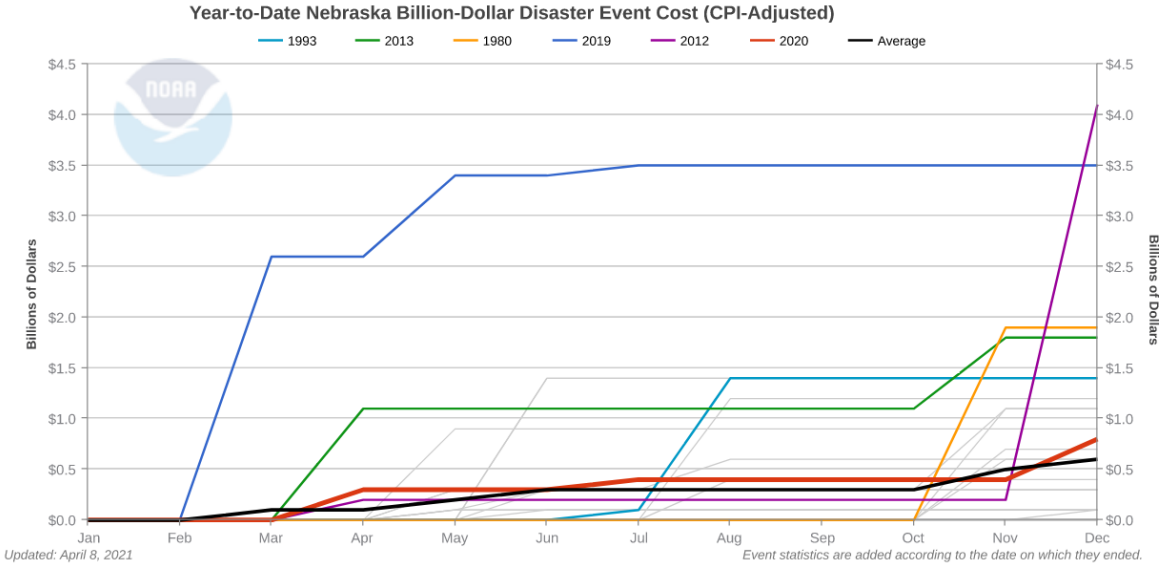
[8] U.S. Environmental Protection Agency. "Climate Impacts on Society." Accessed April 2021. https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-society_.html

Figure 6: Billion Dollar Weather and Climate Disasters (2020)



Source: NOAA, 2021[9]

Figure 7: Billion Dollar Disaster Costs in Nebraska



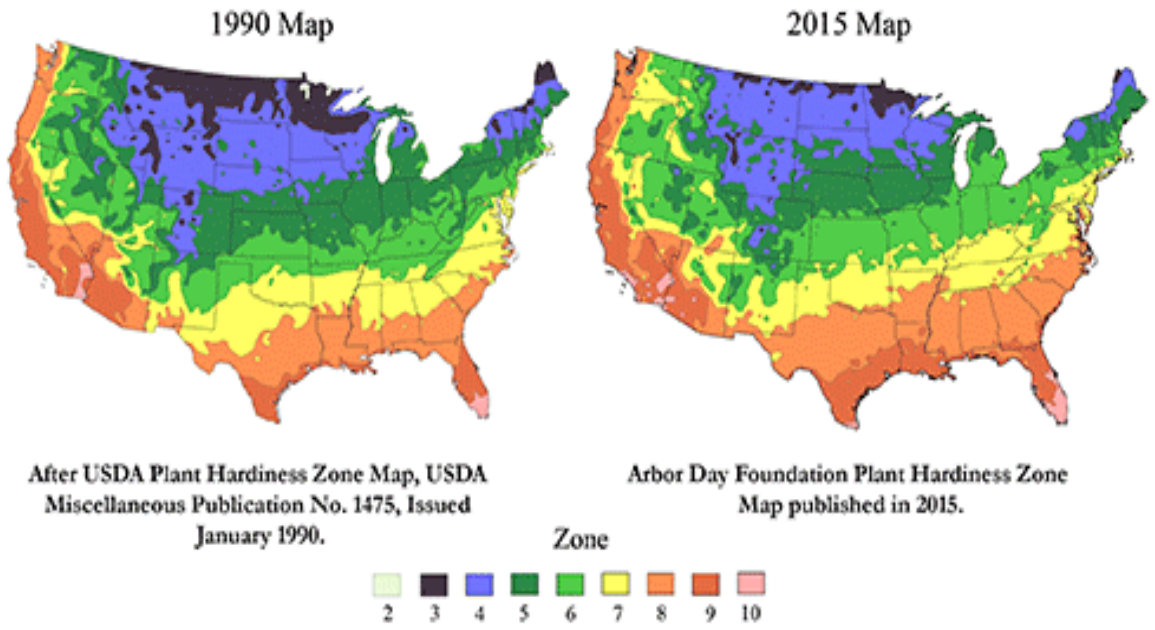
Source: NOAA, 2021

[9] NOAA. 2020. "Billion-Dollar Weather and Climate Disasters: Overview. Accessed April 2021. https://www.ncdc.noaa.gov/billions/overview

Agriculture

The agricultural sector will experience an increase in droughts, an increase in grass and wildfire events, changes in the growth cycle as winters warm, an influx of new and damaging agricultural diseases or pests, and changes in the timing and magnitude of rainfall. As described in the Plant Hardiness Zone map (Figure 8) available for the United States, these changes have shifted the annual growing season and expected agricultural production conditions. Nebraska is vulnerable to changes in growing season duration and growing season conditions as a heavily agriculturally dependent state. These added stressors on agriculture could have devastating economic effects if new agricultural and livestock management practices are not adopted.

Figure 8: Plant Hardiness Zone Change



Source: Arbor Day Foundation, 2018[10]

Air Quality

Rising temperatures will also impact air quality. Harmful air pollutants and allergens increase as temperatures increase. More extended periods of warmth contribute to longer pollen seasons that allow plant spores to travel farther and increase exposure to allergens. More prolonged exposure to allergens can increase the risk and severity of asthma attacks and worsen existing allergies in individuals.[11] An increase in air pollutants can occur from the growing number of grass and wildfires. The public can be exposed to harmful particulate matter from smoke and ash that can cause various health issues. Depending on the length of exposure, age, and individual susceptibility, effects from wildfire smoke can range from eye and respiratory irritation to severe disorders like bronchitis, asthma, and aggravation of pre-existing respiratory and cardiovascular diseases. [12]

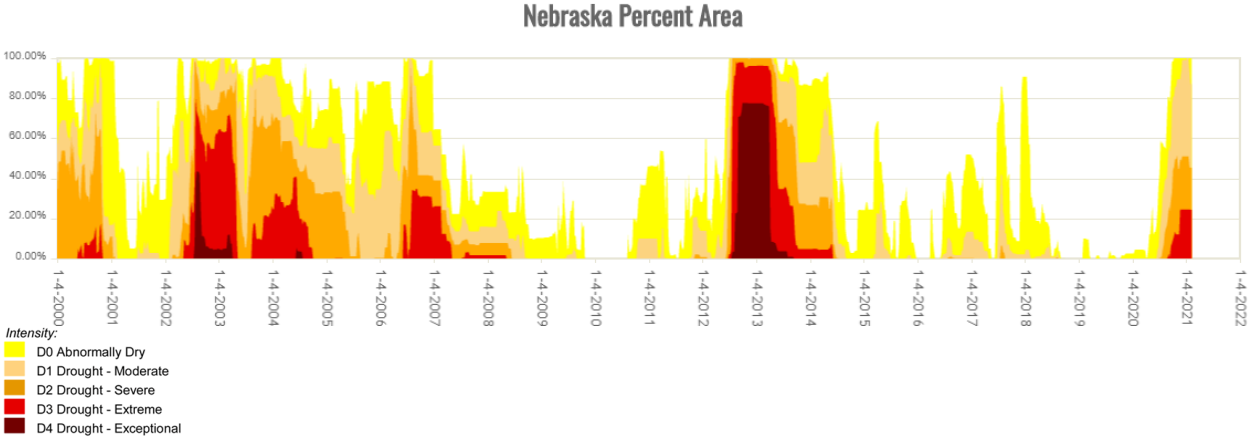
[10] Arbor Day Foundation. 2018. "Hardiness Zones." https://www.arborday.org/media/map_change.cfm.
[11] Asthma and Allergy Foundatino of America. 2010. "Extreme Allergies and Climate Change." Accessed 2021. https://www.aafa.org/extreme-allergies-and-climate-change/
[12] AirNow. 2019. "Wildfire Smoke: A Guide for Healthcare Professionals." Accessed 2021. https://www.airnow.gov/sites/default/files/2020-10/wildfire-smoke-guide-revised-2019-chapters-1-3_0.pdf

Drought and Extreme Heat

An increase in average temperatures will contribute to the rise in the frequency and intensity of hazardous events like extreme heat and drought, which will cause significant economic, social, and environmental impacts on Nebraskans. Although drought is a natural part of the climate system, increasing temperatures will increase evaporation rates, decrease soil moisture, and lead to more intense droughts in the future, having negative impacts on dryland farming. Extreme heat events have adverse effects on both human and livestock health. Heatwaves may also impact plant health, with negative effects on crops during essential growth stages. Increasing temperatures and drought may reduce the potential for aquifers to recharge, which has long-term implications for the viability of agriculture in Nebraska.

Changes in precipitation are tied to changes in drought patterns. The following figure shows the percent of Nebraska's area that experienced significant increases in moderate (D1) to exceptional drought (D4) from 2000 to January 2021. Record dryness occurred in Nebraska between June through August of 2012. Nebraska in 2012 had the driest year on record. The area will remain vulnerable to periodic drought as most projected increases in precipitation are anticipated to occur during the winter months, while increasing temperatures lead to increased soil drying.

Figure 9: Drought Severity 2000-January 2021



Source: NOAA, 2018

Energy

Shifting climate trends will have a direct impact on water and energy demands. As the number of 100°F days increases, along with warming nights, the stress placed on the energy grid will likely increase and possibly lead to more power outages. Severe weather events also stress energy production, infrastructure transmission, and transportation. Roads, pipelines, and rail lines are all at risk of damages from flooding, extreme heat, erosion, or added stress from increased residential demands.[13] Critical facilities and vulnerable populations that are not prepared to handle periods of power outages, particularly during heat waves, will be at risk.

Precipitation

[13] USGCRP, 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II: Report-in-Brief [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 186 pp.

With a changing climate, winter and spring precipitation is projected to increase across Nebraska. Average annual precipitation varies across the state, with the panhandle receiving 15 inches and the southeast receiving up to 35 inches. According to climate projections, winter and spring will likely become 20 percent wetter, with summers becoming 10 percent drier.

Winter precipitation is projected to increase in intensity and may benefit Nebraska's agricultural economy by improving soil moisture but could potentially delay crop planting in the summer. Increased spring precipitation may lead to heightened runoff and flooding, reducing water quality and eroding soils.[14]

Water Quality

Increasing temperatures, shifting precipitation patterns, and extreme weather events impact water quality throughout the state. As average temperatures increase, water temperatures also rise and put water bodies at risk for eutrophication and excess algal growth that reduce water quality. Extreme weather events and shifting precipitation can lead to fluctuating river flows, erosion, sediment accumulation, and morphological changes to water bodies and surrounding landscapes. In agricultural landscapes, major storm events can cause sediment and nutrients such as phosphorous and nitrogen to runoff into nearby water sources. Runoff can contribute to the buildup of nutrients in the water, increasing plant and algae growth that can deplete oxygen and kill aquatic life. Nutrient enrichment can lead to toxic cyanobacterial harmful algae blooms (cyanoHABs), which can be harmful to animal and human health. CyanoHABs can cause economic damage such as decreasing property values, reducing recreational revenue, and increasing the costs for treating drinking water.[15]

With the increasing intensity and frequency of extreme precipitation events, impacts to water systems ultimately threaten human health. Events can lead to flooding and stormwater runoff that can carry pollutants across landscapes and threaten human health by contaminating water wells, groundwater, and other bodies of water. Common pollutants include pesticides, bacteria, nutrients, sediment, animal waste, oil, and hazardous waste. Flooding impacts property, infrastructure, economies, and the ecology of water bodies.

Grass/Wildfire

Rising temperatures can increase the frequency and intensity of wildfires across the state. Warmer temperatures cause snow to melt sooner and create drier soils and forests, which act as kindling to ignite and spread fires. Additionally, warmer nighttime temperatures contribute to the continued spread of wildfires over multiple days.[16]

Severe Storms

Nebraska experiences frequent snowstorms and ice storms during winter, which can produce heavy snowfall and high wind gusts that lead to whiteout conditions. In the warmer months, convective storms are common and include flash flood-producing rainstorms and severe thunderstorms capable of producing hail, damaging winds, and tornadoes. As temperatures

[14] NOAA NCEI. 2017. "Nebraska State Climate Summary." Accessed 2021. https://statesummaries.ncics.org/chapter/ne/

[15] USGS. "Nutrients and Eutrophication". Accessed February 2021. https://www.usgs.gov/mission-areas/water-resources/science/nutrients-and-eutrophication?qt-science_center_objects=0#qt-science_center_objects

[16] NASA Global Climate Change. September 2019. "Satellite Data Record Shows Climate Change's Impact on Fires." Accessed 2021. https://climate.nasa.gov/news/2912/satellite-data-record-shows-climate-changes-impact-on-fires/

continue to rise, more water vapor evaporates into the atmosphere, creating increased humidity, which can develop intense storms.

Future Adaptation and Mitigation

The planning area will have to adapt to a changing climate and its impacts or experience an increase in economic losses, property damages, agricultural damages, and loss of life. Past events have typically informed HMPs to be more resilient to future events. This HMP includes strategies for the planning area to address these changes and increase resilience. However, future updates of this HMP should consider including adaptation as a core strategy to be better informed by "future" projections on the frequency, intensity, and distribution of hazards. Jurisdictions in the planning area should consider past and future climate changes and impacts when incorporating mitigation actions into local planning processes.

Hazard Profiles

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

The following table identifies the top hazards of concern for participating jurisdictions.

Table 7: Top Hazards of Concern by Jurisdiction

Jurisdiction	Agricultural Disease	Dam Failure	Drought and Extreme Heat	Earthquakes	Flooding	Grass/Wildfire	Hazardous Materials	Levee Failure	Public Health Emergency	Severe Thunderstorms	Severe Winter Storms	Terrorism	Tornadoes and High Winds
Little Blue NRD	X	X	X		X			X		X	X		X
Lower Big Blue NRD		X	X		X					X			
Adams County			**X**		**X**					**X**	**X**		**X**
Village of Ayr					X					X			X
City of Hastings		X								X	X		X
Village of Holstein										X	X		X
Village of Juniata			X		X					X	X		X
Village of Kenesaw					X			X			X		X
Village of Prosser										X	X		X
Clay County					**X**	**X**	**X**			**X**	**X**		**X**
City of Clay Center	X									X			X
Village of Deweese										X	X		X
City of Edgar							X			X			X
City of Fairfield					X		X			X			X
Village of Glenvil	X					X	X						X
Village of Ong						X	X			X	X		X
Village of Saronville			X							X	X		X
City of Sutton					X			X		X			X
Village of Trumbull							X			X	X		X
Fillmore County			**X**		**X**	**X**	**X**		**X**		**X**		**X**
Village of Exeter					X					X	X		X
Village of Fairmont										X	X		X
City of Geneva					X					X			X
Village of Grafton							X			X	X		X
Village of Milligan			X							X	X		X

Jurisdiction	Agricultural Disease	Dam Failure	Drought and Extreme Heat	Earthquakes	Flooding	Grass/Wildfire	Hazardous Materials	Levee Failure	Public Health Emergency	Severe Thunderstorms	Severe Winter Storms	Terrorism	Tornadoes and High Winds
Village of Ohiowa					X								X
Village of Shickley			X		X						X		X
Village of Strang										X	X		X
Gage County			**X**		**X**				**X**	**X**	**X**		**X**
Village of Adams		X			X		X				X		X
Village of Barneston					X		X			X	X		X
City of Beatrice					X					X	X		X
City of Blue Springs										X	X		X
Village of Clatonia							X			X	X		X
Village of Cortland										X			X
Village of Filley							X			X	X		X
Village of Liberty			X							X	X		X
Village of Odell			X				X			X	X		X
Village of Pickrell											X		X
Village of Virginia										X			X
City of Wymore			X							X	X		X
Jefferson County					**X**		**X**			**X**	**X**		**X**
Village of Daykin							X			X	X		X
Village of Diller							X			X	X		X
Village of Endicott										X			
City of Fairbury					X		X			X	X		X
Village of Harbine										X	X		X
Village of Jansen							X			X			X
Village of Plymouth							X				X		X
Village of Reynolds					X		X			X			X
Village of Steele City					X					X			X
Nuckolls County					**X**					**X**	**X**		**X**
Village of Hardy							X			X	X		X

Jurisdiction	Agricultural Disease	Dam Failure	Drought and Extreme Heat	Earthquakes	Flooding	Grass/Wildfire	Hazardous Materials	Levee Failure	Public Health Emergency	Severe Thunderstorms	Severe Winter Storms	Terrorism	Tornadoes and High Winds
Village of Lawrence							X			X	X		X
City of Nelson					X					X	X		X
Village of Ruskin						X	X				X		X
City of Superior		X	X		X	X	X				X		X
Saline County					**X**		**X**			**X**	**X**		**X**
City of Crete					X		X				X		X
Village of Dewitt					X					X	X		X
Village of Dorchester			X				X			X	X		X
City of Friend					X					X	X		X
Village of Swanton					X		X						X
Village of Tobias					X		X			X	X		X
Village of Western						X	X			X	X		X
City of Wilber							X		X	X	X	X	X
Thayer County	**X**		**X**		**X**	**X**				**X**	**X**		**X**
Village of Alexandria					X		X				X		X
Village of Belvidere					X					X	X		X
Village of Bruning					X		X			X	X		X
Village of Chester						X				X	X		X
Village of Davenport						X	X				X		X
City of Deshler					X		X				X		X
City of Hebron		X			X		X						X
Village of Hubbell					X					X			X
Webster County					**X**					**X**			**X**
City of Blue Hill						X				X			X
Village of Cowles										X			
Village of Guide Rock					X						X		X
City of Red Cloud					X						X		X
Adams Central Public Schools													X

Jurisdiction	Agricultural Disease	Dam Failure	Drought and Extreme Heat	Earthquakes	Flooding	Grass/Wildfire	Hazardous Materials	Levee Failure	Public Health Emergency	Severe Thunderstorms	Severe Winter Storms	Terrorism	Tornadoes and High Winds
Beatrice Public Schools					X	X	X			X	X		X
Exeter Milligan Public Schools							X			X	X		X
Meridian Public Schools										X	X		X
South Central Nebraska Unified School District						X	X		X	X	X	X	X
Superior Public Schools							X			X	X	X	X
Tri-County Public Schools							X			X	X	X	X
Southeast Community College – Beatrice										X	X		X
South Heartland District Health Department	X		X				X		X		X		X
Adams Fire District							X						
Barneston Fire District						X				X	X		X

Agricultural Plant and Animal Disease

Agricultural diseases include any biological disease or infection that can reduce the quality or quantity of either livestock or vegetative crops. This section looks at both animal disease and plant disease, as both make up a significant portion of Nebraska's and the planning area's economy.

The economy of the State of Nebraska is heavily vested in both livestock and crop sales. According to the Nebraska Department of Agriculture (NDA) in 2017, the market value for Nebraska of agricultural products sold was estimated at $22 billion; this total is split between crops (estimated $9.3 billion) and livestock (estimated $12.7 billion). For the planning area, the market value of sold agricultural products exceeded $2.4 billion ($1.1 billion animal sales and $1.2 billion crop sales).[17]

The following table shows the population of livestock within the planning area. This count does not include wild populations that are also at risk from animal diseases.

Table 8: Livestock Inventory

County	Market Value of 2017 Livestock Sales	Cattle and Calves	Hogs and Pigs	Poultry Egg Layers	Sheep and Lambs
Adams	$219,119,000	66,267	10,947	365	1,297
Clay	$198,519,000	62,013	(D)	(D)	3,770
Fillmore	$60,450,000	24,671	24,464	372	578
Gage	$99,627,000	32,517	470,968	1,443,351	351
Jefferson	$105,396,000	34,658	(D)	(D)	624
Nuckolls	$30,931,000	44,222	13,320	501	1,672
Saline	$62,195,000	28,785	56,470	391	803
Thayer	$98,957,000	45,056	(D)	398	888
Webster	$270,386,000	85,546	(D)	654	3,360
Total	**$1,145,580,000**	**423,735**	**576,169**	**1,446,032**	**13,343**

Source: U.S. Census of Agriculture, 2017; (D) – data not available

According to the NDA, the primary crops grown throughout the state include alfalfa, corn, sorghum, soybeans, wheat, sugar beets, dry beans, sunflowers, and chickpeas. The planning area is a mixture of pasture/grassland, crop land, and incorporated areas. The following tables provide the value and acres of land in farms in the planning area and the crops that make up the bulk of Nebraska's crop production.

[17] US Department of Agriculture, National Agricultural Statistics Server. 2020. "2017 Census of Agriculture – Nebraska." https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/Nebraska/

Table 9: Land and Value of Farms in the Planning Area

County	Number of Farms	Land in Farms (acres)	Market Value of 2017 Crop Sales
Adams	545	340,016	$173,393,000
Clay	441	319,009	$157,532,000
Fillmore	439	329,466	$180,495,000
Gage	1,188	538,982	$180,546,000
Jefferson	590	358,869	$114,177,000
Nuckolls	431	357,443	$116,590,000
Saline	717	360,323	$144,714,000
Thayer	414	325,649	$128,769,000
Webster	406	328,967	$77,466,000
Total	**5,171**	**3,258,724**	**$1,273,682,000**

Source: U.S. Census of Agriculture, 2017

Table 10: Crop Values

County	Corn		Soybeans		Wheat	
	Acres Harvested	Value	Acres Harvested	Value	Acres Harvested	Value
Adams	9,455,031	$113,534,000	5,664,225	$53,508,000	1,060,786	$898,000
Clay	155,125	$106,347,000	86,633	$50,131,000	1,197	$195,000
Fillmore	177,074	$116,865,000	113,624	$61,777,000	1,872	$278,000
Gage	193,150	$93,059,000	197,155	$84,214,000	5,559	$1,075,000
Jefferson	129,239	$62,402,000	118,018	$48,830,000	5,483	$1,256,000
Nuckolls	129,666	$69,803,000	81,764	$40,509,000	16,286	$2,711,000
Saline	153,803	$86,597,000	123,216	$55,859,000	3,536	$623,000
Thayer	128,948	$77,748,000	95,533	$46,642,000	6,688	$1,452,000
Webster	80,618	$43,217,000	59,658	$28,019,000	17,030	$2,684,000
Total	**10,602,654**	**$769,572,000**	**6,539,826**	**$469,489,000**	**1,118,437**	**$11,172,000**

Source: U.S. Census of Agriculture, 2017

Location

Given the strong agricultural presence in the planning area, animal and plant diseases have the potential to occur in any of the nine-county planning area. If a major outbreak were to occur, the economy across the local planning area would likely be affected. Thayer County has the smallest amount of land used for agriculture and Webster County has the fewest number of agricultural farms; however, many residents work in industries closely tied to surrounding agriculture producers which could be impacted by disease outbreaks. The Planning Team did identify the US Meat Animal Research Center in Clay County near Clay Center as a specific area of concern, however, smaller outbreaks may occur in any of the rural agricultural areas of the planning area.

The primary land uses where animal and/or plant diseases will be observed include: agricultural lands; range or pasture lands; forests; and/or concentrated animal feeding operations (CAFOs). It is possible that animal or plant disease will occur in domestic animals or crops in urban areas but their impacts will be limited in scope and severity.

Historical Occurrences

Animal Disease

The NDA provides reports on diseases occurring in the planning area. There were 125 instances of animal diseases reported between January 2014 and June 2020 by the NDA. These outbreaks affected a total of 26,798 animals and impacted all nine counties.

Table 11: Livestock Diseases Reported in the Planning Area

Disease	Year	County	Population Impacted
Anaplasmosis	2016	Adams; Clay; Gage; Saline	1;1;1;1
	2017	Clay; Jefferson	150;1
	2018	Gage	1
	2019	Fillmore; Gage	3;3
	2020	Clay; Gage	1;2
Bovine Genital Campylobacteriosis	2019	Saline	2
Bovine Viral Diarrhea	2014	Jefferson	8
	2015	Thayer	1
	2016	Gage	1
	2018	Gage; Jefferson	1;1
	2020	Jefferson	1
Brucellosis	2015	Clay	1
Caprine Arthritis/Encephalitis	2018	Clay	18
Epizootic Hemorrhagic Disease (Blue Tongue)	2014	Adams; Fillmore	1;1
	2019	Clay; Fillmore	1;1
Enzootic Bovine Leukosis	2014	Jefferson	32
	2015	Gage; Jefferson; Thayer	1;1;1
	2016	Gage, Jefferson	1;2
	2018	Gage; Jefferson; Nuckolls	2;74;1
	2019	Gage; Jefferson	1;43
	2020	Gage; Jefferson; Saline; Thayer	4;26;1;1
Leptospirosis	2014	Clay	1
	2016	Gage; Nuckolls; Webster	1;1;2
	2020	Jefferson	1
Paratuberculosis	2014	Adams; Fillmore; Gage; Jefferson; Nuckolls; Thayer	3;1;13;2;1;1
	2015	Adams; Clay; Gage	1;1;1;
	2016	Adams; Clay; Fillmore; Nuckolls; Thayer; Webster	4;1;2;1;2;2
	2017	Adams; Clay; Gage; Jefferson; Thayer; Webster	3;5;2;2;6;3
	2018	Clay; Gage; Jefferson; Nuckolls; Webster	3;12;6;1;2
	2019	Adams; Clay; Jefferson; Saline; Thayer; Webster	7;10;3;40;1;2
	2020	Adams; Clay; Gage; Jefferson; Thayer	1;3;2;1;1
Porcine Circovirus	2014	Fillmore; Jefferson; Saline	1;1;1
	2015	Saline	1
	2017	Adams	1
	2018	Saline	2
Porcine Circovirus (Type 2)	2017	Saline	1
	2018	Saline	2
Porcine Delta Coronavirus	2014	Clay; Jefferson; Webster	1;2;2
Porcine Epidemic Diarrhea	2014	Gage	2
	2015	Clay; Jefferson	1;1
	2018	Jefferson	25,001
Porcine Reproductive and Respiratory Syndrome	2014	Clay; Fillmore; Gage; Saline	1;1;15;11
	2015	Saline	1
	2016	Clay; Fillmore; Jefferson; Saline	1;1;2;8

Disease	Year	County	Population Impacted
	2017	Fillmore; Jefferson; Saline	2;17;200
	2018	Gage; Jefferson; Saline	400;9;40
	2019	Clay; Jefferson	3;3
	2020	Clay	1
Q Fever	2015	Webster	1
Seneca Valley Virus	2017	Adams; Clay; Gage; Jefferson; Saline; Thayer	1;3;1;1;1;1
Trichomoniasis	2014	Clay	1
	2015	Clay; Nuckolls	1;1
	2020	Clay	1

Source: U.S. Census of Agriculture, 2014-2020[18]

Plant Disease

A variety of diseases can impact crops and often vary from year to year. The NDA and the USDA provide information on some of the most common plant diseases, which are listed below.

Table 12: Common Crop Diseases by Crop Type

Crop Type	Crop Disease	
Corn	Anthracnose	Southern Rust
	Bacterial Stalk Rot	Stewart's Wilt
	Common Rust	Common Smut
	Fusarium Stalk Rot	Gross's Wilt
	Fusarium Root Rot	Head Smut
	Gray Leaf Spot	Physoderma
	Maize Chlorotic Mottle Virus	
Soybeans	Anthracnose	Pot and Stem Blight
	Bacterial Blight	Purple Seed Stain
	Bean Pod Mottle	Rhizoctonia Root Rot
	Brown Spot	Sclerotinia Stem Rot
	Brown Stem Rot	Soybean Mosaic Virus
	Charcoal Rot	Soybean Rust
	Frogeye Leaf Spot	Stem Canker
	Phytophthora Root and Stem Rot	Sudden Death Syndrome
Wheat	Barley Yellow Dwarf	Leaf Rust
	Black Chaff	Tan Spot
	Crown and Root Rot	Wheat soy-borne Mosaic
	Fusarium Head Plight	Wheat Streak Mosaic
Sorghum	Ergot	Zonate Leaf Spot
	Sooty Stripe	
Trees	Burr Oak Blight	Dutch Elm Disease
	Powdery Mildew	Leaf Spot and Blight
	Canker (various types)	Root Rot
	Pine Wilt Disease	Crown Gall

In addition to the viral and bacterial diseases that could impact crops, pests can also result in crop loss or detract from crop quality. Pests present in the planning area include:

- Emerald Ash Borer (EAB)

[18] Nebraska Department of Agriculture. August 2020. "Livestock Disease Reporting." http://www.nda.nebraska.gov/animal/reporting/index.html.

- Grasshoppers
- Western Bean Cutwork
- European Corn Borer
- Corn Rootworm
- Corn Nematodes, Bean Weevil
- Mexican Bean Beetle
- Soybean Aphids
- Rootworm Beetles

Emerald Ash Borer

The spread and presence of the Emerald Ash Borer (EAB) has become a rising concern for many Nebraskan communities in recent years. The beetle spreads through transport of infected ash trees, lumber, and firewood. All species of North American ash trees are vulnerable to infestation. Confirmed cases of EAB have been in three Canadian provinces and 35 U.S. states, primarily in the eastern, southern and midwestern regions. Nebraska's confirmed cases occurred on private land in Omaha and Greenwood in 2016 and Lancaster County in 2018.[19] Figure 10 shows the locations of Nebraska's confirmed EAB cases as of October 2020. Additional confirmed cases have likely occurred since then and many communities across the state and planning area are prioritizing the removal of ash trees to help curb potential infestations and tree mortality.

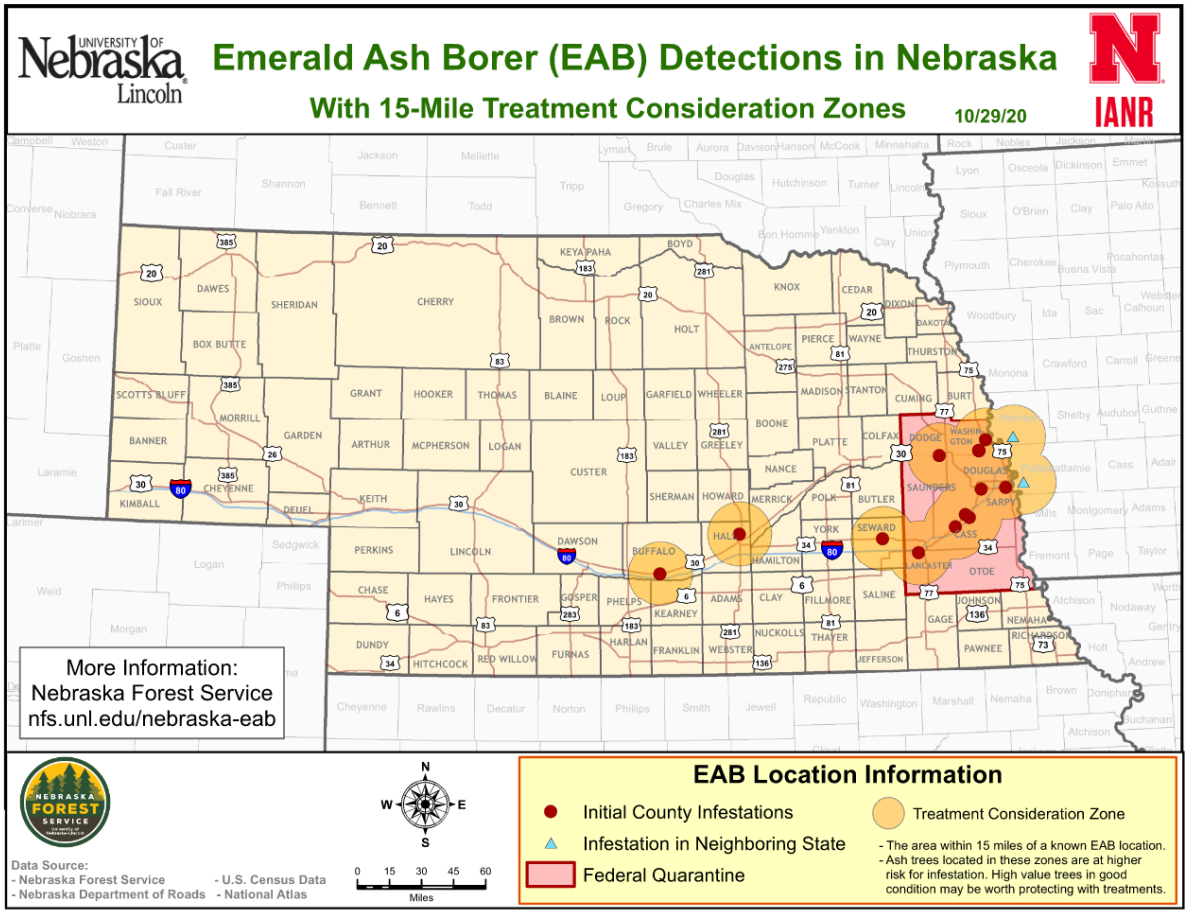
While adult beetles cause little damage, larvae damage trees by feeding on the inner bark of mature and growing trees, causing tunnels. Effects of EAB infestation include: extensive damage to trees by birds, canopy dieback, bark splitting, and water sprout growth at the tree base, and eventual tree mortality. EAB has impacted millions of trees across North America, killing young trees one to two years after infestation and mature trees three to four years after infestation.[20] Estimated economic impacts to Nebraska's 44 million ash trees exceeds $961 million.[21] Dead or dying trees affected by EAB are also more likely to cause damage during high winds, severe Thunderstorms, or severe winter storms from weakened or hazardous limbs and can contribute a significant fuel load to grass/wildfire events.

Because of the Nebraska infestations, a quarantine order has been established in Cass, Dodge, Douglas, Otoe, Sarpy, Saunders, Lancaster, and Washington Counties that restricts the movement of ash trees and lumber to further mitigate the spread of EAB. In the State of Kansas, no adjacent counties to the planning area (Marshall, Washington, Republic, Jewell, and Smith) have confirmed presence of EAB.

No counties in the planning area have reported confirmed cases of EAB; however, it is a rising concern in the planning area. Saline, Gage, and Adams Counties are at greatest risk of spreading EAB from neighboring counties with confirmed cases. The Nebraska Department of Agriculture and Kansas Forest Service regulate and monitor the sale and distribution of firewood in their respective states to restrict the flow of firewood from outside the state.

[19] Emerald Ash Borer Information Network. April 2018. "Emerald Ash Borer." http://www.emeraldashborer.info/.
[20] Arbor Day Foundation. 2015. "Emerald Ash Borer." https://www.arborday.org/trees/health/pests/emerald-ash-borer.cfm.
[21] Nebraska Department of Agriculture. 2019. "Emerald Ash Borer." https://nda.nebraska.gov/plant/entomology/eab/index.html.

Figure 10: EAB Confirmation in Nebraska



Source: NDA, 2020[22]

Average Annual Losses

According to the USDA RMA (2000-2019) there have been 258 plant disease events in the planning area. The RMA does not track losses for livestock, but annual crop loses from plant disease can be estimated. The USDA RMA also does not include losses associated with ash tree mortality from EAB. With the lack of reporting and data gathering, it is hard to determine an accurate account of disease and pests that occur in livestock and plants.

Table 13: Agricultural Disease Losses

Hazard Type	Number of Events	Events per Year	Total Loss	Average Annual Loss
Animal Disease	125	17.8	26,798 animals	3,828 animals/yr
Plant Disease	258	12.3	$3,156,617	$286,965

Source: RMA, 2000-2020; NDA, 2014-2020

Extent

There is no standard for measuring the magnitude of agricultural disease. Historically, the extent of agricultural and plant diseases has been highly localized. Given the high degree of agricultural

[22] Nebraska Department of Agriculture. October 2020. "Emerald Ash Borer." https://nda.nebraska.gov/plant/entomology/eab/index.html.

development in the planning area, potential does exist for a widespread outbreak which could affect a large area if left unattended. The USDA maintains the US Meat Animal Research Center in Clay County near Clay Center. This facility is a complex of laboratories and pastures that sprawls over 55 square miles. The planning team identified this facility as one possible source of risk for agricultural animal disease outbreaks. If an outbreak were to occur, the extent of the outbreak should be confined with the Research Center's property.

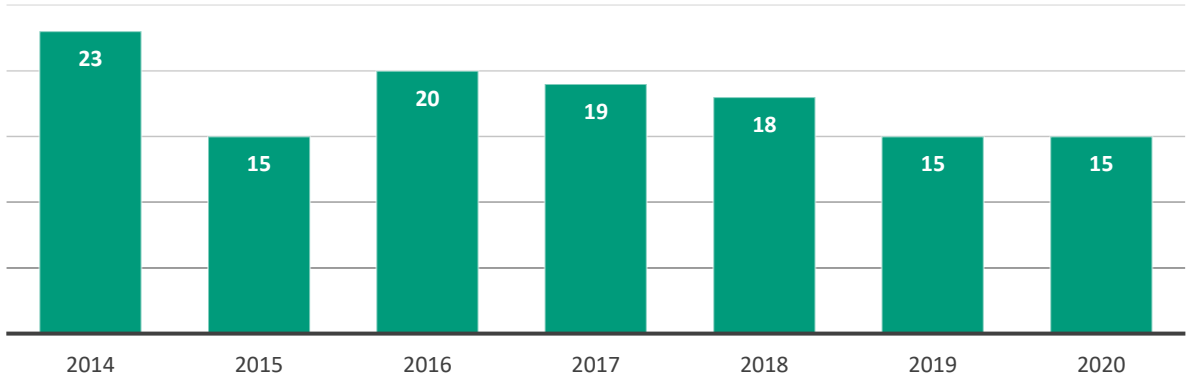
Historical events have impacted a relatively small number of livestock and/or crops in comparison to the planning area. For animal disease events, one large event impacted over 25,000 animals; however, the median impact is one animal per event. The planning area is heavily dependent on the agricultural economy. Any severe plant or animal disease outbreak which may impact this sector would negatively impact the entire planning area.

Nebraska farmers also lose a significant amount of crops each year as a result of wildlife foraging and climate change. This can be particularly problematic in areas where natural habitat has been diminished or in years where weather patterns such as early or late frost, deep snow, or drought have drastically shifted.

Probability

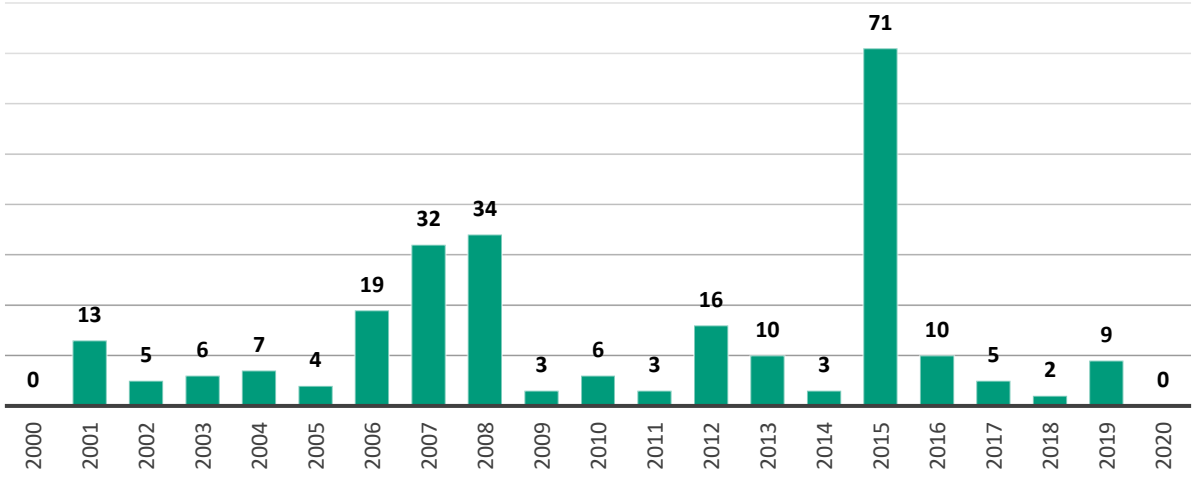
Given the historic record of occurrence for agricultural animal disease events (at least one animal disease outbreak reported in all seven years), for the purposes of this plan, the annual probability of agricultural animal disease occurrence is 100 percent. Given the historic record of occurrence for agricultural plant disease events (19 out of 21 years with a reported event), for the purposes of this plan, the annual probability of agricultural plan disease occurrence is 90%.

Figure 11: Animal Disease Events by Year



Source: NDA, 2014-2020

Figure 12: Plant Disease Events by Year



Source: RMA, 2000-2020

Community Top Hazard Status

The following table lists jurisdictions which identified Agricultural Plant and Animal Disease as a top hazard of concern:

Jurisdictions	
Little Blue NRD	Village of Glenvil
Thayer County	South Heartland District Health Department
City of Clay Center	

Regional Vulnerabilities

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

Table 14: Regional Agricultural Disease Vulnerabilities

Sector	Vulnerability
People	-Those in direct contact with infected livestock -Potential food shortage during prolonged events -Residents in poverty if food prices increase
Economic	-Economic power tied to the agricultural industry -Large scale or prolonged events may impact tax revenues and local capabilities -Land values may largely drive population changes within the planning area
Built Environment	None
Infrastructure	-Transportation routes can be closed during quarantine
Critical Facilities	-None
Climate	-Changes in seasonal normals can promote spread of invasive species and agricultural disease

Dam Failure

According to the Nebraska Administrative Code, dams are "any artificial barrier, including appurtenant works, with the ability to impound water, wastewater, or liquid-borne materials and which is:

- twenty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier, or from the lowest elevation of the outside limit of the barrier if it is not across a stream channel or watercourse, to the maximum storage elevation, or
- has an impounding capacity at maximum storage elevation of fifty acre-feet or more, except that any barrier described in this subsection which is not in excess of six feet in height or which has an impounding capacity at maximum storage elevation of not greater than fifteen acre-feet shall be exempt, unless such barrier, due to its location or other physical characteristics, is classified as a high hazard potential dam.

Dams do not include:

- an obstruction in a canal used to raise or lower water;
- a fill or structure for highway or railroad use, but if such structure serves, either primarily or secondarily, additional purposes commonly associated with dams it shall be subject to review by the department;
- canals, including the diversion structure, and levees; or
- water storage or evaporation ponds regulated by the United States Nuclear Regulatory Commission."[23]

The NeDNR uses a classification system for dams throughout the state, including those areas participating in this plan. The classification system includes three classes, which are defined in the table below.

Table 15: Dam Size Classification

Size	Effective Height (ft) x Effective Storage (acre-ft)	Effective Height
Small	≤ 3,000 acre-ft	And ≤ 35 feet
Intermediate	> 3,000 acre-ft to < 30,000 acre-ft	Or > 35 feet
Large	≥ 30,000 acre-ft	Regardless of height

Source: NeDNR, 2013[24]

The effective height of a dam is defined as the difference in elevation in feet between the natural bed of the stream or watercourse measured at the downstream toe (or from the lowest elevation of the outside limit of the barrier if it is not across stream) to the auxiliary spillway crest. The effective storage is defined as the total storage volume in acre-feet in the reservoir below the elevation of the crest of the auxiliary spillway. If the dam does not have an auxiliary spillway, the effective height and effective storage should be measured at the top of dam elevation.

[23] Nebraska Department of Natural Resources. "Department of Natural Resources Rules for Safety of Dam and Reservoirs." Nebraska Administrative Code, Title 458, Chapter 1, Part 001.09.

[24] Nebraska Department of Natural Resources. 2013. "Classification of Dams: Dam Safety Section." https://dnr.nebraska.gov/sites/dnr.nebraska.gov/files/doc/damsafety/resources/Classification-Dams.pdf.

Dam failure, as a hazard, is described as a structural failure of water impounding structure. Structural failure can occur during extreme conditions, which include but are not limited to:

- Reservoir inflows in excess of design flows
- Flood pools higher than previously attained
- Unexpected drop in pool level
- Pool near maximum level and rising
- Excessive rainfall or snowmelt
- Large discharge through spillway
- Erosion, landslide, seepage, settlement, and cracks in the dam or area
- Earthquakes
- Vandalism
- Terrorism

NeDNR regulates dam safety and has classified dams by the potential hazard each poses to human life and economic loss. The following are classifications and descriptions for each hazard class:

- **Minimal Hazard Potential** - failure of the dam expected to result in no economic loss beyond the cost of the structure itself and losses principally limited to the owner's property.
- **Low Hazard Potential** - failure of the dam expected to result in no probable loss of human life and in low economic loss. Failure may damage storage buildings, agricultural land, and county roads.
- **Significant Hazard Potential** - failure of the dam expected to result in no probable loss of human life but could result in major economic loss, environmental damage, or disruption of lifeline facilities. Failure may result in shallow flooding of homes and commercial buildings or damage to main highways, minor railroads, or important public utilities.
- **High Hazard Potential** - failure of the dam expected to result in loss of human life is probable. Failure may cause serious damage to homes, industrial or commercial buildings, four-lane highways, or major railroads. Failure may cause shallow flooding of hospitals, nursing homes, or schools.

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 efficiency 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). According to NeDNR, there are 14 high hazard dams located within the planning area.

Location

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 577 dams located within the nine-county planning area.

At this time dam owners and the NeDNR have opted at this time to not include dam breach maps or inundation maps in hazard mitigation plans due to the sensitive nature of this information. Requests can be made of the dam owner or the Dam Safety Division of NeDNR to view an inundation to view an inundation map specific to a dam. Figure 13 maps the physical locations of dams in the planning area.

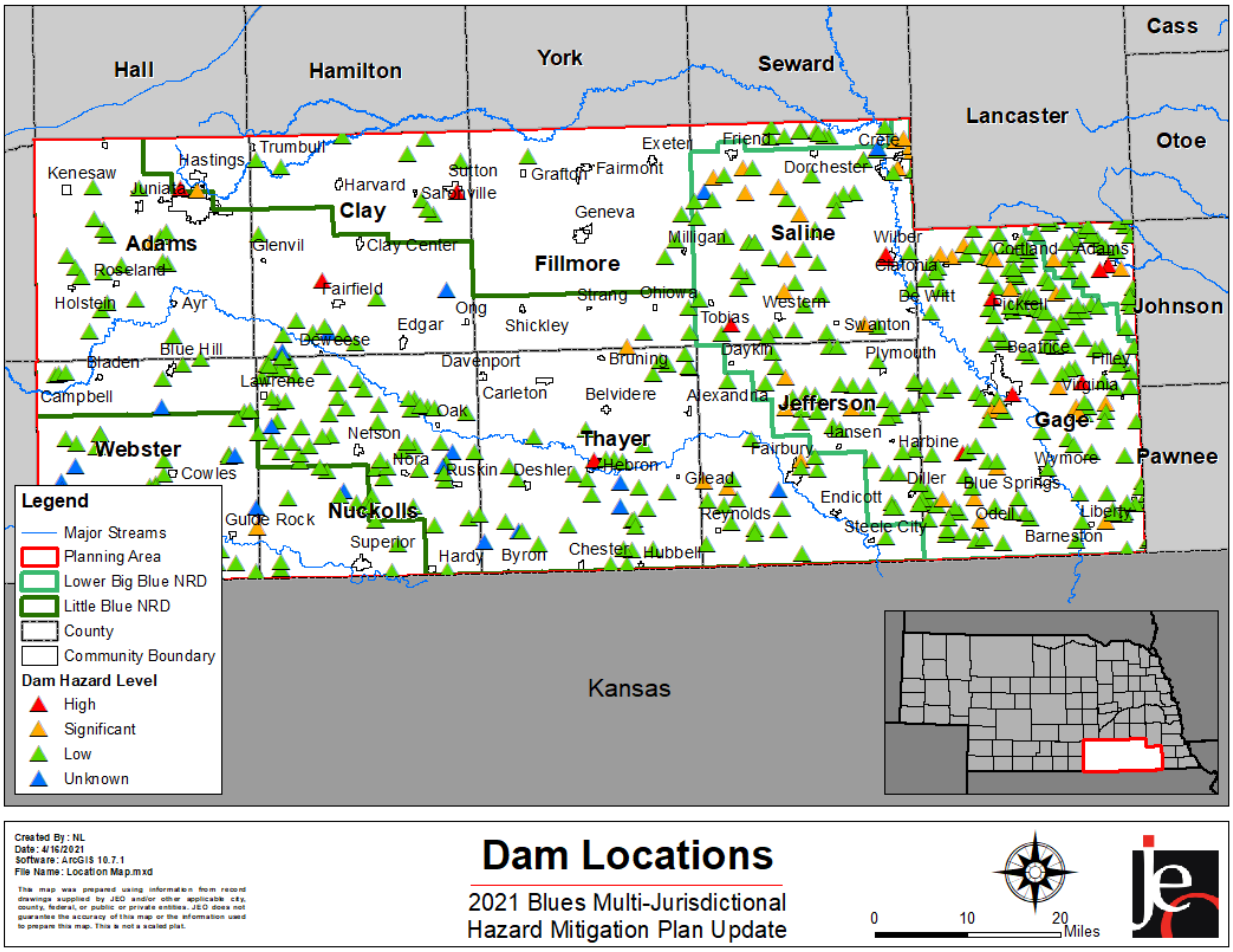
Table 16: Dams in the Planning Area

County	Minimal Hazard	Low Hazard	Significant Hazard	High Hazard	Total
Adams	1	19	4	2	**26**
Clay	4	20	0	2	**26**
Fillmore	0	8	1	0	**9**
Gage	3	179	19	6	**207**
Jefferson	1	57	7	0	**65**
Nuckolls	7	71	1	0	**79**
Saline	2	53	13	3	**71**
thayer	5	34	0	1	**40**
Webster	9	39	6	0	**54**
Total	**32**	**480**	**51**	**14**	**577**

Source: NeDNR, 2021[25]

[25] Nebraska Department of Natural Resources. 2021. "Nebraska Dam Inventory." https://dnr.nebraska.gov/dam-safety/nebraska-dam-inventory.

Figure 13: Dam Locations in the Planning Area



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

Table 17: High Hazard Dams in the Planning Area

NID	Dam Name	Owner	Stream Name	Downstream Town
Adams County				
NE01726	Hastings Northwest Dam	UBBNRD	TR-W FK Big Blue River	Hastings
NE01551	Thirty-Two Mile Creek H	LBNRD	Thirty-Two Mile Creek	Deweese
Clay County				
NE02407	Dam 2-7-5W	City of Sutton	Tr-School Creek	Sutton
NE00703	Big Sandy Creek 20-6-7	LBNRD	Big Sandy Creek	2 Farmsteads
Gage County				
NE00914	Upper Big Nemaha 25-C (Rehab)	Nemaha NRD	Jakes Creek	Railroad
NE00993	Upper Big Nemaha 7-A	Nemaha NRD	TR-Mid BR Big Nemaha River	Adams
NE01000	Mud Creek 2-A	LBBNRD	Mud Creek	Farmstead/Us Hwy 136 (2-Lane)
NE01210	Big Indian Creek 14-B	LBBNRD	Sicily Creek	Farmstead

NID	Dam Name	Owner	Stream Name	Downstream Town
NE04779	Flowing Springs Dam	Flowing Springs Development LLC	TR-Big Blue River	Beatrice
NE00489	Little Indian Creek 15-A	LBBNRD	Possum Creek	US Hwy 77 (4-Lane Divided)
Saline County				
NE07975	Wilber Watershed Dam	Lower Big Blue Natural Resources District	TR-Big Blue River	Wilber
NE01519	Wilber Dam 1	City of Wilber	TR-Big Blue River	Wilber
NE02248	Swan Creek 20	Lower Big Blue Natural Resources District	S FK Swan Creek	Farmstead
Thayer County				
NE01576	Hebron Dam	Thayer County	TR-Little Blue River	Hebron

Source: NeDNR, 2020[26]

Dams of Concern Outside the Planning Area

There is one identified dam upstream of the planning area which, in the case of failure event, would impact communities in the planning area. The Upper Big Nemaha 11-A dam in Firth Nebraska would potentially impact upper Gage County if a failure were to occur. Additionally, there are four high hazard dams in neighboring counties in Kansas to the south, two are in Jewell County and two are in Marshall County. Failure of these dams would not impact locations in the planning area.

Historical Occurrences

According to NeDNR as of December 2020, 18 dam failure events have occurred within the planning area. The following table describes dam failure events.

Table 18: High Hazard Dams in the Planning Area

NID	County	Dam Name	Hazard Class	Year of Failure	Description of Failure
NE00275	Adams	Dominy Dam 1	Low	1998E	Piping Along Conduit – Failure likely caused by corroded CMP spillway conduit. No damages reported.
NE01017	Gage	Barneston Power Plant Dam	Low	1993	Gate Washed Out – No damages reported.
NE01461	Gage	Blue Springs Power Plant Dam	Low	2004	Overtopped During Flooding – No damages reported.
NE00490	Gage	Snyder Dam 490	Low	2006E	Unknown Breach – No damages reported.
NE04758	Gage	Kapke Dam	Low	2015	Piping Along Conduit – Damages unknown, failure occurred during widespread flooding.
NE00206	Jefferson	Davis Dam 206	Low	1995E	Unknown Breach – No damages reported.

[26] Nebraska Department of Natural Resources. 2020. "Nebraska Dam Inventory." https://dnr.nebraska.gov/dam-safety/nebraska-dam-inventory.

NID	County	Dam Name	Hazard Class	Year of Failure	Description of Failure
NE05530	Jefferson	Schmidt Ag Irrig Dam	Low	2019	Internal Erosion Along Conduit – No damages reported. Likely due to dispersive clay.
NE06106	Jefferson	Dowdy Dam 6106	Low	2019	Conduit Corrosion – No damages reported. Local road that ran along the crest of the dam was closed for several months.
NE01612	Nuckolls	Jones Dam 1612	Low	1988E	Unknown Breach – No damages reported.
NE00218	Nuckolls	Saul Dam	Low	1994E	Unknown Breach – Breached between 1994 and 1997. No damages reported.
NE01613	Nuckolls	Adams Dam	Low	2015E	Unknown Breach – No damages reported.
NE01499	Saline	Dudley Dam	Low	1978E	Spillway Erosion – No damages reported.
NE04436	Saline	Stehlik Dam	Low	2016	Unknown Breach – No damages reported.
NE01383	Thayer	Elting Dam	Low	2007E	Internal Erosion Along Conduit – No damages reported.
NE00453	Thayer	Fintel Dam	Low	2009E	Overtopped – Erosion over principal spillway. No damages reported.
NE06722	Thayer	Hintz Dam	Low	2015	Overtopped – minor flooding of country roads, rebuilt in 2016.
NE08657	Thayer	Dageforde Dam	Low	2019E	Conduit Corrosion – No damages reported.
NE01291	Webster	Schmidt Dam 1291	Low	2007E	Auxiliary Spillway Erosion – No damages reported.

Source: NeDNR private correspondence, 2020; E indicates year of failure is estimated

Additionally, the planning team highlighted a historical occurrence on May 10, 1982 in which a road dam failed and caused road damages in Adams and Webster County. No specific damages, injuries, fatalities, or evacuations were reported from these dam failure events. All dams are inspected on a regular basis and after area flash flood events. If problems are found during an inspection, the proper course of action is taken to ensure the structural integrity of the dam is preserved. In the event that dam failure is imminent, the Emergency Action Plan (EAP) for the dam governs the course of action.

Average Annual Losses

Due to a lack of data and the sensitive nature of this hazard, potential losses are not calculated for this hazard. Community members in the planning area that wish to quantify the threat of dam failure should contact their County Emergency Management, the LBNRD, the LBBNRD, or the NeDNR.

Extent

The extent of dam failure is indicated by its hazard classification and location. 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 dam in the planning area would have the greatest impact if it were to fail.

Since inundation maps are not made publicly available for security reasons, the following is provided as a description of areas affected in the inundation area from the County's Local Emergency Operations Plan (LEOP) where available for specific high hazard dams. Note that not all of the high hazard dams in each county are given extended descriptions in the county LEOPs.

Adams County

- *Northwest Watershed Dam Adams County – owned by Adams County, City of Hastings, and Upper Blue Natural Resource District.*
- *Lake Hastings Dam – owned by City of Hastings.*

Clay County

- *Flood Control Dam Site #2-7-5w, School Creek Watershed – owned by City of Sutton.* Approximately 2 to 3 percent of the population of Clay County could be affected by the failure of this dam.

Fillmore County

- *None identified in LEOP.*

Gage County

- *Site 7-A Dam-Adams: Upper Nemaha Watershed – owned by Nemaha NRD.* Inundation Area: this would affect Jakes Creek and the Middle Branch of the Big Nemaha as far as Tecumseh, Johnson County. In Gage County, the area affected would be slightly greater than the 100-year floodplain with the greatest affect on 15% of the population and the business area of Adams. Refer to the Nemaha NRD Warning and Information Plan for detailed maps.
  Approximately 4% of the population of Gage County could be affected by the failure of one or another of these dams.

Jefferson County

- *None identified in LEOP.*

Nuckolls County

- *None identified in LEOP.*

Saline County

- *Wilber Detention Dam No 1 – owned by Lower Big Blue Natural Resources District.* Located at the west edge of Wilber, south of Highway 41 with a total drainage of .44 square miles. It is a rolled earth fill structure with a crest length of 542 feet, a crest width of 28 feet, and 22 feet in height above the streambed. It will store 13 acre-feet at normal pool, 85 acre-feet at spillway crest, and 127 acre-feet at

maximum pool. Inundation Area: In Wilber, the area affected would be slightly greater than the 100-year floodplain with the greatest effect on an area approximately two blocks wide and 11 blocks long in the City of Wilber with 100 percent inundation.

- *Wilber Detention Dam No 2 – owned by Lower Big Blue Natural Resources District.* Located at the northwest edge of Wilber just west and north of the water tower with a total drainage of 474 acres. It is a rolled earth fill structure with a crest length of 1,020 feet and 28 feet in height above the streambed. It will store 38.1acre-feet at normal pool, 141 acre-feet at spillway crest, and 400.5 acre-feet at maximum pool. Inundation Area: in Wilber, the area affected would be slightly greater than the 100-year floodplain with the greatest effect on an area approximately two blocks wide and 11 blocks long in the City of Wilber with 100 percent inundation.
- *Swan Creek Watershed Dam No 20 – owned by Lower Big Blue Natural Resources District.* Located 2 miles east and 2 miles south of Tobias. It is located on a tributary on the South Fork of Swan Creek. The drainage area of the dam is 4,926 acres. The basin has a total length of 5 miles and an average width of 2 miles. The topography of the area is nearly level to moderate steep and drainage patterns are well defined. Slopes along the main channel average about 37 feet per mile. The crest length is 1,760 feet; crest width is 18 feet, and 55 feet high above the streambed. It will store 340.5 acre-feet at normal pool, 1,838 acre-feet at spillway crest, and 4,277.5 acre-feet at maximum pool. Inundation Area: In saline County the area affected would be slightly greater than the 100-year floodplain with the greatest effect upon an area approximately 0.2 mile in width and 2 miles downstream which would approach 100 percent inundation.

  Approximately 5% of the population of Saline County could be affected by the failure of one or another of these dams.

Thayer County

- *None identified in LEOP.*

Webster County

- *Harlan County Dam – owned by USACE.* Inundation Area: this would affect the Republican River in Webster County. The area affected would be slightly greater than the 100-year floodplain with the greatest effect on Inavale which would approach 100 percent inundation as well as Red Cloud and Guide Rock which would approach 50% inundation. Refer to the Harlan County Dam Warning and Information Plan for detailed maps.

  Approximately 1% of the population of Webster County could be affected by the failure of one or another of these dams.

Probability

According to the 2019 Nebraska State Hazard Mitigation Plan and NeDNR, the probability of a high hazard dam failing is “very low” due to the high design standards for this class of dam. There is a higher possibility of a significant or low hazard dam failing as those dams are not designed to the same standard. There have been 13 years with a reported dam failure out of 129 years, so the probability of dam failure will be stated as ten percent annually.

Community Top Hazard Status

The following table lists jurisdictions which identified Dam Failure as a top hazard of concern:

Jurisdictions	
Little Blue NRD	City of Hebron
Lower Big Blue NRD	City of Superior
City of Hastings	Village of Adams

Regional Vulnerabilities

According to the *Classification of Dams (2013)* developed and updated by NeDNR, "*the potential for future development must be taken into consideration when determining the hazard potential class for a dam. Any dam located in close proximity to a city or village as detailed in Table 68 must be designed to meet the requirements for a high hazard potential structure. The design requirements can be adjusted if development in the downstream breach inundation area is sufficiently curtailed due to zoning restrictions, easements, deed restrictions, or other methods of restriction acceptable to the Department*."[27] Regional vulnerabilities to dam failure vary based on surrounding development and other flood control measures. A minor dam failure also has the potential to cause loss of life and property damage. When dams fail suddenly their contents are released at a high rate of speed, this has the potential to cause injuries, loss of life, or property damage. As communities and the region develop, considerations should be made to a variety of local vulnerabilities. The following table provides information related to regional vulnerabilities; for jurisdictional-specific vulnerabilities, refer to *Section Seven: Community Profiles.* Specifically communities at greater risk include Adams, Hebron, Sutton, and Wilber.

Table 19: Regional Dam 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
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
BUILT ENVIRONMENT	-Damage to homes and buildings
INFRASTRUCTURE	-Transportation routes could be closed for extended periods of time
CRITICAL FACILITIES	-Critical facilities in inundation areas are vulnerable to damages
CLIMATE	-Increased annual precipitation contributes to sustained stress on systems -Changes in water availability and supply can constrain energy production and reservoir stores

[27] Nebraska Department of Natural Resources. March 2013. "Classification of Dams." https://dnr.nebraska.gov/sites/dnr.nebraska.gov/files/doc/dam-safety/resources/Classification-Dams.pdf.

Drought and Extreme Heat

Drought is generally defined as a natural hazard that results from a substantial period of below normal precipitation. Although many erroneously consider it a rare and random event, drought is a normal, recurrent feature of climate. It occurs in virtually all climatic zones, but its characteristics 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. Extreme heat can also 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.

The planning area is a mixture of rural and moderately sized metropolitan areas, which presents an added vulnerability to extreme heat and drought events as:

- In rural areas those suffering from an extreme heat event may be farther away from medical resources;
- Drought conditions can significantly and negatively impact the agricultural economic base and numerous affiliate industries.
- Cities trap heat to a greater extent, exacerbating extreme heat events for residents; and

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 extreme heat or 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:

- **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.[28]

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.

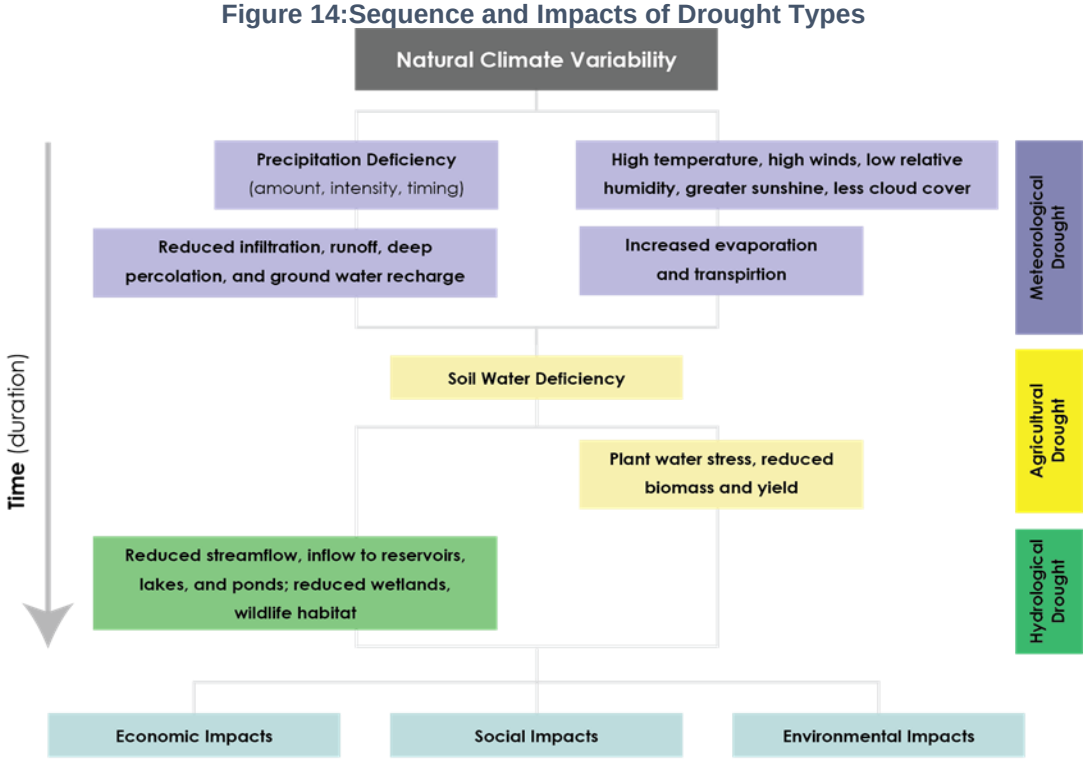
Along with humans, animals also can be affected by high temperatures, drought conditions, and humidity levels. For instance, cattle and other farm animals respond to heat by reducing feed intake, increasing their respiration rate, and increasing their body temperature. These responses assist the animal 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.

The following figure indicates different types of droughts, their temporal sequence, and the various types of effects they can have on a community.

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

Figure 14:Sequence and Impacts of Drought Types



Source: National Drought Mitigation Center, University of Nebraska-Lincoln, 2017[29]

Location

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

Historical Occurrences

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 planning area was collected from Climate Division 8 – South Central Nebraska which includes Adams and Webster Counties and from Climate Division 9 – Southeast Nebraska which includes Clay, Fillmore, Saline, Nuckolls, Thayer, Jefferson, and Gage Counties between the years of 1895 and 2020. The table below shows details of the Palmer classifications. The figures below show the data from this time period from NCEI. 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 1980s and the most recent 2012 drought. The planning area has a cyclical wet and dry period.

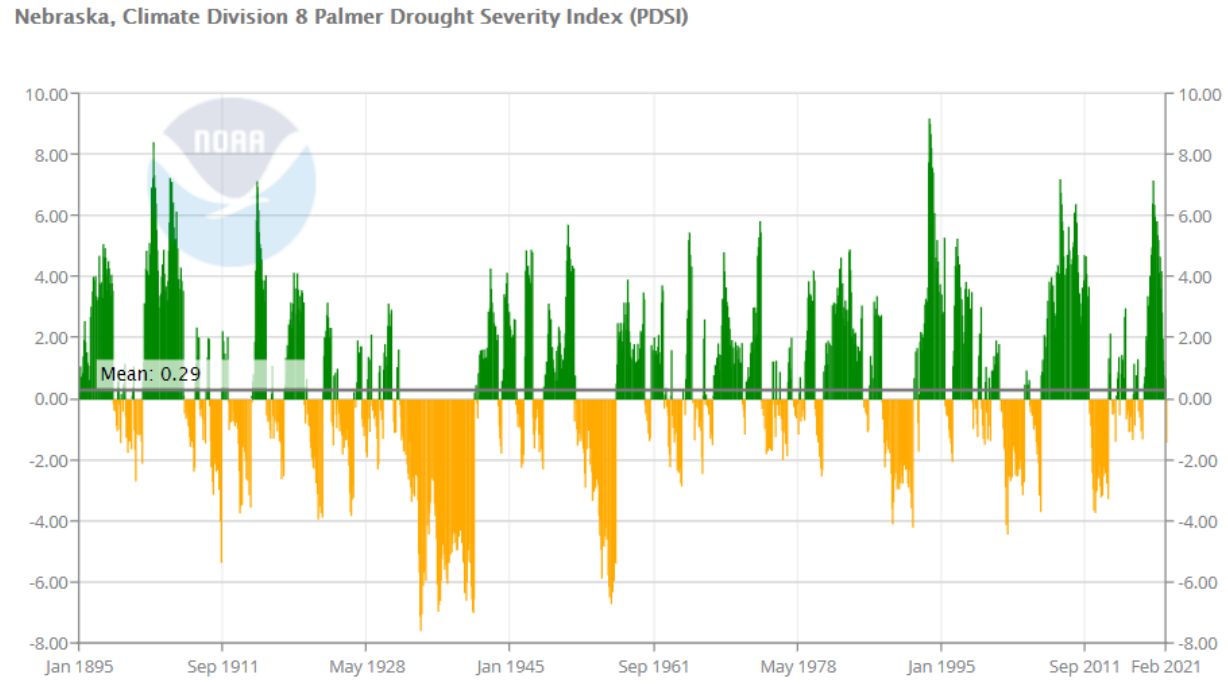
Table 20: Palmer Drought Magnitude

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	--	--

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

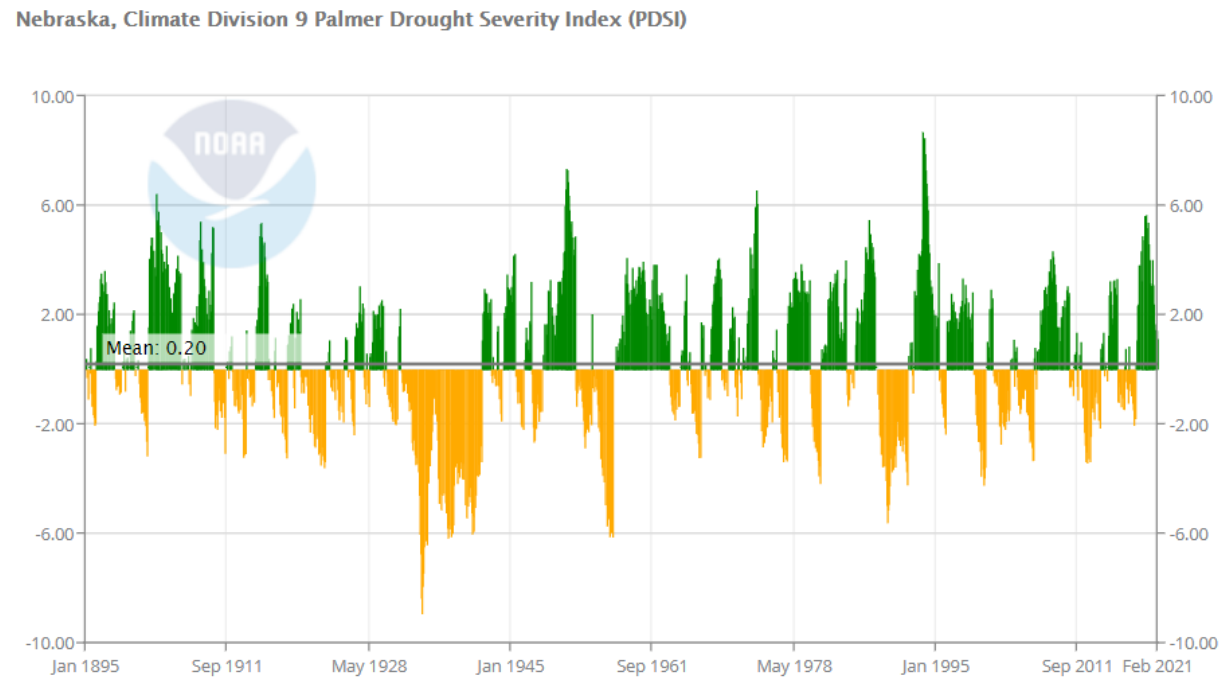
Source: NCEI

Figure 15: Palmer Drought Severity Index – South Central



Source: NOAA

Figure 16: Palmer Drought Severity Index – Southeast



Source: NOAA

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

Table 21: Historic Drought Events and Probability

Drought Magnitude	Months in Drought	Percentage
-1 Magnitude (Mild)	209/1,504	13.9%
-2 Magnitude (Moderate)	108/1,504	7.2%
-3 Magnitude (Severe)	95/1,504	6.3%
-4 Magnitude or Greater (Extreme)	81/1,504	5.4%
Total Months in Drought	**493/1,504**	**32.8%**

Source: NCEI, Jan 1895-July 2020

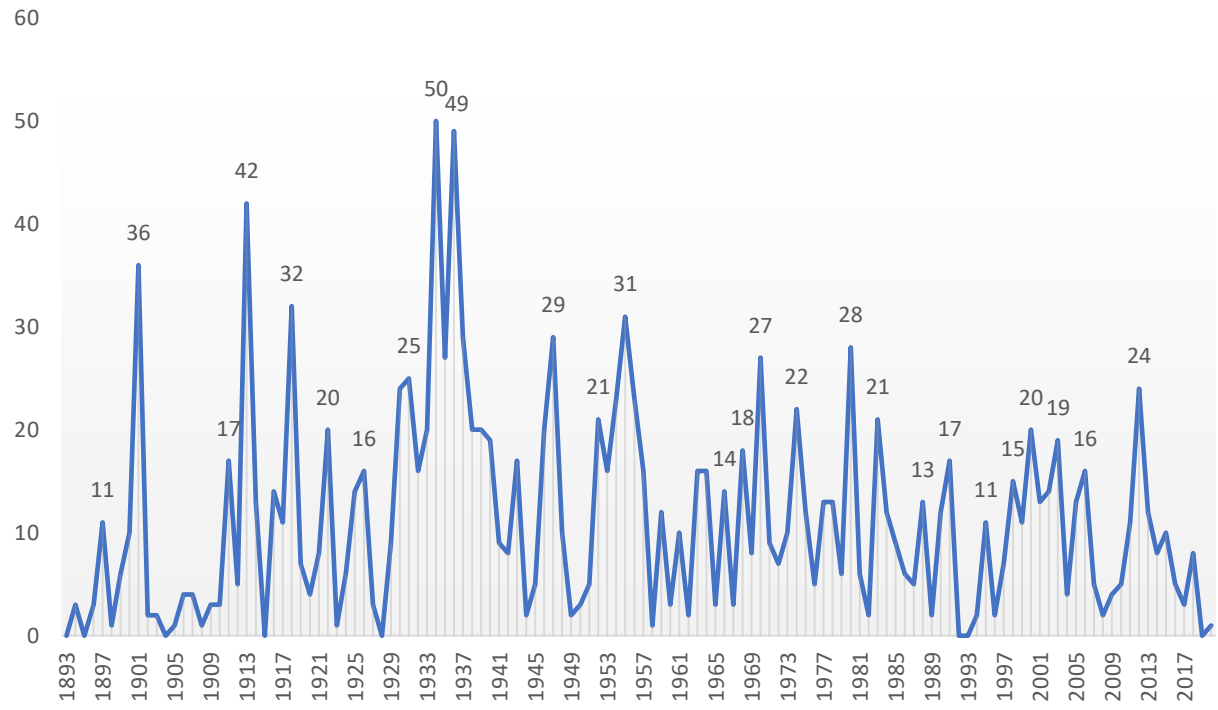
Using the data from the PDSI, the planning area has exceptional droughts approximately 15 times since 1895. Some of the exceptional drought events have lasted for multiple years (1930's, 1950's). Other exceptional droughts occurred in the 1980's and most recently in 2000. Severe droughts occurred in most decades dating back to the 1900's with the exception of the 1950's and 1990's. Over half of all years dating back to 1895 experienced precipitation levels below what is considered the norm for the planning area.

The most recent drought of note for the planning area was in 2014 (moderate drought), per the National Climatic Data Center. Impacts from recent droughts that were reported by local planning teams include shortages of water available for irrigation, water restrictions for households, shortages of potable water from wells, decreases in water quality, and excessive wear on water pumping equipment.

The 2012 drought event is the most recent significant event on record for the planning area; however, the overall event did not warrant a presidential disaster declaration within Nebraska. The whole state of Nebraska was in severe drought conditions from the middle of July in 2012 to the end of May in 2013 and over 70% of the state was in exceptional drought conditions for over eight months. Numerous cities implemented mandatory water restrictions, and some encouraged voluntarily water conservation during the period of drought. Local planning teams reported a few impacts from the 2012 drought which were primarily lower water well levels and some communities encouraged water restrictions.

According to the High Plains Regional Climate Center (HPRCC), on average, the planning area experiences six days above 100°F per year. The planning area experienced the most days on record above 100°F in 1934 with 50 days and 1936 with 49 days. Conversely, 2020 was the most recent 'coolest' year on record with only one reported day above 100°F. However, this is likely attributed to a lack of reportable data.

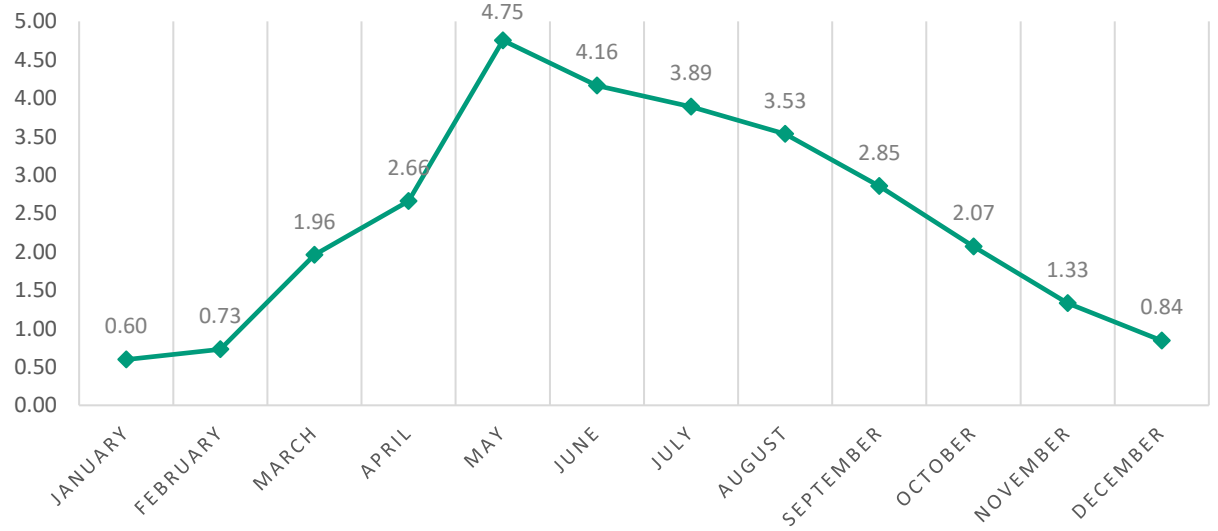
Figure 17:Number of Days above 100°F



Source: HPRCC, 2020

On average, the planning area receives approximately 29 inches of precipitation annually.[30] The following figure shows average precipitation per month in the planning area. Prolonged deviations from the norm showcase drought conditions and influence growing conditions for farmers or resource management needs for local agricultural producers.

Figure 18:Average Monthly Precipitation



Source: NCEI, 2020

[30] NOAA National Centers for Environmental Information. January 2020. "Data Tools: 1981-2010 Normals." [datafile]. https://www.ncdc.noaa.gov/cdoweb/datatools/normals.

For the purposes this plan, only reports of 'Excessive Heat' are analyzed from the NCEI Storm Events Database. However, several 'Heat' events have caused significant impacts to the planning area. Event information for significant Excessive Heat and Heat events are described below:

- **Heat – Clay and Fillmore County 6/22/2009 –** *A strong upper level ridge anchored across the central U.S. allowed for hot air to build into the region, and along with surface dewpoints in the upper 60s and lower 70s, made for muggy conditions. Heat indices across the area reached into the 100 to 110 degree range on the 23rd, which lead to the deaths of approximately 4,000 head of cattle. The afternoon high temperatures reached into the mid to upper 90s, which was a change from the previous few weeks, where highs had generally been in the 70s and 80s. The cooler than normal high temperatures had prevented the cattle from properly shedding their winter coats, which aided in their overheating.*
- **Excessive Heat - Fillmore County 7/15/2011 –** *July 2011 will be remembered for the heat across South Central Nebraska, with nearly the entire area averaging 3-4 degrees above 30-year normals when factoring in both the daily highs and lows. The overall hottest 10-11 day stretch of the month centered from the 14th through the 24th, as an expansive upper level high pressure ridge became dominant over the Central Plains. During this time frame, daily high temperatures were well into the 90s to near 100, with locations such as Hastings reaching at least 96 degrees six times. Factoring in high humidity, with dewpoints well into the 70s most days, afternoon heat index values across the 24-county area climbed to around 105 degrees on several afternoons, and topped out closer to 110 or higher in eastern counties such as York, Fillmore, Thayer and Nuckolls. Although the heat put a strain on area crops, including corn entering the pollination stage, significant agricultural impacts were minimized as most of South Central Nebraska received near-to-above-normal precipitation for the month*
- **Excessive Heat – Jefferson 6/22/2009 -** *A period of hot and very humid conditions was observed over eastern Nebraska and southwest Iowa on June 22nd and 23rd. High temperatures on the 22nd were in the lower to mid 90s and in the mid to upper 90s on the 23rd. Overnight lows on the 23rd were in the mid to upper 70s. Dew point temperatures on the 23rd were in the mid 70s to lower 80s. The combination of the heat and humidity brought heat index values up into the 108 to 118 degree range during the afternoon of the 23rd. Since these extremely uncomfortable temperatures occurred with light winds, generally less than 10 mph, conditions became deadly for livestock, especially during the afternoon of the 23rd. It was estimated that at least 2,000 head of cattle died because of the heat in eastern Nebraska and western Iowa, most of them on the 23rd. Conditions improved a bit during the late afternoon and early evening of the 23rd when isolated thunderstorms and associated outflow brought a little cooler temperatures and increased winds.*

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 the RMA Cause of Loss Historical Database since 2000. This does not include losses from displacement, functional downtime, economic loss, injury, or loss of life. The direct and indirect effects of extreme heat and drought are difficult to quantify. Potential losses such as power outages could affect businesses, homes, and critical facilities. High demand and intense use of air conditioning or water pumps can overload the electrical systems and cause damages to infrastructure. The NCEI database

reported $70,400,000 in property damages and over $268,000,000 in crop damages from drought and extreme heat. However, it is important to note that additional heat damages were reported which were the result of loss of livestock during extreme heat events.

Table 22: Drought and Extreme Heat Losses

Hazard Type	Avg. # Days over 100°F[1]	Total Property Loss[2]	Average Annual Property Loss	Total Crop Loss[3]	Average Annual Crop Loss
Drought	-	$70,000,000	$2,800,000	$246,935,998	$11,758,857
Extreme Heat	6 days	$400,000	$16,000	$22,026,050	$1,048,860

Source: 1 HPRCC (1893-2020), 2 NCEI (Jan 1996-April 2020), 3 USDA RMA (2000-Aug 2020)

The USDA reported a total of $139,957,809 in drought relief to Nebraska from 2008 to 2011 for all five disaster programs: Supplemental Revenue Assistance payments (SURE); Livestock Forage Disaster Assistance Program (LFD); Emergency Assistance for Livestock, Honeybees, and Emergency Assistance for Livestock, Honey Bees, and Farm-Raised Fish Program (ELAP); Livestock Indemnity Program (LIP); and Tree Assistance program (TAP).

The extreme drought in 2012 significantly affected the agricultural sector across the State of Nebraska and for the planning area. According to the PDSI, 2012's average severity index was ranked at a -4.47, with extremes in August and September of -7.35 and -7.57 respectively. The Farm Credit Services reported total indemnity payments to Nebraska totaled $1.49 billion from crop loss. Cattle ranching is a large driver of the local planning area's economy. The 2012 drought forced ranchers to cull herds by as much as 60% to cope with reduced forage production with an estimated loss of $200 per head by taking cattle to market earlier than normal. Neighborhood plots and small organic farms up to large-scale corn and soybean productions and ranches all faced agricultural declines. Hay production was down 28%, corn was down 16%, and soybean production dropped by 21%.[31]

Estimated Loss of Electricity

According to the FEMA Benefit Cost Analysis (BCA) Reference Guide, if an extreme heat event occurred within the planning area, 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.[32] 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 23: Loss of Electricity – Assumed Damage by Jurisdiction

County	2018 (est.) Population	Population Affected (assumed 10%)	Electric Loss of Use Assumed Damage per Day
Adams	31,583	3,158	$397,908
Clay	6,232	623	$78,498
Fillmore	5,574	557	$70,182
Gage	21,595	2,159	$272,034
Jefferson	7,188	718	$90,468
Nuckolls	4,275	427	$53,802

[31] National Integrated Drought Information System, National Drought Mitigation Center, and University of Nebraska-Lincoln. 2015. "From Too Much to Too Little: how the central U.S. drought of 2012 evolved out of one of the most devastating floods on record in 2011." https://www.drought.gov/drought/sites/drought.gov.drought/files/media/reports/regional_outlooks/CentralRegion2012DroughtAssessment_1-5-15.pdf.

[32] Federal Emergency Management Agency. June 2009. "BCA Reference Guide."

County	2018 (est.) Population	Population Affected (assumed 10%)	Electric Loss of Use Assumed Damage per Day
Saline	14,288	1,428	$179,928
Thayer	5,098	509	$64,134
Webster	3,571	357	$44,982
Total	99,404	9,936	$1,251,936

Extent

A key factor to consider regarding drought and 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 19: 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										

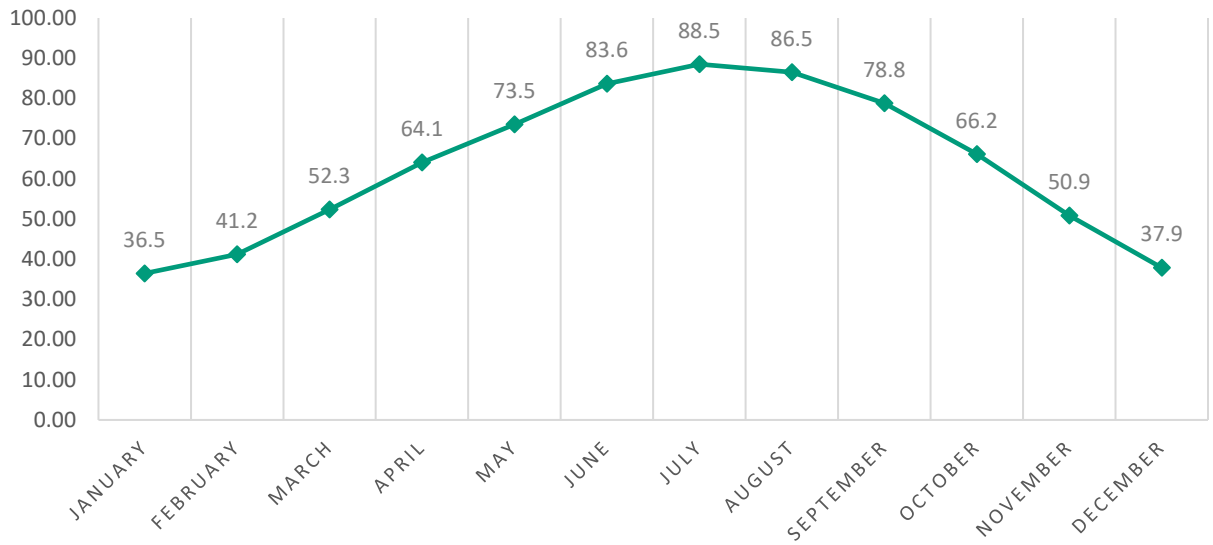
Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

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 planning area the months with the highest average temperatures are June, July, and August.

Figure 20: Monthly Climate Normals Max Temperature (1981-2010)



Source: NCEI, 2019

Probability

Extreme heat is a regular part of the climate; with 125 years out of 128 having at least one day over 100°F. On average the planning area experiences six days over 100°F. The probability that extreme heat will occur in any given year in the planning area is 98 percent. Drought conditions are also likely to occur regularly in the planning area. The following table summarizes the magnitude of drought and monthly probability of occurrence.

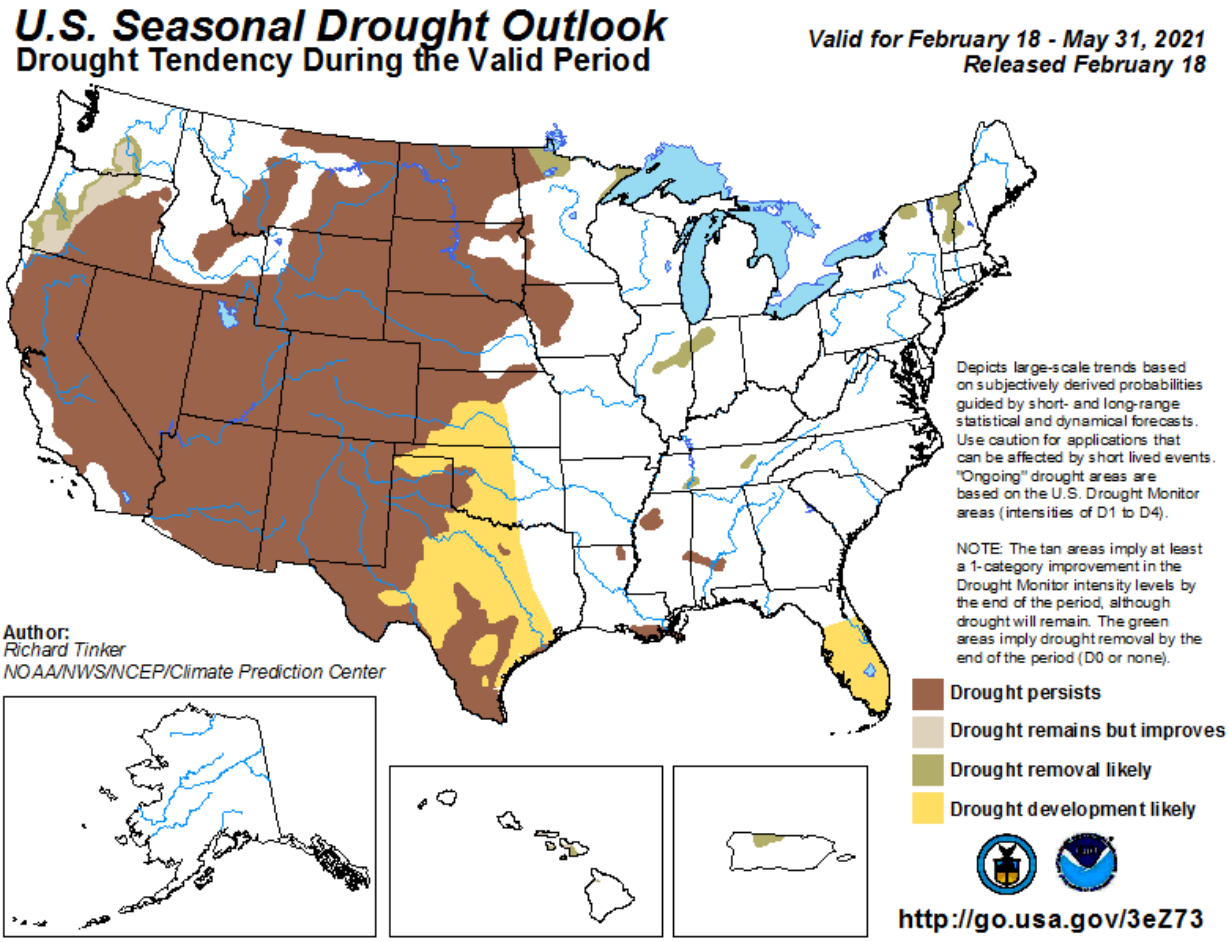
Table 24: Record of Drought in the Planning Area

Drought Magnitude	Magnitude	Months in Drought	Percentage
4 or more to -0.99	No Drought	1,011/1,504	67.2%
-1 to -1.99	Mild Drought	209/1,504	13.9%
-2 to -2.99	Moderate Drought	108/1,504	7.2%
-3 to -3.99	Severe Drought	95/1,504	6.3%
-4.0 or less	Extreme Drought	81/1,504	5.4%

Source: NCEI, Jan 1895-July 2020

The U.S. Seasonal Drought Outlook (Figure 21) provides a short-term drought forecast that can be utilized by local officials and residents to examine the likelihood of drought developing or continuing depending on 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 March 2021 as an example.

Figure 21: U.S. Seasonal Drought Outlook



Source: NCEI, March 2021

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*[33] 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 planning area. It is worth noting period of records and available data used in the following report is different than information provided by the more local HPRCC and may not be fully reflected.

[33] 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.

Table 25: Extreme Heat Predictions for Days over 100F

County	Historical Average 1971-2000 (days per year)	Midcentury Prediction 2036-2065 (days per Year)	Late Century 2070-2099 (days per year)
Adams	3	30	58
Clay	4	30	58
Fillmore	5	36	63
Gage	7	41	68
Jefferson	8	41	68
Nuckolls	6	36	64
Saline	7	39	66
Thayer	6	39	66
Webster	5	36	63

Source: Union of Concerned Scientists, 1971-2000[34]

Community Top Hazard Status

The following table lists jurisdictions which identified Drought and Extreme Heat as a top hazard of concern:

Jurisdictions	
Little Blue NRD	City of Wymore
Lower Big Blue NRD	Village of Dorchester
South Heartland District Health Department	Village of Juniata
Adams County	Village of Liberty
Fillmore County	Village of Milligan
Gage County	Village of Odell
Thayer County	Village of Saronville
City of Superior	Village of Shickley

Regional Vulnerabilities

As identified in Nebraska's Drought Mitigation and Response Plan, drought is a common feature of the Nebraska landscape and often causes significant economic, environmental, and social impacts. Although agriculture is the major sector affected, impacts on rural and municipal water supplies, fish and wildlife, tourism, recreation, water quality, soil erosion, the incidence of wildland fires, electricity demand, and other sectors are also significant. Also, 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.

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 5 are especially at risk and susceptible to the effects of extreme temperatures. Young children have a smaller body mass

[34] Union of Concerned Scientists. 2019. "Extreme Heat and Climate Change: Interactive Tool". https://www.ucsusa.org/resources/killer-heat-interactive-tool.

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.

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:

- Western Governors Association talking about coping with drought's effect on agriculture (November 2014);
- Vegetable supplies short in US through Thanksgiving (November 2014);
- Large food companies buying up smaller ones in an effort to remain competitive as drought, other factors challenge profitability (June 2014);
- Great Plains winter wheat in poor shape (June 2014);
- High milk prices (April 2014);
- Turkey hunters were urged by the Nebraska Game and Parks Commission to be careful to avoid starting wildfires (April 2014); and
- Beef prices highest in US history (January 2014).

The Drought Impact Reporter has recorded a total of 40 drought-related impacts throughout the region. This is not a comprehensive list of droughts which may have impacted the planning area, but only those with reported impacts. These impacts are summarized in the following table.

Table 26: Drought Impacts in Planning Area

Category	Date	Affected Counties	Title
Water Supply & Quality	7/21/2005	Saline County, NE	Water Supply & Quality impact from Media submitted on 7/21/2005
Water Supply & Quality	7/27/2005	Adams County, NE	Water Supply & Quality impact from Media submitted on 7/27/2005
Relief, Response & Restrictions	9/30/2005	Adams County, NE, Clay County, NE, Fillmore County, NE, Gage County, NE, Jefferson County, NE, Nuckolls County, NE, Saline County, NE, Thayer County, NE, Webster County, NE	Relief, Response & Restrictions impact from Media submitted on 9/30/2005
Society & Public Health	10/14/2005	Webster County, NE	Society & Public Health impact from Media submitted on 10/14/2005
Relief, Response & Restrictions	10/28/2005	Clay County, NE, Fillmore County, NE, Gage County, NE	Relief, Response & Restrictions impact from Government submitted on 10/28/2005

Category	Date	Affected Counties	Title
Relief, Response & Restrictions	10/28/2005	Thayer County, NE	Relief, Response & Restrictions impact from Government submitted on 10/28/2005
Relief, Response & Restrictions	11/1/2005	Adams County, NE, Nuckolls County, NE, Webster County, NE	Relief, Response & Restrictions impact from Media submitted on 11/1/2005
Relief, Response & Restrictions	11/3/2005	Clay County, NE, Fillmore County, NE, Gage County, NE, Jefferson County, NE, Saline County, NE, Thayer County, NE	Relief, Response & Restrictions impact from Media submitted on 11/3/2005
Relief, Response & Restrictions	11/17/2005	Webster County, NE	Relief, Response & Restrictions impact from Media submitted on 11/17/2005
Relief, Response & Restrictions	12/15/2005	Nuckolls County, NE, Webster County, NE	Relief, Response & Restrictions impact from Government submitted on 12/15/2005
Relief, Response & Restrictions	2/22/2006	Nuckolls County, NE, Webster County, NE	Relief, Response & Restrictions impact from Government submitted on 2/22/2006
Relief, Response & Restrictions	3/1/2006	Adams County, NE, Clay County, NE, Fillmore County, NE, Gage County, NE, Jefferson County, NE, Nuckolls County, NE, Saline County, NE, Thayer County, NE, Webster County, NE	Relief, Response & Restrictions impact from Media submitted on 3/1/2006
Relief, Response & Restrictions	7/17/2006	Adams County, NE, Clay County, NE, Nuckolls County, NE, Webster County, NE	Relief, Response & Restrictions impact from Media submitted on 7/17/2006
Water Supply & Quality	7/27/2006	Adams County, NE, Clay County, NE, Fillmore County, NE, Gage County, NE, Jefferson County, NE, Nuckolls County, NE, Saline County, NE, Thayer County, NE, Webster County, NE	Water Supply & Quality impact from Media submitted on 7/27/2006

Category	Date	Affected Counties	Title
Relief, Response & Restrictions	9/28/2006	Adams County, NE, Clay County, NE, Fillmore County, NE, Gage County, NE, Jefferson County, NE, Nuckolls County, NE, Saline County, NE, Thayer County, NE	Relief, Response & Restrictions impact from Media submitted on 9/28/2006
Relief, Response & Restrictions	10/12/2006	Adams County, NE, Clay County, NE, Fillmore County, NE, Saline County, NE	Relief, Response & Restrictions impact from Media submitted on 10/12/2006
Agriculture	6/22/2009	Nuckolls County, NE	Agriculture impact from Government submitted on 6/22/2009
Agriculture	6/23/2009	Webster County, NE	Agriculture impact from Government submitted on 6/23/2009
Agriculture	7/6/2009	Nuckolls County, NE	Agriculture impact from Government submitted on 7/6/2009
Agriculture	7/6/2009	Webster County, NE	Agriculture impact from Government submitted on 7/6/2009
Agriculture	7/13/2009	Webster County, NE	Agriculture impact from Government submitted on 7/13/2009
Agriculture	9/3/2009	Webster County, NE	Agriculture impact from Government submitted on 9/3/2009
Agriculture	9/28/2009	Webster County, NE	Agriculture impact from Government submitted on 9/28/2009
Agriculture	6/4/2012	Nuckolls County, NE, Webster County, NE	Alfalfa yields down in Nuckolls and Webster counties, Nebraska
Agriculture, Relief, Response & Restrictions, Water Supply & Quality	7/20/2012	Adams County, NE, Clay County, NE, Gage County, NE, Jefferson County, NE, Nuckolls County, NE, Saline County, NE, Thayer County, NE, Webster County, NE	Low flow in several Nebraska rivers brought surface irrigation closures
Society & Public Health, Tourism & Recreation	8/22/2012	Gage County, NE, Cortland, NE,	Hot, dry conditions damage hiker/biker trails in Butler, Cass, Gage, and Lancaster counties in Nebraska

Category	Date	Affected Counties	Title
Agriculture, Plants & Wildlife	12/17/2012	Adams County, NE, Clay County, NE, Nuckolls County, NE, Webster County, NE	Drought led ranchers in western Nebraska to cull cow herds by 25 to 60 percent
Agriculture, Relief, Response & Restrictions, Water Supply & Quality	4/9/2013	Nuckolls County, NE, Webster County, NE	The Nebraska Department of Natural Resources ordered that 12,000 acre-feet of water held in four federal Bureau of Reclamation reservoirs be released to honor the Republican River Compact
Agriculture, Relief, Response & Restrictions	5/17/2013	Adams County, NE, Clay County, NE, Fillmore County, NE, Gage County, NE, Jefferson County, NE, Nuckolls County, NE, Saline County, NE, Thayer County, NE, Webster County, NE	Drought-related USDA disaster declarations in 2013
Agriculture, Plants & Wildlife	8/2/2013	Saline County, NE	Lack of rain causes hay to stop growing in Saline County, Nebraska
Agriculture, Relief, Response & Restrictions, Water Supply & Quality	12/5/2013	Gage County, NE, Jefferson County, NE,	The Lower Big Blue Natural Resources District in southeastern Nebraska announced a moratorium on new wells for 180 days
Agriculture, Relief, Response & Restrictions	2/7/2014	Gage County, NE, Jefferson County, NE, Thayer County, NE, Webster County, NE	Drought-Related USDA Disaster Declarations in 2014
Fire, Relief, Response & Restrictions	2/22/2018	Adams County, NE, Clay County, NE, Fillmore County, NE, Gage County, NE, Jefferson County, NE, Nuckolls County, NE, Saline County, NE, Thayer County, NE, Webster County, NE	Nebraskans urged to leave the fireworks to the professionals
Agriculture, Business & Industry	11/28/2018	Saline County, NE, Crete, NE	Dearth of mature Christmas trees on Nebraska tree farms
Relief, Response & Restrictions, Water Supply & Quality	12/12/2018	Jefferson County, NE, Thayer County, NE	Water restrictions for Nebraska communities

Category	Date	Affected Counties	Title
Fire, Society & Public Health	3/27/2019	Fillmore County, NE, Gage County, NE, Jefferson County, NE, Saline County, NE, Thayer County, NE	Drought prevented agricultural burning in Kansas, Oklahoma in 2018
Agriculture	4/22/2019	Clay County, NE, Fillmore County, NE, Gage County, NE, Jefferson County, NE, Nuckolls County, NE, Saline County, NE, Thayer County, NE	Corn chopped for silage in eastern Nebraska
Agriculture, Water Supply & Quality	4/23/2019	Adams County, NE, Clay County, NE, Fillmore County, NE, Gage County, NE, Jefferson County, NE, Nuckolls County, NE, Saline County, NE, Thayer County, NE, Webster County, NE	Nebraska ranchers hauling water to livestock
Plants & Wildlife, Tourism & Recreation, Water Supply & Quality	1/27/2020	Adams County, NE, Clay County, NE, Fillmore County, NE, Nuckolls County, NE, Saline County, NE, Thayer County, NE, Webster County, NE	Nebraska's Rainwater Basin being refilled with groundwater
Plants & Wildlife, Relief, Response & Restrictions, Water Supply & Quality	1/29/2020	Adams County, NE, Clay County, NE, Fillmore County, NE, Nuckolls County, NE, Saline County, NE, Thayer County, NE, Webster County, NE	Water pumped into Nebraska's Rainwater Basin

Source: NDMC, 2000-2020

The following table provides information related to regional vulnerabilities for drought and extreme heat. For jurisdictional-specific vulnerabilities, refer to *Section Seven: Community Profiles*.

Table 27: Regional Drought and Extreme Heat Vulnerabilities

SECTOR	VULNERABILITY
PEOPLE	-Insufficient water supply -Loss of jobs in agriculture sector -Residents in poverty if food prices increase -Health impacts: heat exhaustion; heat stroke; those working outdoors; people without air conditioning; young children/elderly outside or without air conditioning
ECONOMIC	-Closure of water intensive businesses (carwashes, pool, etc.) -short-term interruption of business -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 -Damage to air conditioning/HVAC systems if overworked
INFRASTRUCTURE	-Damages to waterlines below ground -Damages to roadways (prolonged extreme events) -Stressing of electrical systems (brownouts during peak usage)
CRITICAL FACILITIES	-Loss of power and impact on infrastructure
CLIMATE	-Increased risk of wildfire events, damaging buildings and agricultural land -Increases in extreme heat conditions are likely, adding stress on livestock, crops, people, and infrastructure

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. Although rather uncommon, earthquakes do occur in Nebraska and are usually small, generally not felt, and cause little to no damage. 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 figure shows the fault lines in Nebraska and the following tables summarize the Richter Scale and Modified Mercalli Scale.

Table 28: 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[35]

Table 29: 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

[35] Federal Emergency Management Agency. 2020. "Earthquake Risk." https://www.fema.gov/emergency-managers/risk-management/earthquake

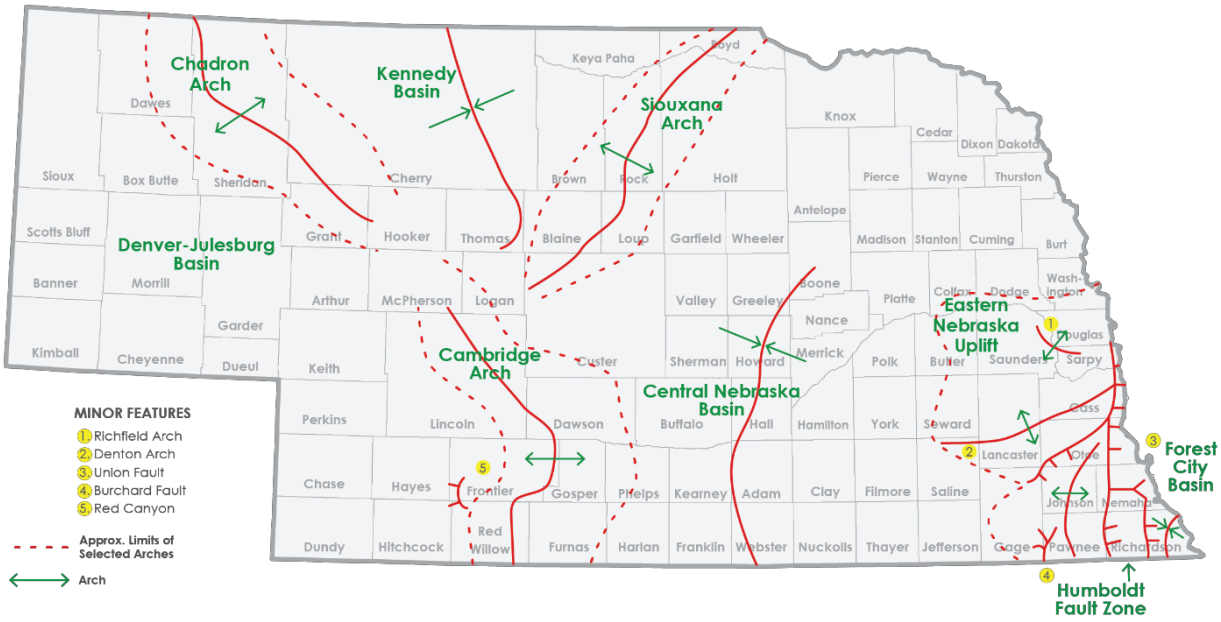
Scale	Intensity	Description of Effects	Corresponding Richter Scale Magnitude
X	Disastrous	Ground cracks profusely; many buildings destroyed; liquefaction and landslides widespread	< 7.3
XI	Very Disastrous	Most Buildings and bridges collapse; roads, railways, pipes, and cables destroyed; general triggering of other hazards	< 8.1
XII	Catastrophic	Total destruction; trees fall; ground rises and falls in waves	> 8.1

Source: FEMA, 2020

Location

The most likely locations in the planning area to experience an earthquake are near a fault line (Figure 22). Adams, Webster, Saline, and Gage Counties are most likely to experience an earthquake as they are nearest established fault lines in the state. The Central Nebraska Basin would impact Adams and Webster Counties while portions of the Eastern Nebraska Uplift and Humboldt Fault Zones could impact Saline and Gage Counties if an earthquake were to occur in Nebraska. The Humboldt Fault Zone does extend south into Kansas near the planning area.

Figure 22: Fault Lines in Nebraska



Historical Occurrences

The NCEI reported two earthquakes in the planning area during the 121 year time frame between 1900 and 2020.[36] The first event occurred on June 30, 1979 in the southwest corner of Jefferson County. This event did not produce any recorded damages. The event measured 3.3 of the Richter scale. The second event occurred on January 6, 2014 in the southeast corner of Gage

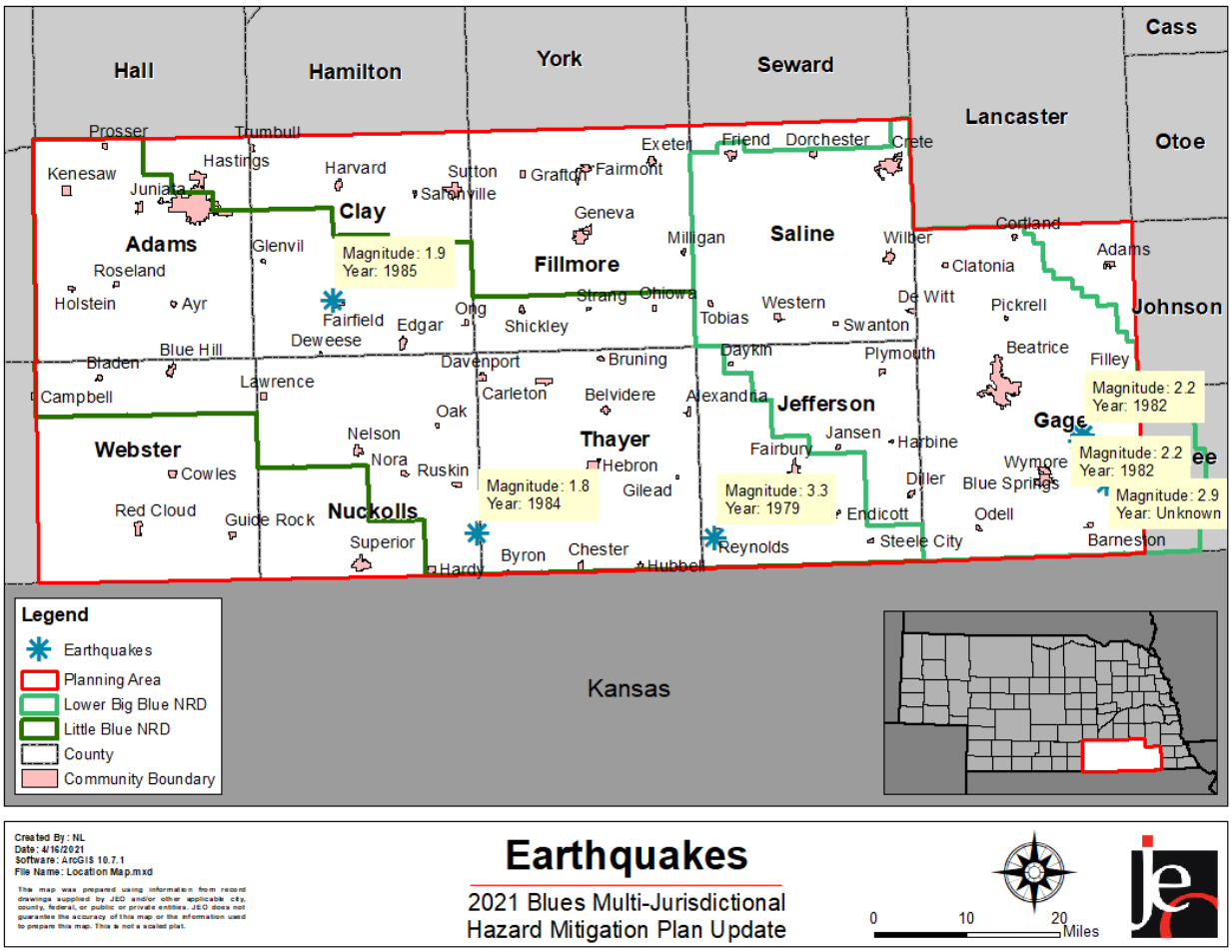
[36] United States Geological Survey. 2020. "Information by Region – Nebraska." https://earthquake.usgs.gov/earthquakes/byregion/nebraska.php.

County, approximately 6.2 miles east of Wymore. This event did not produce any recorded damages. The event measured 2.9 of the Richter scale.

The USDA RMA also reported indemnity crops losses since 2000 attributed to earthquakes. These totaled $6,326 in damages. Since no other information is available for these events, the planning team used the USGS to indicate historical earthquake events, given its higher degree of accuracy and more available information.

The following figure displays historical occurrences of earthquakes in and around the planning area and state of Nebraska. The information displayed is from the NEIC Earthquake Search database provided by the USGS Earthquake Hazards Program.

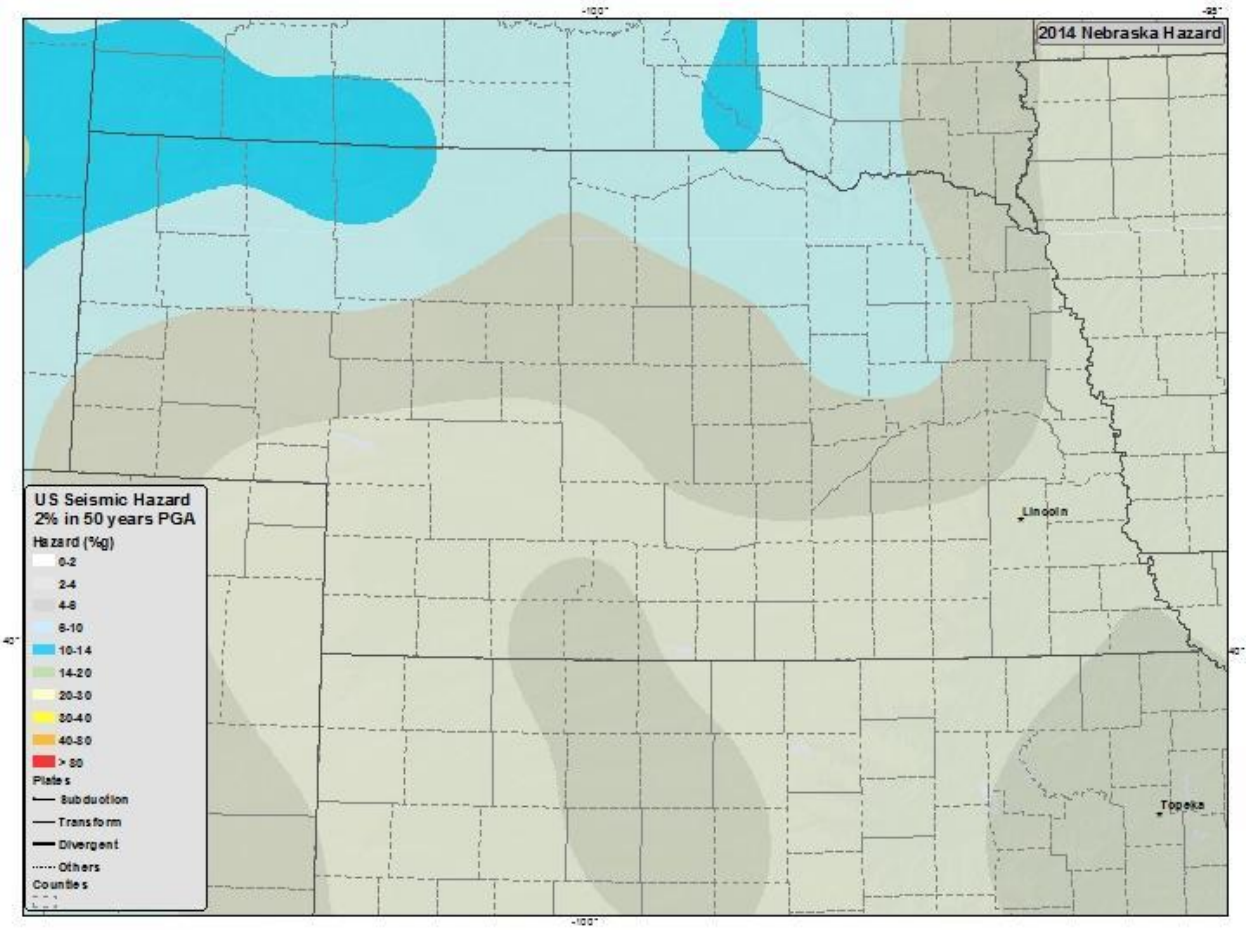
Figure 23: Earthquake Events in the Planning Area



Average Annual Losses

Neither the 1979 nor 2014 earthquakes caused damage in the planning area. Due to the lack of sufficient earthquake data, limited resources, low earthquake risk for the area, and no recorded damages, it is not feasible to utilize the 'event damage estimate formula' to estimate potential losses for the planning area. Figure 24 shows the State of Nebraska's seismic hazard risk across the state. According to the USGS, the planning area has a less than 0.2 percent change of damages from earthquakes.

Figure 24: 2014 Seismic Hazard Map - Nebraska



Source: USGS, 2020[37]

Extent

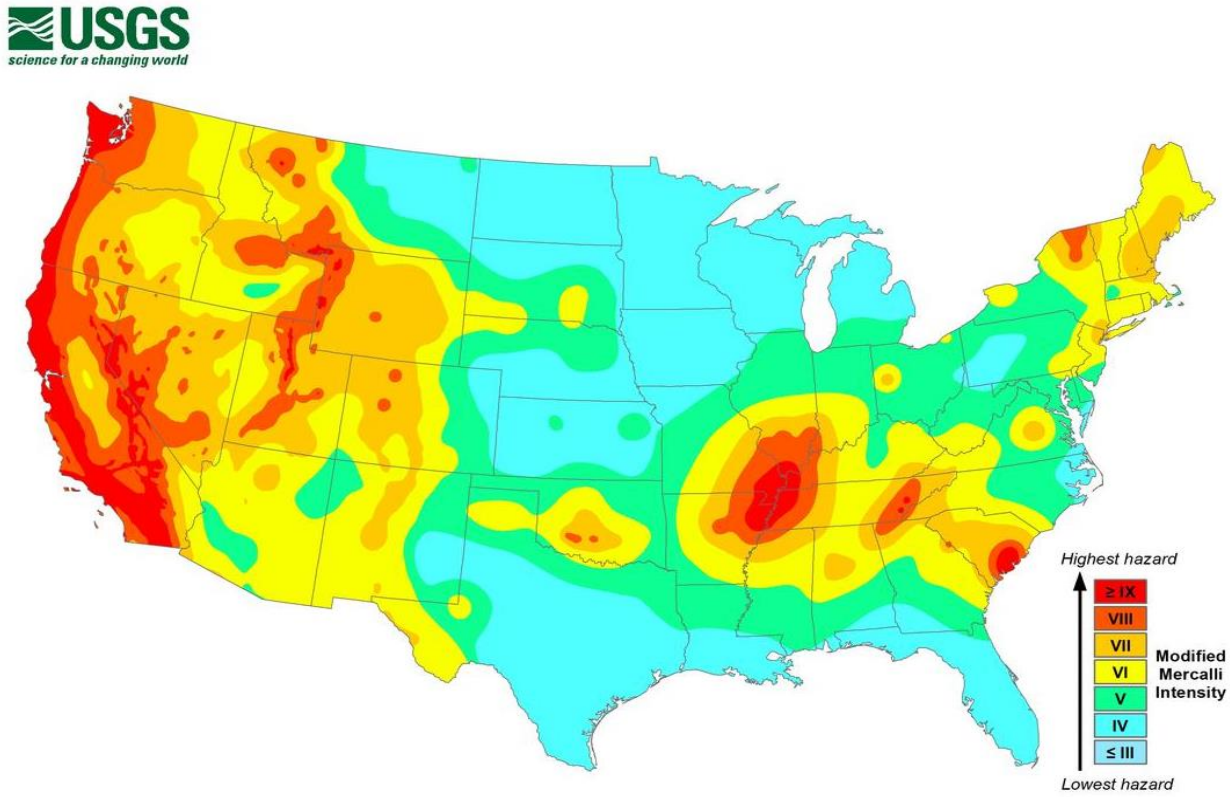
The extent of damages from earthquakes is often limited to areas near fault lines. In the planning area, the Central Nebraska Basin, which runs through Adams and Webster Counties, and the Eastern Nebraska Uplift, which may impact Saline and Gage Counties, both pose risk. The Humboldt Fault Zone, which runs through Jefferson, Gage, and Saline, in also seismically active. Based on historical record, the magnitude for earthquakes in the planning area ranges from approximately 2 to 4 on the Richter Scale.

Probability

The following figure summarizes the probability of an intense earthquake occurring in the planning area. Based on the two years with a recorded occurrence of an earthquake over a 121-year period, the probability of an earthquake in the nine-county region in any given year is approximately two percent.

[37] USGS. 2014. "2014 Seismic Hazard Map – Nebraska." Accessed September 2020. https://www.usgs.gov/media/images/2014-seismic-hazard-map-nebraska.

Figure 25: Earthquake Probability



USGS map showing the intensity of potential earthquake ground shaking that has a 2% chance of occurring in 50 years

Source: USGS, 2016

Community Top Hazard Status

No participating jurisdictions identified Earthquakes as a top hazard of concern.

Regional Vulnerabilities

Particularly vulnerable populations for earthquake include, but are not limited to:

- *Low income individuals*
  - Often, low income individuals and families live in lower cost homes (older homes, mobile homes) that are less able to withstand disaster.
- *Older homes and mobile homes*
  - These may not have been constructed using the most advanced building codes or have received updates and retrofits that would have increased their stability and ability to withstand seismic events. Damages resulting from the 1994 Northridge earthquake in California were disproportionately focused on low and moderate income rental housing units that were older and thus more vulnerable to seismic damages.
- *Elderly citizens*
  - Senior citizens living on a fixed income may lack the disposable income necessary to upgrade their homes to withstand seismic events. In addition, senior citizens may lack the mobility required to implement low cost mitigation measures. A 2006

Census Bureau report found that 20-percent of the US Population age 65 and older report some level of disability.

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

Table 30: Regional Earthquake Vulnerabilities

SECTOR	VULNERABILITY
PEOPLE	-Risk of injury or death from falling objects and structures
ECONOMIC	-Short term to long term interruption of business
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) -Damage to roadways
CRITICAL FACILITIES	-Same as other structures
CLIMATE	-None

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 stage. These events are complicated by the freeze/thaw cycles characterized by moisture thawing during the day and freezing at night. There are four main types of flooding in the planning area: riverine flooding, flash flooding, sheet flooding, and ice jam flooding.

Riverine Flooding

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 draining to a river and its tributaries.

Flash Flooding, including Levee or Dam Failure

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. Flooding from excessive rainfall in Nebraska usually occurs between late spring and early fall.

Urban Flooding

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 into homes or basements, which damages mechanical systems and can create serious public health and safety concerns.

Ice Jam Flooding

Ice jams occur when ice breaks up in moving waterways, and then stacks on itself where channels narrow or human-made obstructions constrict the channel. This creates an ice dam, often causing flooding within minutes of the dam formation. Ice formation in streams occurs during periods of cold weather when finely divided colloidal particles called "frazil ice" form. These particles combine to form what is commonly known as “sheet ice.” This type of ice covers the entire river. The thickness of this ice sheet depends upon the degree and duration of cold weather in the area. This ice sheet can freeze to the bottom of the channel in places. During spring thaw, rivers frequently become clogged with this winter accumulation of ice. Because of relatively low stream

banks and channels blocked with ice, rivers overtop existing banks and flow overland. This type of flooding tends to more frequently occur on wide, shallow rivers such as the Platte, although other rivers can be impacted.

Location

The major rivers in the planning area include the Republican River, the Little Blue River and its tributaries, and the Big Blue River and its tributaries. These rivers as well as smaller streams and creeks are potential locations for flooding to occur.

Table 31 shows the current status of Flood Insurance Rate Map (FIRM) panels within the study areas. Figure 29 shows flood risk hazard areas for the floodway, one percent annual chance, and 0.2 percent annual chance flood events for counties in the planning area. For jurisdictional-specific maps as well as an inventory of structures in the floodplain, please see *Section Seven: Community Profiles.* For additional details on localized flood risk such as flood zone types, please refer to the official FIRM available from FEMA's Flood Map Service Center.

Table 31: FEMA FIRM Panel Status

Jurisdiction	Panel Number	Effective Date
Adams County	31001CIND0A; 31001C0025C; 31001C0040C; 31001C0050C; 31001C0070C; 31001C0075C; 31001C0100C; 31001C0110C; 31001C0125C; 31001C0135C; 31001C0139C; 31001C0150C; 31001C0157C; 31001C0160C; 31001C0175C; 31001C0176C; 31001C0180C; 31001C0200C; 31001C0210C; 31001C0225C; 31001C0250C; 31001C0255C; 31001C0265C; 31001C0275C; 31001C0300C; 31001C0325C; 31001C0350C; 31001C0375C; 31001C0400C	7/5/18
Village of Ayr	31001CIND0A; 31001C0255C; 31001C0265C; 31001C0275C	7/5/18
City of Hastings	31001CIND0A; 31001C0070C; 31001C0075C; 31001C0100C; 31001C0157C; 31001C0160C; 31001C0175C; 31001C0176C; 31001C0180C; 31001C0200C	7/5/18
Village of Holstein	31001CIND0A; 31001C0210C; 31001C0250C	7/5/18
Village of Juniata	31001CIND0A; 31001C0135C; 31001C0139C; 31001C0175C	7/5/18
Village of Kenesaw	31001CIND0A; 31001C0025C; 31001C0110C; 31001C0125C	7/5/18
Village of Prosser	31001CIND0A; 31001C0040C; 31001C0050C	7/5/18
Village of Roseland	31001CIND0A; 31001C0250C	7/5/18
Clay County	31035CIND0A; 31035C0025C; 31035C0050C; 31035C0075C; 31035C0100C; 31035C0125C; 31035C0150C; 31035C0175C; 31035C0200C; 31035C0225C; 31035C0250C; 31035C0275C; 31035C0300C; 31035C0325C; 31035C0350C; 31035C0375C; 31035C0400C; 31035C0425C; 31035C0450C; 31035C0475C; 31035C0500C	7/5/18
City of Clay Center	31035CIND0A; 31035C0200C	7/5/18
Village of Deweese	31035CIND0A; 31035C0425C	7/5/18

Jurisdiction	Panel Number	Effective Date
City of Edgar	31035CIND0A; 31035C0350C; 31035C0475C	7/5/18
City of Fairfield	31035CIND0A; 31035C0300C; 31035C0325C	7/518
Village of Glenvil	31035CIND0A; 31035C0150C; 31035C0175C; 31035C0275C; 31035C0300C	7/5/18
City of Harvard	31035CIND0A; 31035C0075C; 31035C0200C	7/5/18
Village of Ong	31035CIND0A; 31035C0375C	7/5/18
Village of Saronville	31035CIND0A; 31035C0225C	7/5/18
City of Sutton	31035CIND0A; 31035C0100C; 31035C0125C; 31035C0225C; 31035C0250C	7/5/18
Village of Trumbull	31001CIND0A; 31035CIND0A; 31081CIND0A; 31001C0100C; 31035C0025C; 31035C0050C; 31081C0375D	7/5/18 & 8/1/2019
Fillmore County	31059CIND0A; 31059C0025B; 31059C0050B; 31059C0075B; 31059C0100B; 31059C0125B; 31059C0150B; 31059C0175B; 31059C0190B; 31059C0200B; 31059C0225B; 31059C0250B; 31059C0275B; 31059C0286B; 31059C0290B; 31059C0300B; 31059C0315B; 31059C0325B; 31059C0332B; 31059C0350B; 31059C0375B; 31059C0400B; 31059C0425B; 31059C0450B; 31059C0475B; 31059C0500B	9/16/04
Village of Exeter	31059CIND0A; 31059C0100B; 31059C0225B	9/16/04
Village of Fairmont	31059CIND0A; 31059C0075B; 31059C0200B	9/16/04
City of Geneva	31059CIND0A; 31059C0175B; 31059C0190B	9/16/04
Village of Grafton	31059CIND0A; 31059C0050B; 31059C0175B	9/16/04
Village of Milligan	31059CIND0A; 31059C0225B; 31059C0250B; 31059C0332B; 31059C0350B; 31059C0375B	9/16/04
Village of Ohiowa	31059CIND0A; 31059C0350B	9/16/04
Village of Shickley	31059CIND0A; 31059C0286B	9/16/04
Village of Strang	31059CIND0A; 31059C0315B	9/16/04
Gage County	31067CIND0B; 31067C0020C; 31067C0050C; 31067C0064C; 31067C0075C; 31067C0100C; 31067C0115C; 31067C0150C; 31067C0151C; 31067C0153C; 31067C0175C; 31067C0188C; 31067C0200C; 31067C0209C; 31067C0225C; 31067C0250C; 31067C0275C; 31067C0292C; 31067C0293C; 31067C0294C; 31067C0300C; 31067C0311C; 31067C0313C; 31067C0314C; 31067C0325C; 31067C0341C; 31067C0342C; 31067C0350C; 31067C0375C; 31067C0400C; 31067C0407C; 31067C0425C; 31067C0426C; 31067C0443C; 31067C0444C; 31067C0450C; 31067C0460C; 31067C0475C; 31067C0480C; 31067C0500C; 31067C0525C; 31067C0541C; 31067C0550C; 31067C0556C; 31067C0557C; 31067C0575C; 31067C0587D; 31067C0600C; 31067C0603C; 31067C0625C	6/18/2010 & 5/2/2016
Village of Adams	31067CIND0B; 31067C0209C	5/2/2016 & 6/18/2010
Village of Barneston	31067CIND0B; 31067C0587D	5/2/16

Jurisdiction	Panel Number	Effective Date
City of Beatrice	31067CIND0B; 31067C0292C; 31067C0293C 31067C0294C; 31067C0300C; 31067C0311C; 31067C0313C; 31067C0314C; 31067C0325C; 31067C0407C; 31067C0425C; 31067C0426C; 31067C0450C	5/2/16 & 6/18/10
City of Blue Springs	31067CIND0B; 31067C0443C; 31067C0444C; 31067C0450C	5/2/16 & 6/18/10
Village of Clatonia	31067CIND0B; 31067C0151C; 31067C0153C	5/2/16 & 6/18/10
Village of Cortland	31067CIND0B; 31067C0064C; 31067C0075C; 31067C0200C	5/2/16 & 6/18/10
Village of Filley	31067CIND0B; 31067C0341C; 31067C0342C	5/2/16 & 6/18/10
Village of Liberty	31067CIND0B; 31067C0603C	5/2/16 & 6/18/10
Village of Odell	31067CIND0B; 31067C0541C	5/2/16 & 6/18/10
Village of Pickrell	31067CIND0B; 31067C0188C	5/2/16 & 6/18/10
Village of Virginia	31067CIND0B; 31067C0460C; 31067C0480C	5/2/16 & 6/18/10
City of Wymore	31067CIND0B; 31067C0443C; 31067C0444C; 31067C0450C; 31067C0556C; 31067C0557C; 31067C0575C; 31067C0600C	5/2/16 & 6/18/10
Jefferson County	31095CIND0A; 31095C0010D; 31095C0025D; 31095C0050D; 31095C0075D; 31095C0090D; 31095C0100D; 31095C0125D; 31095C0140D; 31095C0145D; 31095C0150D; 31095C0155D; 31095C0165D; 31095C0175D; 31095C0180D; 31095C0200D; 31095C0215D; 31095C0225D; 31095C0250D; 31095C0255D; 31095C0260D; 31095C0265D; 31095C0270D; 31095C0280D; 31095C0285D; 31095C0300D	8/17/2015
Village of Daykin	31095CIND0A; 31095C0010D; 31095C0025D	8/17/15
Village of Diller	31095CIND0A; 31067C0525C; 31095C0200D; 31095C0280D; 31095C0285D	8/17/2015 &6/18/10
Village of Endicott	31095CIND0A; 31095C0255D; 31095C0265D	8/17/15
City of Fairbury	31095CIND0A; 31095C0140D; 31095C0145D; 31095C0250D	8/17/2015
Village of Harbine	31095CIND0A; 31095C0180D; 31095C0200D	8/17/15
Village of Jansen	31095CIND0A; 31095C0155D; 31095C0165D; 31095C0175D	8/17/15
Village of Plymouth	31095CIND0A; 31095C0075D; 31095C0090D; 31095C0100D	8/17/15
Village of Reynolds	31095CIND0A; 31095C0215D; 31095C0225D	8/17/15
Village of Steele City	31095CIND0A; 31095C0270D; 31095C0300D	8/17/15
Nuckolls County	31129CIND0A; 31129C0025C; 31129C0050C; 31129C0075C; 31129C0100C; 31129C0125C; 31129C0150C; 31129C0175C; 31129C0180C; 31129C0185C; 31129C0200C; 31129C0210C; 31129C0225C; 31129C0250C; 31129C0275C; 31129C0300C; 31129C0315C; 31129C0320C; 31129C0325C; 31129C0345C; 31129C0350C; 31129C0375C	12/16/04
Village of Hardy	31129CIND0A; 31129C0345C	12/16/04

Jurisdiction	Panel Number	Effective Date
Village of Lawrence	31129CIND0A; 31129C0025C	12/16/04
City of Nelson	31129CIND0A; 31129C0180C; 31129C0185C; 31129C0200C	12/16/04
Village of Nora	N/A	N/A
Village of Oak	31129CIND0A; 31129C0210C	
Village of Ruskin	31129CIND0A; 31129C0225C; 31129C0250C	12/16/04
City of Superior	31129CIND0A; 31129C0315C; 31129C0320C	12/16/04
Saline County	31151CIND0A; 31151C0020D; 31151C0025D; 31151C0050D; 31151C0065D; 31151C0075D; 31151C0088D; 31151C0089D; 31151C0093D; 31151C0100D; 31151C0125D; 31151C0150D; 31151C0175D; 31151C0176D; 31151C0177D; 31151C0180D; 31151C0185D; 31151C0190D; 31151C0195D; 31151C0215D; 31151C0225D; 31151C0240D; 31151C0250D; 31151C0265D; 31151C0275D; 31151C0276D; 31151C0277D; 31151C0280D; 31151C0281D; 31151C0283D; 31151C0290D; 31151C0291D; 31151C0293D; 31151C0325D; 31151C0350D; 31151C0375D; 31151C0400D	11/4/10
City of Crete	31151CIND0A; 31151C0088D; 31151C0089D; 31151C0093D; 31151C0176D; 31151C0177D; 31151C0185D	11/4/10
Village of Dewitt	31151CIND0A; 31151C0290D; 31151C0291D; 31151C0292D; 31151C0293D; 31151C0294D	11/4/10
Village of Dorchester	31151CIND0A; 31151C0065D	11/4/10
City of Friend	31151CIND0A; 31151C0020D	11/4/10
Village of Swanton	31151CIND0A; 31151C0265D	11/4/10
Village of Tobias	31151CIND0A; 31151C0215D	11/4/10
Village of Western	31151CIND0A; 31151C0240D	11/4/10
City of Wilber	31151CIND0A; 31151C0190D; 31151C0276D; 31151C0277D; 31151C0280D; 31151C0281D	11/4/10
Thayer County	31169CIND0A; 31169C0025C; 31169C0045C; 31169C0050C; 31169C0070C; 31169C0075C; 31169C0100C; 31169C0125C; 31169C0138C; 31169C0139C; 31169C0150C; 31169C0155C; 31169C0160C; 31169C0161C; 31169C0162C; 31169C0163C; 31169C0164C; 31169C0170C; 31169C0182C; 31169C0200C; 31169C0225C; 31169C0250C; 31169C0269C; 31169C0275C; 31169C0288C; 31169C0300C	9/30/04
Village of Alexandria	31169CIND0A; 31169C0100C; 31169C0182C; 31169C0200C	9/30/04
Village of Belvidere	31169CIND0A; 31169C0070C; 31169C0075C; 31169C0155C; 31169C0160C	9/30/04
Village of Bruning	31169CIND0A; 31169C0075C	9/30/04
Village of Byron	31169CIND0A; 31169C0225C; 31169C0250C	9/30/04
Village of Carleton	31169CIND0A; 31169C0045C; 31169C0050C	9/30/04
Village of Chester	31169CIND0A; 31169C0250C; 31169C0275C	9/30/04

Jurisdiction	Panel Number	Effective Date
Village of Davenport	31169CIND0A; 31169C0025C	9/30/04
City of Deshler	31169CIND0A; 31169C0138C; 31169C0139C; 31169C0150C; 31169C0250C	9/30/04
Village of Gilead	31169CIND0A; 31169C0200C	9/30/04
City of Hebron	31169CIND0A; 31169C0155C; 31169C0161C; 31169C0162C; 31169C0163C; 31169C0164C; 31169C0170C	9/30/04
Village of Hubbell	31169CIND0A; 31169C0269C; 31169C0288C	9/30/04
Webster County	31181CIND0A; 31181C0025C; 31181C0030C; 31181C0050C; 31181C0055C; 31181C0075C; 31181C0100C; 31181C0125C; 31181C0150C; 31181C0165C; 31181C0175C; 31181C0200C; 31181C0210C; 31181C0225C; 31181C0235C; 31181C0250C; 31181C0275C; 31181C0280C; 31181C0300C	5/16/08
Village of Bladen	31181CIND0A; 31181C0030C	5/16/08
City of Blue Hill	31181CIND0A; 31181C0055C; 31181C0075C	5/16/08
Village of Cowles	31181CIND0A; 31181C0165C	5/16/08
Village of Guide Rock	31181CIND0A; 31181C0280C; 31181C0300C	5/16/08
City of Red Cloud	31181CIND0A; 31181C0235C; 31181C0250C; 31181C0275C	5/16/08

Source: FEMA[38]

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 2021, portions of the planning area are currently undergoing flood risk mapping activities (Figure 26).

Portions of Gage, Jefferson, Saline, Fillmore, and Clay County (X Watershed) is currently in the data development stage for additional flood risk mapping efforts. The entirety of Thayer County and portions of Nuckolls County are under development. As data becomes available, Nebraska Department of Natural Resources (NeDNR) hosts the Risk Map products on an interactive web map, which can be viewed here: https://dnr.nebraska.gov/floodplain/interactive-maps. This data can also be obtained from the FEMA Flood Map Service Center.

[38] Federal Emergency Management Agency. Accessed February 2021. "FEMA Flood Map Service Center." http://msc.fema.gov/portal/advanceSearch .

Figure 26: NeDNR Floodplain Management Projects – February 2021

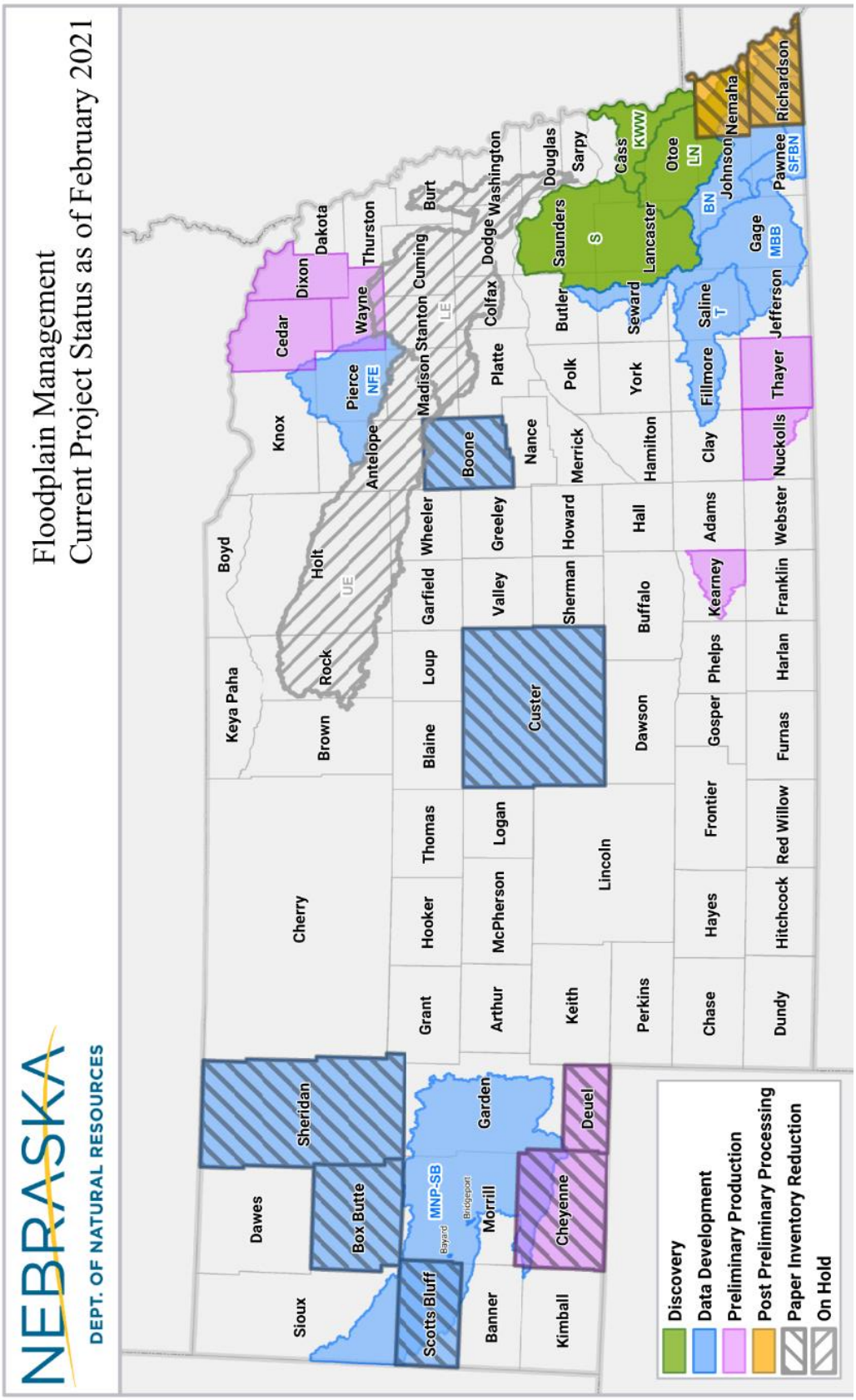


Figure 27: Upper Little Blue Watershed Flood Risk Map

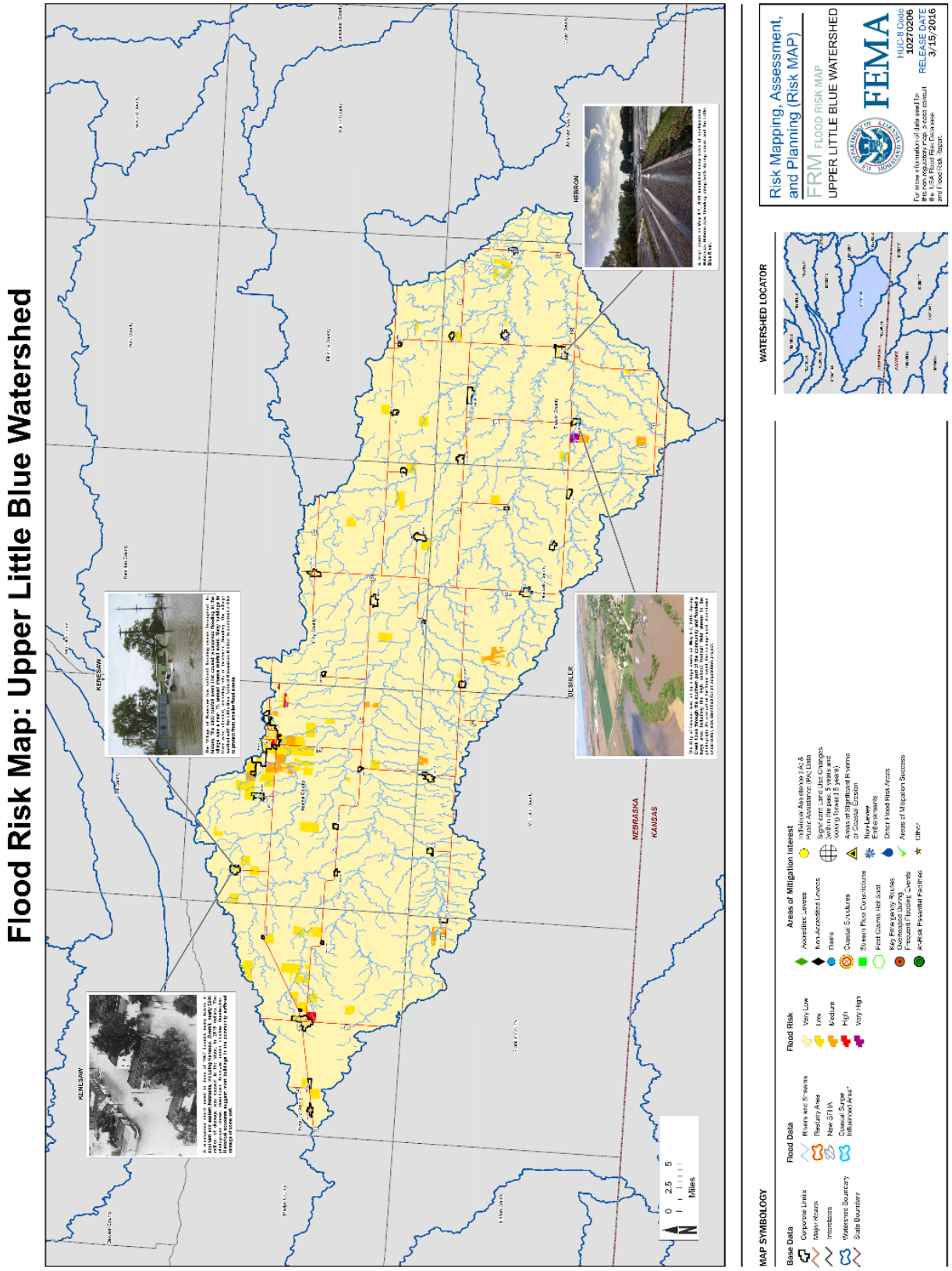


Figure 28: West Fork Big Blue Watershed Flood Risk Map

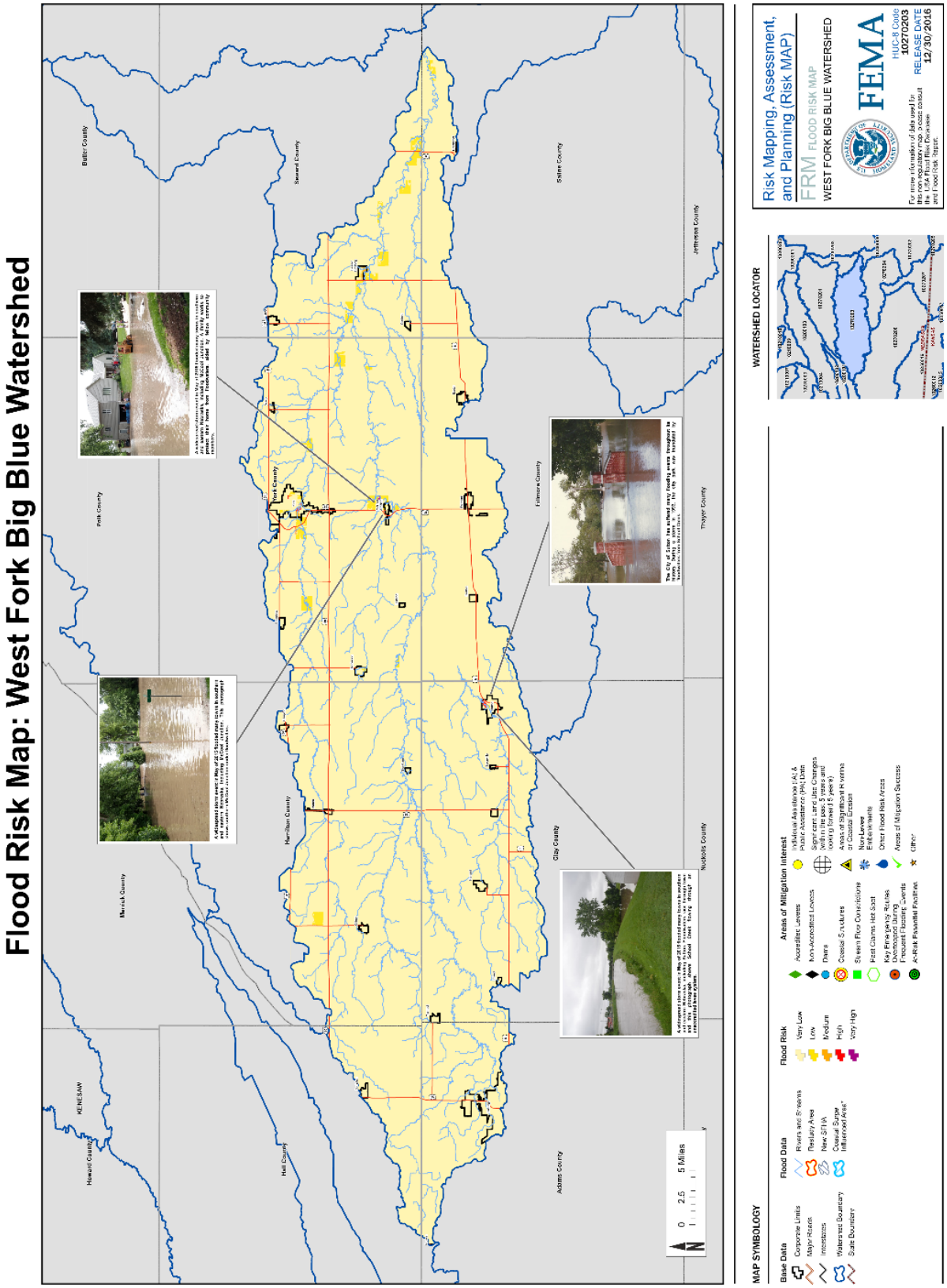
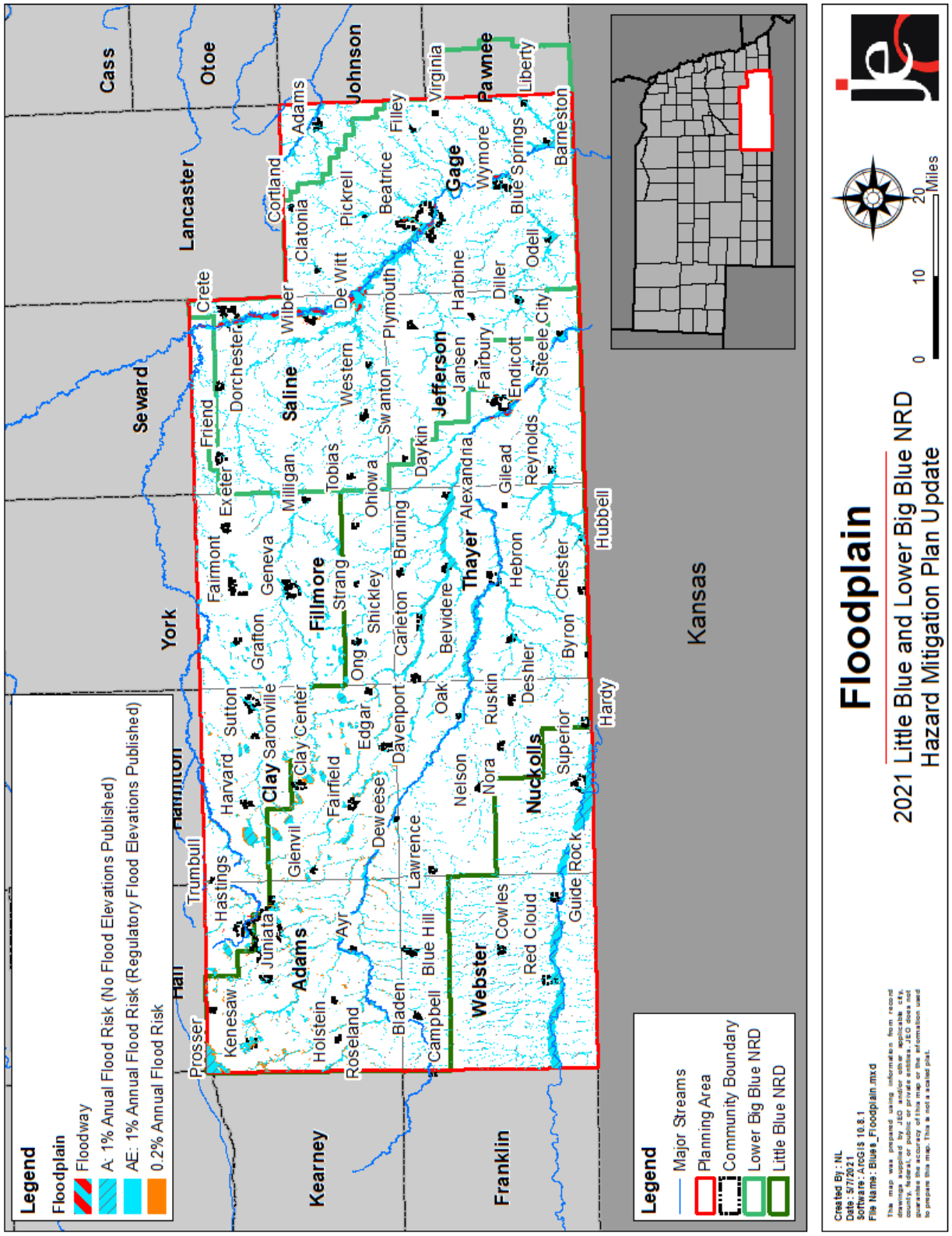


Figure 29: Flood Risk Hazard Areas



Other regulatory products reviewed and utilized in this planning process include Letter of Map Amendments (LOMAs), Letter of Map Revisions (LOMR), and Flood Insurance Studies (FIS) as available and applicable for each of the nine counties in the planning area. Specific LOMAs as identified in the planning process are described in their appropriate community profiles in *Section Seven.*

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, multi-county events as separate events. The result is a single flood event covering a large portion of the planning area could be reported by the NCEI as several events. According to the NCEI, 112 flash flooding events resulted in $21,010,000 in property damage, while 122 riverine flooding events caused $117,270,900 in property damage. USDA RMA data does not distinguish the difference between riverine flooding damages and flash flooding damages. The total crop loss according to the RMA is $2,408,030.

During the 2015 HMP planning process, the planning area experienced one of the largest flooding events in its history. Severe storms and flooding events resulted in presidential disaster declarations for Gage, Jefferson, Saline, and Thayer Counties. These events occurred intermittently between May 6, 2015 and June 17, 2015. Communities impacted by these events, including Hebron, Deshler, Roseland DeWitt and Fairbury, saw hundreds of residents evacuate to avoid danger. One elderly woman drowned in Fairbury. The town of Crete saw 8.10 inches of rain fall in 24 hours. Salt Creek and the Little Blue River were reported to be at flood stage at several points in the area. The following are pictures documenting some of the flood damages from this event.

Figure 30: 2015 Flooding in Deshler

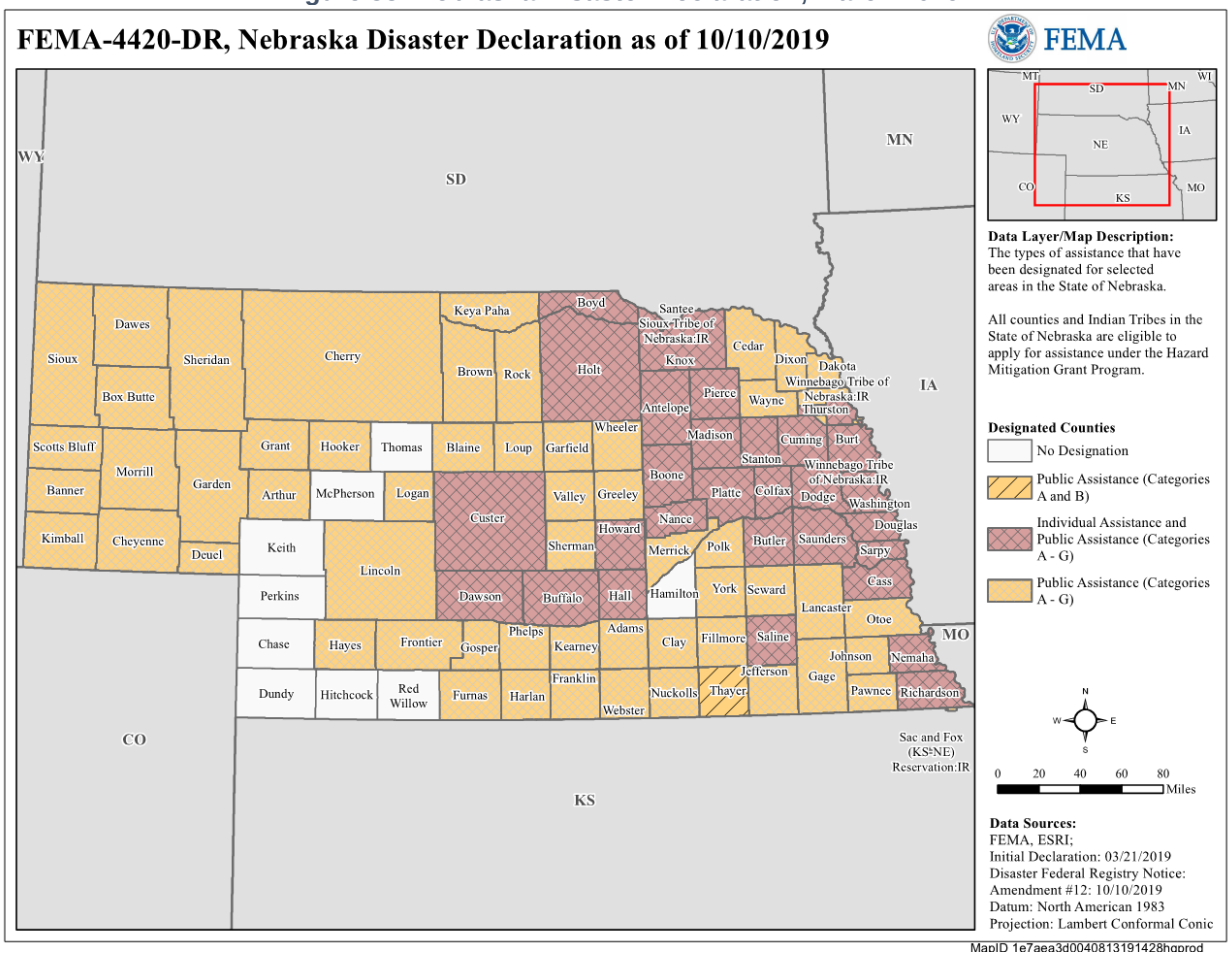
Figure 31: 2015 Flooding in Hebron (1st and Lincoln Ave)

Figure 32: 2015 Flooding in DeWitt

March 2019 Flood Event

The March 2019 flood event was a major flood event in the state which impacted most areas. Fortunately the planning area did not experience direct impacts from the catastrophic flooding on the eastern edge of the state. However, each of the nine counties applied for some form of disaster assistance due to subsequent impacts. In total, 104 cities, 81 counties, and 5 tribal nations in Nebraska received State or Federal Disaster Declarations due to the flood events.

Figure 33: Nebraska Disaster Declaration, March 2019



The NeDNR has collected and reviewed extensive data records from the flood event. An event-wide storymap has been developed and provides an excellent resource to understand the cause, duration, impacts, and recovery efforts from this event. The storymap can be viewed at: https://storymaps.arcgis.com/stories/9ce70c78f5a44813a326d20035cab95a.

Impacts from this event included significant damage to homes, commercial buildings, agriculture, bridges, and roads. Agriculturally, hundreds of acres of pastureland and fields were destroyed by several inches to feet of sand and silt left behind by receding flood waters. The flooding event also occurred in the midst of calving season, resulting in the loss of hundreds of calves for ranchers across the state. Roads, bridges, and critical transportation routes across the state were blocked by flood waters or washed out entirely. At least three fatalities occurred during the flood event while the Nebraska National Guard performed dozens of rescues in inundated areas. No fatalities were reported within the nine-county planning area during this event.

In total, the U.S. Army Corps of Engineers reported 41 breaches to federal and non-federal levees across the state of Nebraska. The failure of these structures significantly impacted subsequent flooding in neighboring communities. No levee breaches occurred in the planning area during this event. Community specific impacts reported by affected communities are included in *Section Seven: Community Profiles* as appropriate.

Average Annual Losses

The average damage per event estimate was determined based upon the NCEI Storm Events Database since 1996 and number of historical occurrences. This does not include losses from displacement, functional downtime, economic loss, injury or loss of life. Flooding caused a total average of $5,531,236 in property damages and $2,408,030 in crop losses per year for the planning area.

Table 32: 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	112	4.5	$21,010,000	$840,400	$2,408,030	$114,668
Flood	122	4.9	$117,270,900	$4,690,836		
Total	**234**	**9.36**	**$138,280,900**	**$5,531,236**	**$2,408,030**	**$114,668**

Source: 1 NCEI (1996-April 2020), 2 USDA RMA (2000-Aug 2020)

Extent

The NWS has three categories to define the typical severity of a flood once a river reaches flood stage as indicated in Table 33. Actual impacts will vary by community.

Table 33: Flooding Stages

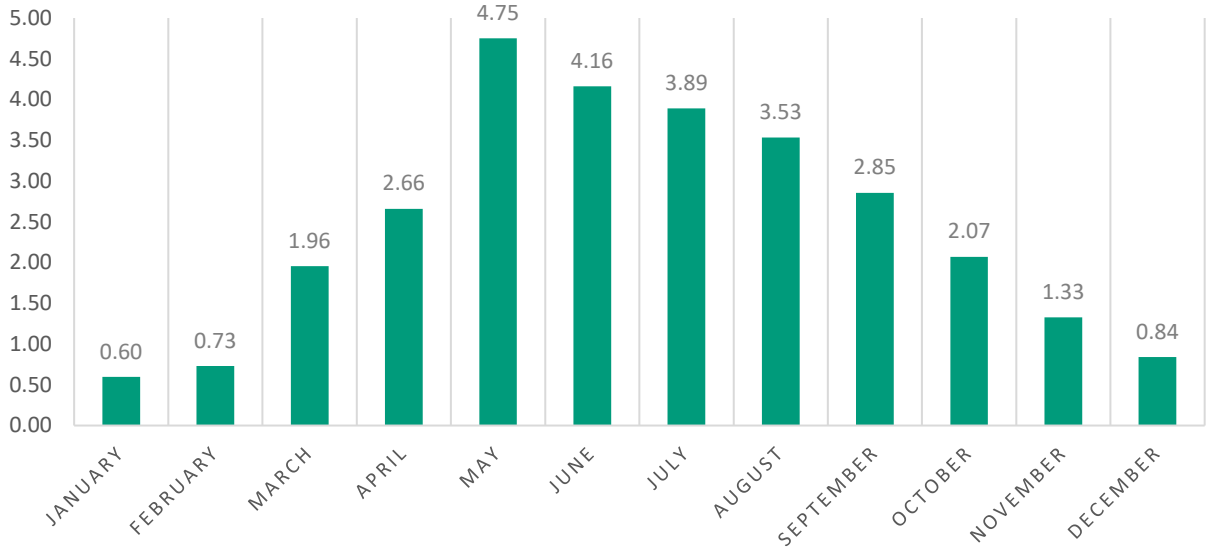
Flood Stage	Description of Typical Flood Impacts
Minor Flooding	Minimal or no property damage, but possibly some public threat or inconvenience
Moderate Flooding	Some inundation of structures and roads near streams. Some evacuations of people and/or transfer of property to higher elevations are necessary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

Source: NOAA, 2017[39]

The following figure shows the normal average monthly precipitation for the planning area, which is helpful in determining whether any given month is above, below, or near normal in precipitation. As indicated in Figure 34, the most common month for flooding within the planning area is in May.

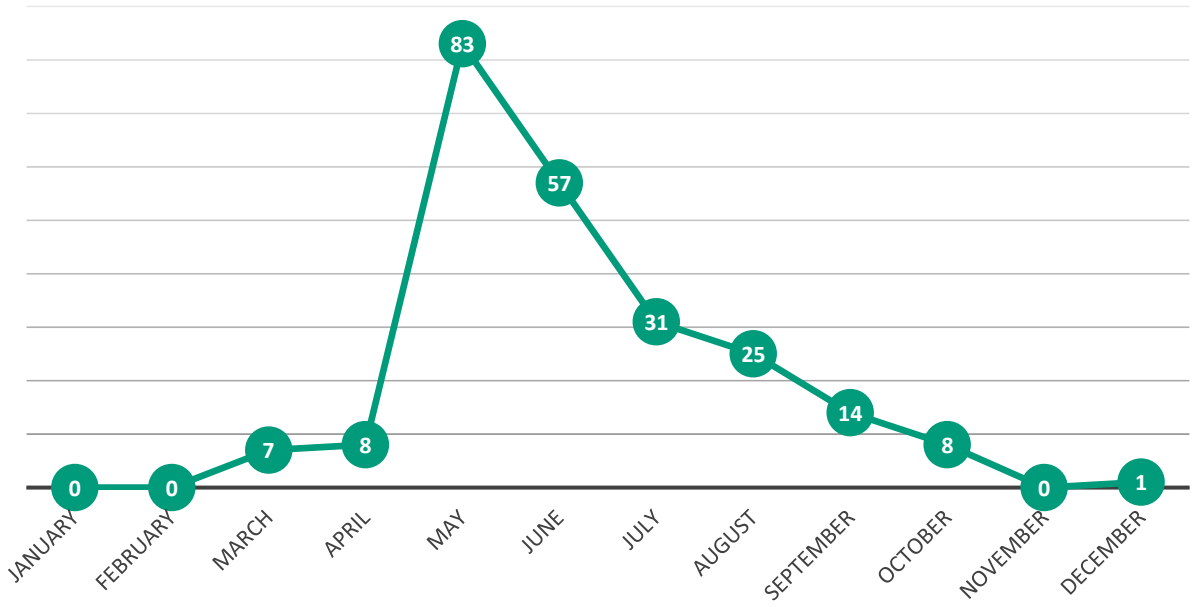
[39] National Weather Service. 2017. "Flood Safety." http://www.floodsafety.noaa.gov/index.shtml.

Figure 34: Average Monthly Precipitation



Source: NCEI

Figure 35: Monthly Events for Flood/Flash Floods in the Planning Area



Source: NCEI, 2020

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 planning area as of March 2020.

Table 34: NFIP Participants

Jurisdiction	Participate in NFIP?	Eligible-Regular Program	Date Current Map	Sanction	Suspension	Rescinded
Adams County	**Yes**	**6/1/1988**	**7/5/2018**	**-**	**-**	**-**
Village of Ayr	No	-	-	7/5/19	-	-
City of Hastings	Yes	8/17/1981	7/5/2018	-	-	-
Village of Holstein	Yes	4/1/1992	07/05/18(M)	-	-	-
Village of Juniata	Yes	6/18/1990	7/5/2018	-	-	-
Village of Kenesaw	Yes	7/5/2018	07/05/18(M)	-	-	-
Village of Prosser	Yes	7/5/2018	07/05/18(M)	-	-	-
Village of Roseland	No	-	-	7/5/19	-	-
Clay County	**Yes**	**9/1/1986**	**07/05/18(L)**	**-**	**-**	**-**
City of Clay Center	Yes	7/5/2018	07/05/18(M)	-	-	-
Village of Deweese	No	-	-	11/8/75	-	-
City of Edgar	Yes	7/5/2018	07/05/18(M)	-	-	-
City of Fairfield	No	-	-	8/22/76	-	-
Village of Glenvil	No	-	-	-	-	-
City of Harvard	Yes	7/5/2018	(NSFHA)	-	-	-
Village of Ong	No	-	-	-	-	-
Village of Saronville	No	-	-	-	-	-
City of Sutton	Yes	9/1/1986	07/05/18(M)	-	-	-
Village of Trumbull	No	-	-	8/1/20	-	-
Fillmore County	**Yes**	**9/16/2004**	**9/16/2004**	**-**	**-**	**-**
Village of Exeter	Yes	9/16/2004	(NSFHA)	-	-	-
Village of Fairmont	Yes	9/16/2004	9/16/2004	-	-	-
City of Geneva	Yes	9/16/2004	9/16/2004	-	-	-
Village of Grafton	No	-	-	9/16/05	-	-
Village of Milligan	No	-	-	7/9/77	-	-
Village of Ohiowa	No	-	-	11/8/75	-	-
Village of Shickley	Yes	7/2/1987	9/16/2004	-	-	-

Jurisdiction	Participate in NFIP?	Eligible-Regular Program	Date Current Map	Sanction	Suspension	Rescinded
Village of Strang	No	-	-	-	-	-
Gage County	**Yes**	**5/1/1990**	**5/2/2016**	**-**	**-**	**-**
Village of Adams	Yes	6/1/1988	7/5/2018	-	-	-
Village of Barneston	No	-	-	5/17/89	5/17/89(S)	-
City of Beatrice	Yes	9/30/1977	6/18/2010	-	-	-
City of Blue Springs	Yes	6/3/1986	6/18/2010	-	-	-
Village of Clatonia	No	-	-	9/18/85	9/18/85(S)	-
Village of Cortland	Yes	6/18/2010	06/18/10(M)	-	-	-
Village of Filley	No	-	-	-	-	-
Village of Liberty	No	-	-	6/18/11	-	-
Village of Odell	Yes	6/1/1987	06/18/10(M)	-	-	-
Village of Pickrell	No	-	-	6/18/11	-	-
Village of Virginia	No	-	-	-	-	-
City of Wymore	Yes	7/2/1987	6/18/2010	-	-	-
Jefferson County	**Yes**	**6/1/1988**	**8/17/2015**	**-**	**-**	**-**
Village of Daykin	No	-	-	8/17/16	-	-
Village of Diller	Yes	6/18/2010	08/17/15(M)	-	-	-
Village of Endicott	No	-	-	8/17/16	-	-
City of Fairbury	Yes	9/3/1980	8/17/2015	-	-	-
Village of Harbine	No	-	-	8/17/16	-	-
Village of Jansen	No	-	-	8/17/16	-	-
Village of Plymouth	No	-	-	8/17/16	-	-
Village of Reynolds	No	-	-	8/17/16	-	-
Village of Steele City	Yes	6/1/1987	8/17/2015	-	-	-
Nuckolls County	**Yes**	**12/16/2004**	**12/16/2004**	**-**	**-**	**-**
Village of Hardy	No	-	-	11/19/77	-	-
Village of Lawrence	Yes	12/16/2004	(NSFHA)	-	-	-
City of Nelson	Yes	9/4/1987	12/16/04(M)	-	-	-
Village of Nora	No	-	-	-	-	-
Village of Oak	No	-	-	11/15/75	-	-

Jurisdiction	Participate in NFIP?	Eligible-Regular Program	Date Current Map	Sanction	Suspension	Rescinded
Village of Ruskin	No	-	-	-	-	-
City of Superior	Yes	8/19/1987	12/16/04(M)	-	-	-
Saline County	**Yes**	**10/13/1987**	**11/4/2010**	**-**	**-**	**-**
City of Crete	Yes	10/15/1982	11/4/2010	-	-	-
Village of Dewitt	Yes	10/15/1982	11/4/2010	-	-	-
Village of Dorchester	No	-	-	3/26/77	-	-
City of Friend	Yes	11/4/2010	11/04/10(M)	-	-	-
Village of Swanton	Yes	8/19/1985	11/04/10(M)	-	-	-
Village of Tobias	No	-	-	-	-	-
Village of Western	No	-	-	-	-	-
City of Wilber	Yes	11/3/1982	11/4/2010	-	-	-
Thayer County	**Yes**	**9/30/2004**	**9/30/2004**	**-**	**-**	**-**
Village of Alexandria	Yes	9/30/2004	9/30/2004	-	-	-
Village of Belvidere	Yes	9/30/2004	9/30/2004	-	-	-
Village of Bruning	Yes	9/30/2004	9/30/2004	-	-	-
Village of Byron	Yes	9/30/2004	9/30/2004	-	-	-
Village of Carleton	Yes	9/30/2004	9/30/2004	-	-	-
Village of Chester	Yes	9/30/2004	9/30/2004	-	-	-
Village of Davenport	Yes	9/30/2004	9/30/2004	-	-	-
City of Deshler	Yes	2/1/1987	09/30/04(L)	-	-	-
Village of Gilead	No	-	-	9/30/05	-	-
City of Hebron	Yes	7/16/1987	09/30/04(M)	-	-	-
Village of Hubbell	Yes	2/1/1987	09/30/04(L)	-	-	-
Webster County	**Yes**	**5/1/1987**	**5/16/2008**	**-**	**-**	**-**
Village of Bladen	No	-	-	7/11/76	-	-
City of Blue Hill	Yes	5/16/2008	5/16/2008	-	-	-
Village of Cowles	No	-	-	5/16/09	-	-
Village of Guide Rock	Yes	3/1/2001	5/16/2008	-	-	-

Jurisdiction	Participate in NFIP?	Eligible-Regular Program	Date Current Map	Sanction	Suspension	Rescinded
City of Red Cloud	Yes	1/1/1987	5/16/2008	-	-	-

Source: FEMA, NFIP Community Status Book Report[40]
Note: (M) – No elevation determined – All Zone, A, C, and X; (L) – Original FIRM by Letter – All Zone A, C, and X

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 35: NFIP Policies in Force and Total Payments

Jurisdiction	Policies in-force	Total Coverage	Total Premiums	Closed Losses*	Total Payments*
Adams County	**19**	**$5,299,000**	**$10,374**	**5**	**$5,946**
Village of Ayr	-	-	-	-	-
City of Hastings	24	$7,128,900	$15,437	18	$293,728
Village of Holstein	-	-	-	-	-
Village of Juniata	10	$1,559,000	$6,865	-	-
Village of Kenesaw	15	$1,477,600	$12,731	-	-
Village of Prosser	-	-	-	-	-
Village of Roseland	-	-	-	-	-
Clay County	**6**	**$1,157,400**	**$7,225**	**-**	**-**
City of Clay Center	1	$350,000	$467	-	-
Village of Deweese	-	-	-	-	-
City of Edgar	-	-	-	-	-
City of Fairfield	-	-	-	-	-
Village of Glenvil	-	-	-	-	-
City of Harvard	1	$210,000	$395	-	-
Village of Ong	-	-	-	-	-
Village of Saronville	-	-	-	-	-
City of Sutton	13	$3,232,700	$64,839	1	$1,561
Village of Trumbull	-	-	-	-	-
Fillmore County	**4**	**$560,600**	**$3,431**	**-**	**-**
Village of Exeter	-	-	-	-	-
Village of Fairmont	-	-	-	-	-
City of Geneva	2	$377,000	$1,525	-	-
Village of Grafton	-	-	-	-	-
Village of Milligan	-	-	-	-	-
Village of Ohiowa	-	-	-	-	-
Village of Shickley	2	$405,000	$64,839	2	$25,000
Village of Strang	-	-	-	-	-
Gage County	**15**	**$2,671,200**	**$10,559**	**7**	**$281,257**
Village of Adams	2	$225,000	$2,628	-	-
Village of Barneston	-	-	-	-	-
City of Beatrice	61	$17,032,000	$69,466	153	$1,339,522
City of Blue Springs	1	$40,000	$457	-	-
Village of Clatonia	-	-	-	-	-
Village of Cortland	1	$350,000	$467	-	-
Village of Filley	-	-	-	-	-
Village of Liberty	-	-	-	-	-

[40] Federal Emergency Management Agency. 2020. "The National Flood Insurance Program Community Status Book." https://www.fema.gov/cis/NE.html.

Jurisdiction	Policies in-force	Total Coverage	Total Premiums	Closed Losses*	Total Payments*
Village of Odell	2	$108,500	$1,694	-	-
Village of Pickrell	-	-	-	-	-
Village of Virginia	-	-	-	-	-
City of Wymore	-	-	-	5	$17,419
Jefferson County	**2**	**$519,400**	**$8,489**	**-**	**-**
Village of Daykin	-	-	-	-	-
Village of Diller	-	-	-	-	-
Village of Endicott	-	-	-	-	-
City of Fairbury	2	$269,000	$5,463	2	$7,969
Village of Harbine	-	-	-	-	-
Village of Jansen	-	-	-	-	-
Village of Plymouth	-	-	-	-	-
Village of Reynolds	-	-	-	-	-
Village of Steele City	-	-	-	8	$6,217
Nuckolls County	**2**	**$150,000**	**$819**	**-**	**-**
Village of Hardy	-	-	-	-	-
Village of Lawrence	-	-	-	-	-
City of Nelson	1	$150,000	$1,742	-	-
Village of Nora	-	-	-	-	-
Village of Oak	-	-	-	-	-
Village of Ruskin	-	-	-	-	-
City of Superior	3	$93,700	$1,228	3	$7,070
Saline County	**15**	**$2,829,900**	**$13,797**	**11**	**$74,432**
City of Crete	92	$8,008,700	$116,536	18	$46,539
Village of Dewitt	55	$4,365,700	$62,207	152	$956,716
Village of Dorchester	-	-	-	-	-
City of Friend	-	-	-	-	-
Village of Swanton	-	-	-	-	-
Village of Tobias	-	-	-	-	-
Village of Western	-	-	-	-	-
City of Wilber	12	$1,319,000	$15,690	4	-
Thayer County	**6**	**$688,500**	**$8,411**	**4**	**$128,993**
Village of Alexandria	4	$110,800	$1,771	-	-
Village of Belvidere	12	$752,700	$8,528	1	$1,124
Village of Bruning	-	-	-	-	-
Village of Byron	2	$29,700	$212	-	-
Village of Carleton	1	$25,000	$401	-	-
Village of Chester	-	-	-	-	-
Village of Davenport	-	-	-	-	-
City of Deshler	8	$1,183,200	$4,836	5	$5,874
Village of Gilead	-	-	-	-	-
City of Hebron	3	$320,000	$5,423	10	$72,983
Village of Hubbell	7	$826,300	$14,243	5	$116,863
Webster County	**2**	**$149,500**	**$580**	**-**	**-**
Village of Bladen	-	-	-	-	-
City of Blue Hill	-	-	-	-	-
Village of Cowles	-	-	-	-	-
Village of Guide Rock	-	-	-	1	$11,599
City of Red Cloud	10	$3,140,000	$4,169	2	$1,727

Source: FEMA, HUDEX Policy Loss Data, November 30 2020[41]

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 encourage to initiate activities above the minimum participation requirements, such as those described in the Community Rating System (CRS) Coordinator's Manual (FIA-15/2017).[42] The Village of Dewitt has participated in the program in the past but is currently inactive.

NFIP Repetitive Loss Structures

NeDNR and FEMA Region VII were contacted to determine if any existing buildings, infrastructure, or critical facilities are classified as NFIP Repetitive Loss Structures. Note there are two definitions for repetitive loss structures. Severe repetitive loss is a grant definition for HMA purposes that has specific criteria while repetitive loss is a general NFIP definition. There are 17 repetitive loss properties located in the planning area as of February 2020. Only jurisdictions with reported properties are included in the following table.

Table 36: Repetitive Loss and Severe Repetitive Loss Properties

Jurisdiction	NFIP Repetitive Loss	# of Repetitive Loss Properties	Repetitive Loss Type	# of Severe Repetitive Loss Properties	Severe Repetitive Loss Type
City of Beatrice	9	1	Single Family	0	Single Family
City of Crete	1	-	-	-	-
City of Hastings	1	-	-	-	-
City of Hebron	1	-	-	-	-
Thayer County	1	-	-	-	-
Village of Dewitt	4	-	-	-	-

Source: NeDNR, February 2020 (personal correspondence)

NFIP RL: Repetitive Loss Structure refers to a structure covered by a contract for flood insurance under the NFIP that has incurred flood-related damage on two occasions during a 10-year period, each resulting in at least a $1,000 claim payment.

NFIP SRL: Severe Repetitive Loss Properties are defined as single or multifamily residential properties that are covered under an NFIP flood insurance policy and:

(1) That have incurred flood-related damage for which four or more separate claims payments have been made, with the amount of each claim (including building and contents payments) exceeding $5,000, and with the cumulative amount of such claim payments exceeding $20,000; or

(2) For which at least two separate claims payments (building payments only) have been made under such coverage, with cumulative amount of such claims exceeding the market value of the building.

[41] Federal Emergency Management Agency: National Flood Insurance Program. December 2019. Policy & Claim Statistics for Flood Insurance." Accessed November 2020. https://www.fema.gov/policy-claim-statistics-flood-insurance.

[42] 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.

(3) In both instances, at least two of the claims must be within 10 years of each other, and claims made within 10 days of each other will be counted as one claim.

HMA RL: A repetitive loss property is a structure covered by a contract for flood insurance made available under the NFIP that:

(1) Has incurred flood-related damage on two occasions, in which the cost of the repair, on the average, equaled or exceeded 25 percent of the market value of the structure at the time of each such food event; and

(2) At the time of the second incidence of flood-related damage, the contract for flood insurance contains increased cost of compliance coverage.

HMA SRL: A severe repetitive loss property is a structure that:

(1) Is covered under a contract for flood insurance made available under the NFIP.

(2) Has incurred flood related damage –

(a) For which four or more separate claims payments (includes building and contents) have been made under flood insurance coverage with the amount of each such claim exceeding $5,000, and with the cumulative amount of such claim payments exceeding $20,000; or

(b) For which at least two separate claims payments (includes only building) have been made under such coverage, with the cumulative amount of such claims exceeding the market value of the insured structure.

Purpose of the HMA definitions: The HMA definitions were allowed by the Biggert-Waters Flood Insurance Reform Act of 2012 to provide an increased federal cost share under the FMA grant when a property meets the HMA definition.

Supplemental Analysis

In order to conduct an analysis of potential impacts utilizing current critical facility and structure data, GIS was used to identify which structures and critical facilities fell within mapped flood risk hazard areas. GIS parcel data were acquired from each County Assessor. This data was analyzed for the location, number, and value of property improvements at the parcel level. Property improvements include any built structures such as roads, buildings, and paved lots. 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 jurisdictional parcel improvements in the floodplain can be found in the corresponding community profile in *Section Seven: Community Profiles*.

Table 37: Planning Area Parcel Improvements and Value in the Floodplain

Jurisdiction	# of Total Parcels	# of Total Improvements	Total Improvements Value	# of Improvements in Floodplain	Total Improvements Value in Floodplain
Adams County	**17,106**	**11,849**	**$1,522,604,325**	**2351**	**$210,265,755**
Village of Ayr	102	54	$2,212,825	3	$84,375
City of Hastings	10,500	9,014	$1,101,530,865	361	$136,311,000
Village of Holstein	165	125	$7,010,975	0	-
Village of Juniata	469	306	$26,506,960	207	$16,405,610
Village of Kenesaw	508	411	$34,765,685	628	$46,601,920
Village of Prosser	95	54	$2,089,510	0	-
Village of Roseland	196	135	$11,587,895	0	-
Clay County	**8,130**	**2,652**	**$234,382,635**	**699**	**$82,165,635**
City of Clay Center	551	318	$26,460,750	8	$1,287,100
Village of Deweese	105	36	$1,350,380	2	$313,380
City of Edgar	495	206	$11,861,425	5	$105,295
City of Fairfield	443	168	$9,696,540	0	-
Village of Glenvil	189	129	$8,393,265	0	-
City of Harvard	646	358	$15,891,605	0	-
Village of Ong	139	50	$896,660	0	-
Village of Saronville	84	19	$1,159,130	0	-
City of Sutton	1,009	578	$61,007,870	299	$30,933,660
Village of Trumbull	182	77	$7,528,905	0	-

Jurisdiction	# of Total Parcels	# of Total Improvements	Total Improvements Value	# of Improvements in Floodplain	Total Improvements Value in Floodplain
Fillmore County	**7,649**	**2,913**	**$259,949,565**	**255**	**$28,677,310**
Village of Exeter	475	326	$21,886	0	-
Village of Fairmont	441	280	$27,361	0	-
City of Geneva	1,349	1,068	$111,742,155	8	$4,828,960
Village of Grafton	170	86	$3,612,920	0	-
Village of Milligan	241	166	$7,732,140	1	$65,830
Village of Ohiowa	172	72	$1,184,705	0	-
Village of Shickley	299	196	$14,239,500	12	$951,420
Village of Strang	78	23	$717,015	0	-
Gage County	**18,626**	**10,162**	**$1,110,892,070**	**11331**	**$1,327,537,730**
Village of Adams	368	256	$30,539,685	269	$33,787,680
Village of Barneston	138	77	$3,463,040	78	$3,490,110
City of Beatrice	7,021	5,391	$579,905,675	5612	$630,351,970
City of Blue Springs	408	205	$6,783,570	216	$7,082,890
Village of Clatonia	189	145	$9,040,100	145	$9,040,100
Village of Cortland	298	233	$23,980,655	233	$23,980,655
Village of Filley	124	88	$4,185,355	88	$4,185,355
Village of Liberty	179	73	$1,604,355	74	$1,907,440
Village of Odell	238	161	$8,511,555	170	$9,873,865
Village of Pickrell	124	104	$10,172,500	105	$11,550,185
Village of Virginia	102	55	$4,079,690	55	$4,079,690
City of Wymore	1,121	825	$27,686,765	846	$28,419,640
Jefferson County	**9,637**	**3,979**	**$306,058,640**	**4413**	**$351,086,654**
Village of Daykin	179	106	$6,758,888	106	$6,758,888
Village of Diller	280	153	$10,043,368	160	$11,927,353
Village of Endicott	232	88	$3,729,668	92	$4,268,589
City of Fairbury	2,756	1,990	$121,545,108	1999	$122,301,819
Village of Harbine	58	31	$1,243,963	31	$1,243,963

Jurisdiction	# of Total Parcels	# of Total Improvements	Total Improvements Value	# of Improvements in Floodplain	Total Improvements Value in Floodplain
Village of Jansen	144	83	$2,748,664	83	$2,748,664
Village of Plymouth	296	214	$15,866,226	214	$15,866,226
Village of Reynolds	116	51	$1,092,277	52	$1,096,094
Village of Steele City	167	62	$1,188,734	65	$1,222,594
Nuckolls County	**6,673**	**2,148**	**$109,711,650**	**2458**	**$128,576,205**
Village of Hardy	179	70	$845,045	71	$860,525
Village of Lawrence	257	150	$6,342,115	151	$6,452,615
City of Nelson	606	258	$8,545,270	269	$9,021,790
Village of Nora	67	9	$340,865	9	$340,865
Village of Oak	93	29	$471,145	34	$541,615
Village of Ruskin	186	69	$3,467,050	69	$3,467,050
City of Superior	1,460	927	$44,390,030	973	$46,352,640
Saline County	**11,176**	**5,658**	**$603,581,315**	**6393**	**$718,132,135**
City of Crete	2,571	2,010	$234,846,480	2156	$254,535,180
Village of Dewitt	390	281	$7,962,645	562	$35,925,290
Village of Dorchester	368	289	$27,687,245	0	-
City of Friend	759	549	$53,288,025	551	$53,434,390
Village of Swanton	133	79	$3,646,685	85	$4,736,510
Village of Tobias	202	104	$1,969,630	104	$1,969,630
Village of Western	260	186	$7,125,025	189	$7,256,875
City of Wilber	968	796	$75,310,290	858	$81,031,710
Thayer County	**7,071**	**2,292**	**$169,015,679**	**2574**	**$196,794,768**
Village of Alexandria	241	79	$1,616,668	106	$2,161,267
Village of Belvidere	125	29	$496,893	44	$685,227
Village of Bruning	284	139	$8,936,418	139	$8,936,418
Village of Byron	111	49	$1,539,790	49	$1,539,790
Village of Carleton	160	40	$2,079,407	40	$2,079,407
Village of Chester	346	120	$4,424,201	120	$4,424,201

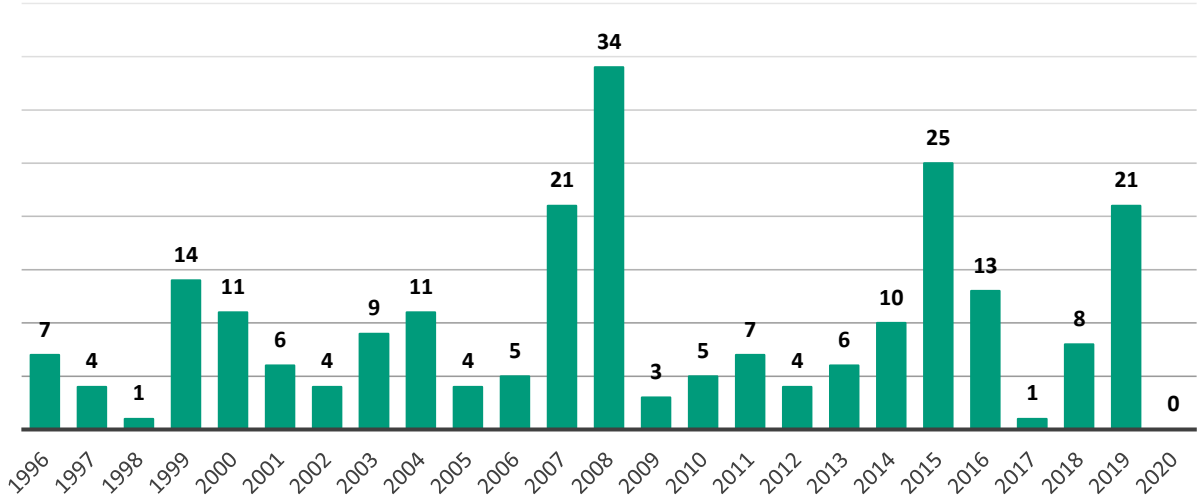
Jurisdiction	# of Total Parcels	# of Total Improvements	Total Improvements Value	# of Improvements in Floodplain	Total Improvements Value in Floodplain
Village of Davenport	344	167	$5,592,729	167	$5,592,729
City of Deshler	558	316	$17,230,669	324	$17,849,067
Village of Gilead	80	18	$452,550	18	$452,550
City of Hebron	1,014	610	$45,806,797	633	$47,207,531
Village of Hubbell	155	38	$798,290	52	$1,184,687
Webster County	**4,859**	**1,841**	**117,393,615**	**2192**	**144,030,020**
Village of Bladen	177	114	$4,339,220	115	$4,347,885
City of Blue Hill	467	365	$32,672,040	369	$33,173,290
Village of Cowles	48	16	$464,695	16	$464,695
Village of Guide Rock	258	145	$3,124,225	152	$3,245,515
City of Red Cloud	766	579	$27,881,815	610	$29,608,770

Source: County Assessors 2019, JEO GIS analysis

Probability

The NCEI reports 122 flooding and 112 flash flooding events from January 1996 to April 2020. Some years had multiple flooding events. The following figure shows the events broken down by year. Based on the historic record and reported incidents by participating communities, there is a 96 percent probability that flooding will occur annually in the planning area. It is worth noting that while no events were reported for 2020, data utilized in this analysis only included January 2020 to April 2020. Flood events likely occurred during 2020 but were not reported here.

Figure 36: Nebraska Disaster Declaration, March 2019



Source: NCEI, 1996-April 2020

Community Top Hazard Status

The following table lists jurisdictions which identified Flooding as a top hazard of concern:

Jurisdictions	
Little Blue NRD	City of Superior
Lower Big Blue NRD	City of Sutton
Adams County	Village of Adams
Clay County	Village of Alexandria
Fillmore County	Village of Ayr
Gage County	Village of Barneston
Jefferson County	Village of Belvidere
Nuckolls County	Village of Bruning
Saline County	Village of DeWitt
Thayer County	Village of Exeter
Webster County	Village of Guide Rock
Beatrice Public Schools	Village of Hubbell
City of Beatrice	Village of Juniata
City of Crete	Village of Kenesaw
City of Deshler	Village of Ohiowa
City of Fairbury	Village of Reynolds
City of Fairfield	Village of Shickley
City of Friend	Village of Steele City

Jurisdictions	
City of Geneva	Village of Swanton
City of Hebron	Village of Tobias
City of Red Cloud	

Regional 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.[43] 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. And finally flash floods are more often responsible for injuries and fatalities than prolonged flood events.

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.

On a state level, the Nebraska's State National Flood Insurance Coordinator's office has done some interesting work, studying who lives in special flood hazard areas. According to the NeDNR, floodplain areas have a few unique characteristics which differ from non-floodplain areas:

- Higher vacancy rates within floodplain
- Far higher percentage of renters within floodplain
- Higher percentage of non-family households in floodplain
- More diverse population in floodplain
- Much higher percentage of Hispanic/Latino populations in the floodplain

[43] 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

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

Table 38: Regional 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 losses from flooded fields or cattle loss -Closed roads and railroads would impact commercial transportation of goods
BUILT ENVIRONMENT	-Building may be damaged
INFRASTRUCTURE	-Damages to roadways and railways
CRITICAL FACILITIES	-Wastewater facilities are at risk, particularly those in the floodplain -Critical facilities, especially those in the floodplain, are at risk to damage (critical facilities are noted within individual community profiles)
CLIMATE	-Changes in seasonal and annual precipitation normals will likely increase frequency and magnitude of flood events

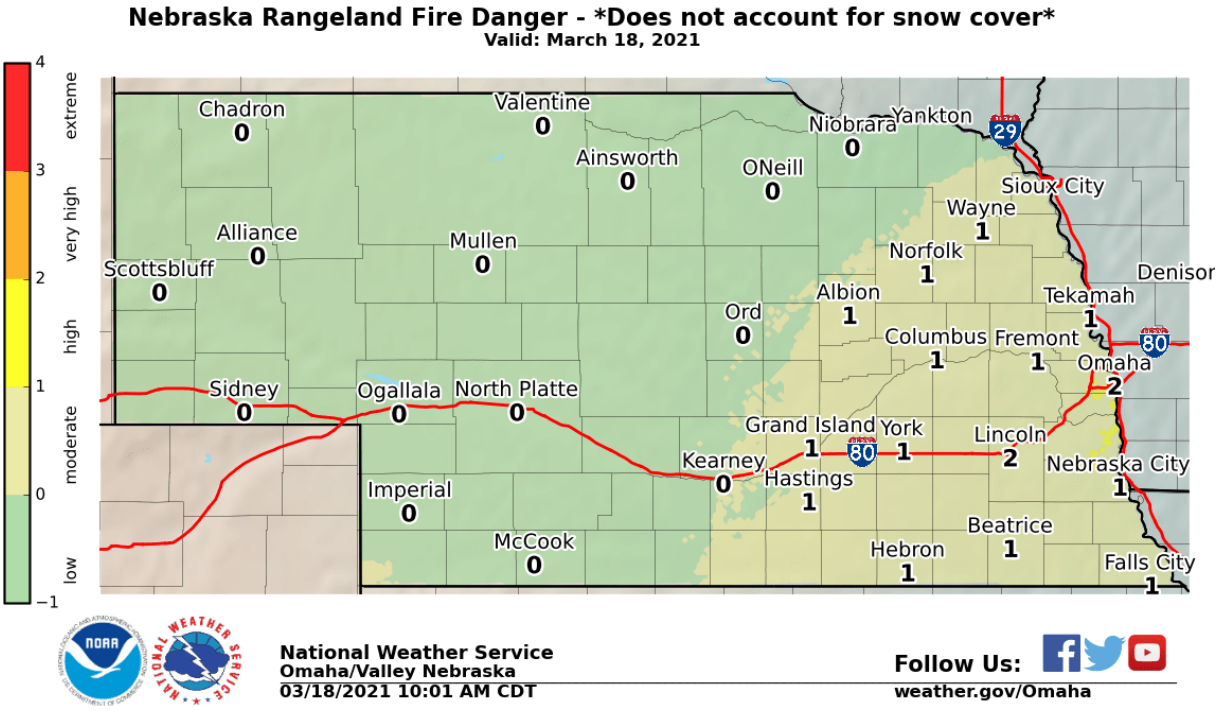
Grass/Wildfires

Wildfires, also known as grassfires, brushfires, forest fires, or wildland fires, are any uncontrolled fire that occurs in the countryside or wildland. Wildland areas may include, but are not limited to: grasslands; forests; woodlands; agricultural fields; pastures; and other vegetated areas. Wildfires range in size from a few acres (the most common) to thousands of acres in some cases. Fire events can quickly 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 surrounding 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.

Wildfires are a growing hazard in most regions of the United States, posing a threat to life and property, particularly where rural or native ecosystems meet urban developed areas or where local economies are heavily dependent on open agricultural land. Although fire is a natural and often beneficial process, fire suppression can lead to more severe fires due to the buildup of vegetation, which creates more fuel and increases the intensity and devastation of future fires.

Wildfires are characterized in terms of their physical properties including topography, weather, and fuels. Wildfire behavior is often complex and variably dependent on factors such as fuel type, moisture content in the fuel, humidity, wind speed, topography, geographic location, ambient temperature, the effect of weather on the fire, and the cause of ignition. Fuel and structure durability are the primary factors can control and are the target of most mitigation efforts. The NWS monitors the risk factors including high temperature, high wind speed, fuel moisture (greenness of vegetation), low humidity, and cloud cover in the state on a daily basis (Figure 37). Fire danger predictions are updated regularly and should be reviewed frequently by community leaders and fire department officials.

Figure 37: Rangeland Fire Danger Example



In recent decades, as the population of the United States has decentralized and residents have moved farther away from the center of villages and cities, the area known as the wildland urban interface (WUI) has developed significantly, in both terms of population and building stock. The WUI is defined as the zone of transition between developed areas and undeveloped wilderness, where structures and other human development meet wildland. The expansion of the WUI increases the likelihood that wildfires will threaten people and homes, making it the focus of the majority of wildfire mitigation efforts. The Nebraska Forest Service (NFS) develops Community Wildfire Protection Plans for regions across the state. Gage County is located in the Southeast CWPP region with a completed plan (August 2020) while Adams, Clay, Fillmore, Jefferson, Nuckolls, Saline, Thayer, and Webster Counties are all located in the South Central East region which anticipated to be developed in 2022.[44]

The following figure produced by the USDA Forest Service displays the State of Nebraska's WUI conditions as of 2010. The approximate location of the planning area is indicated by the black outline. Areas that are indicated by the WUI (Figure 38), either interface (yellow) or intermix (orange) are primarily found in portions of Gage and Adams Counties. The rest of the planning area is located in primarily non-WUI vegetated designated areas, with no or low-density housing with a mix of vegetated, non-vegetated, and agricultural land.

[44] Nebraska Forest Service. 2020. "Community Wildfire Protection Plans." https://nfs.unl.edu/publications/community-wildfire-protection-plans.

Figure 38: 2010 Wildland Urban Interface Map of Nebraska

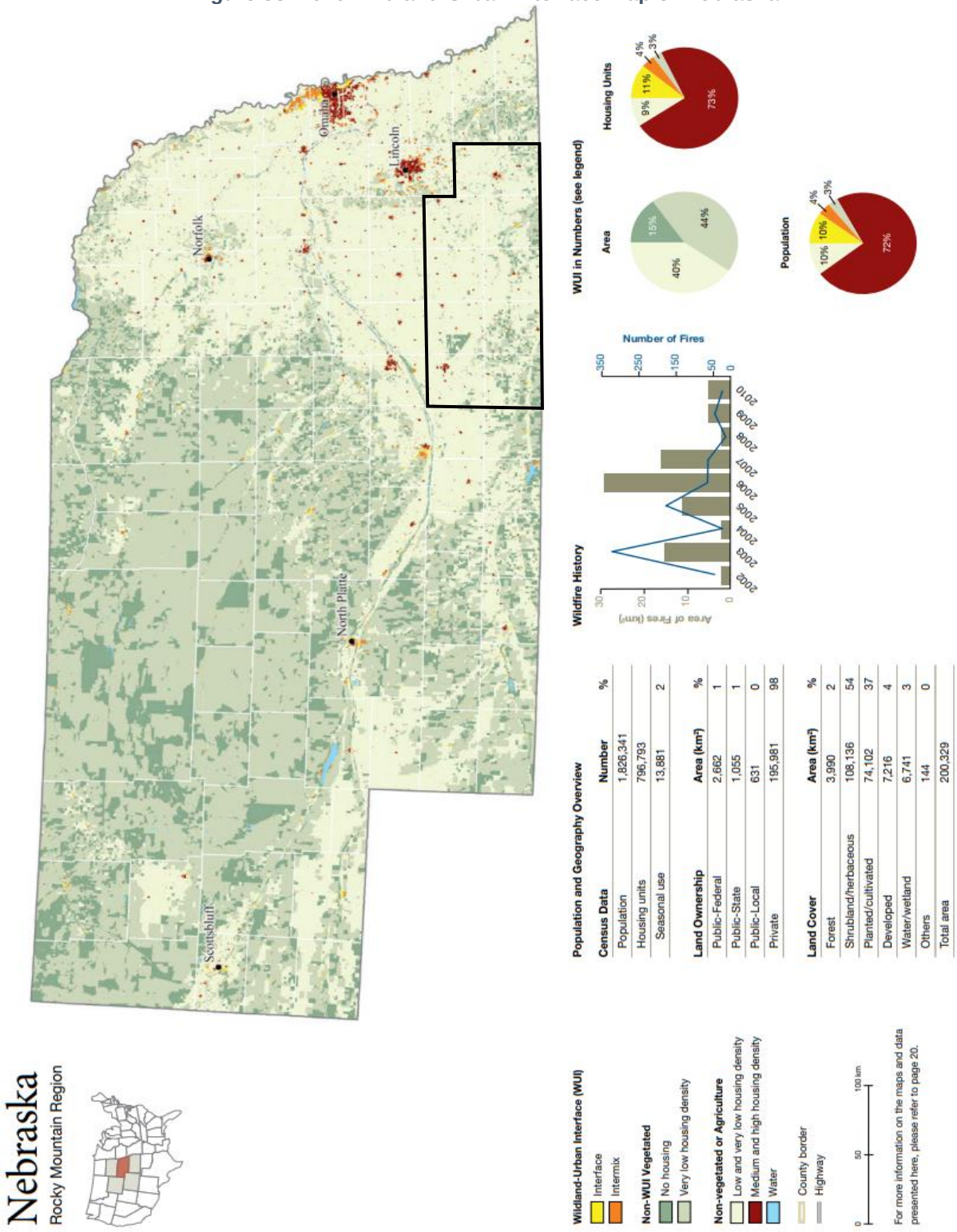


Figure 39: Lower Big Blue District Wildland Urban Interface Map

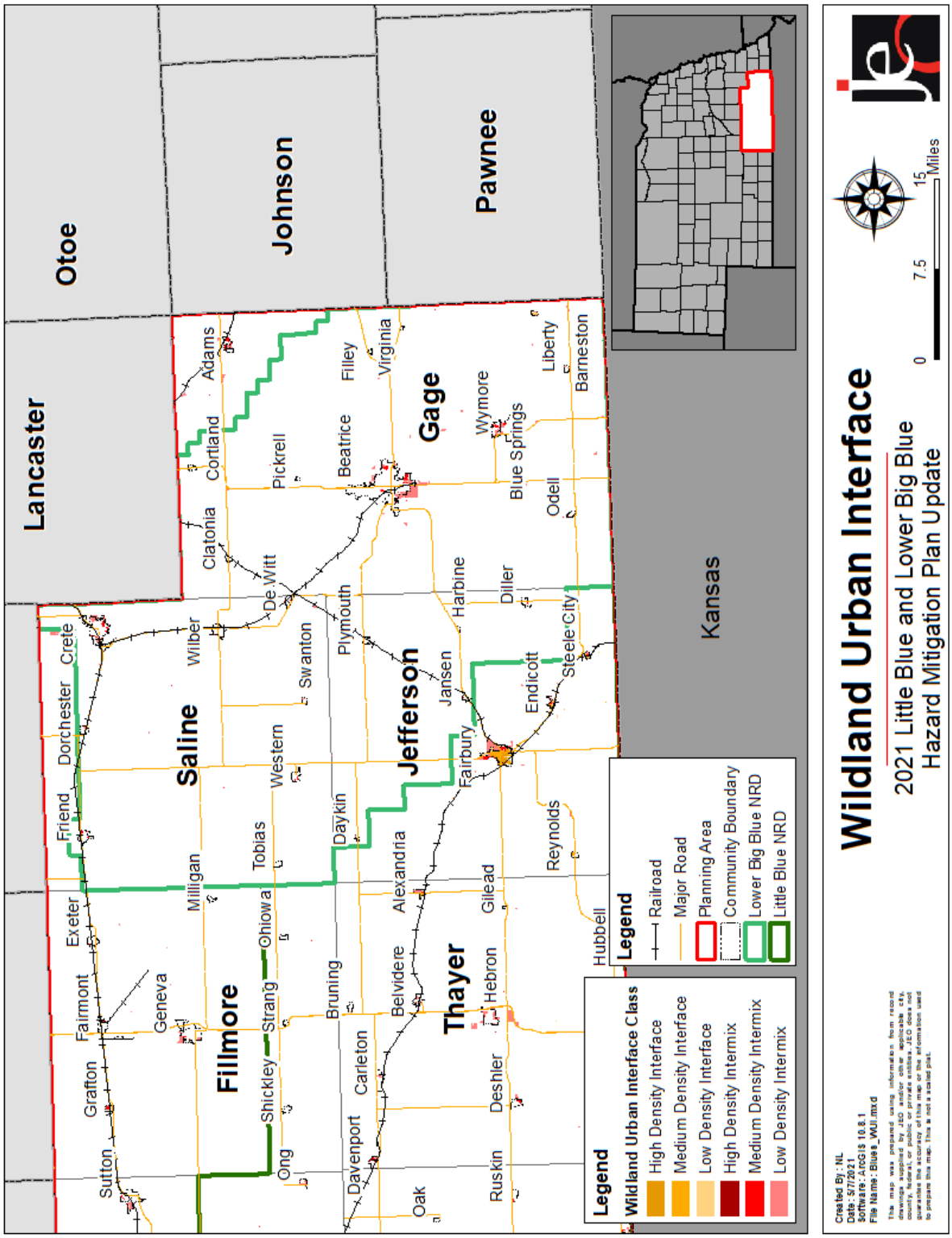
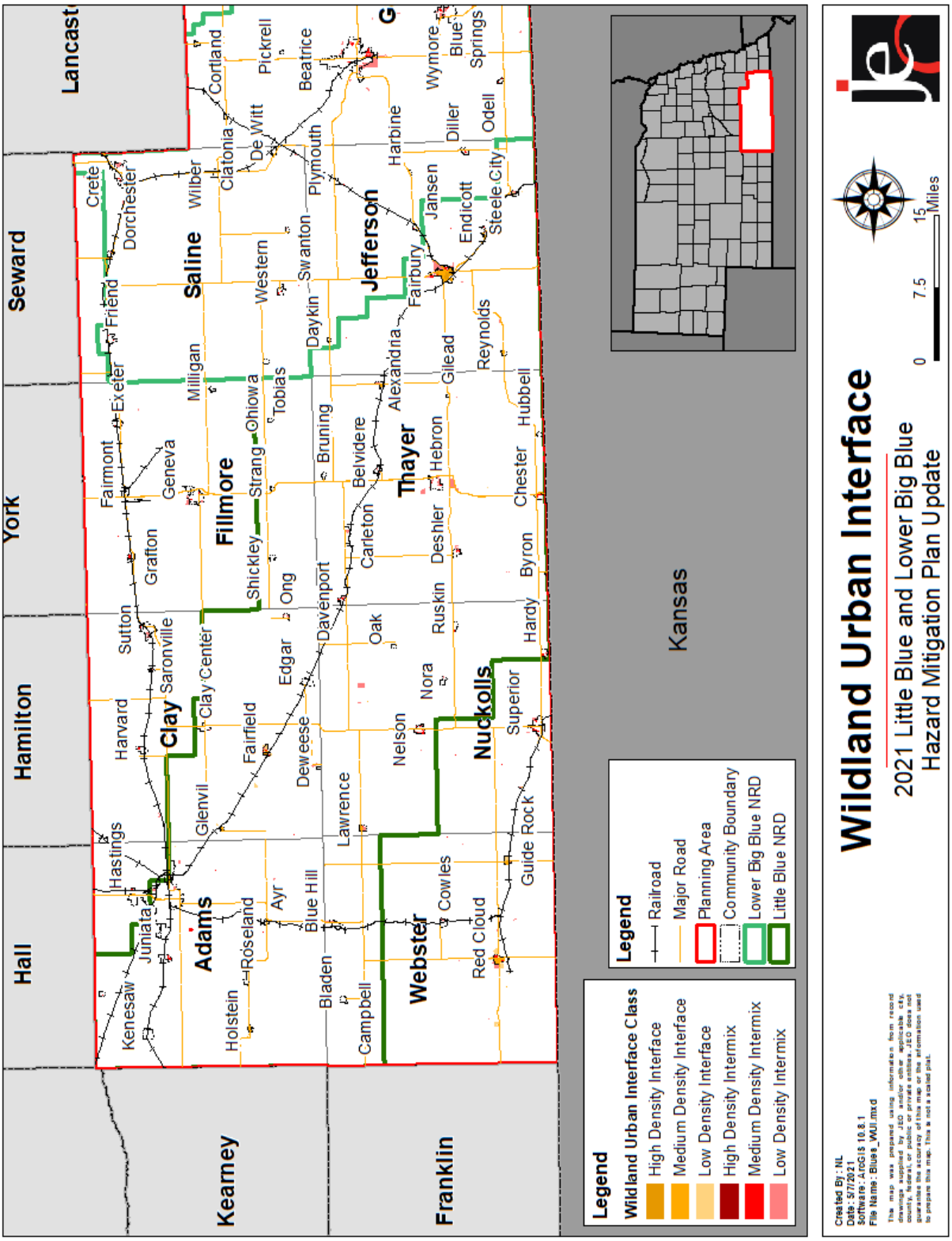


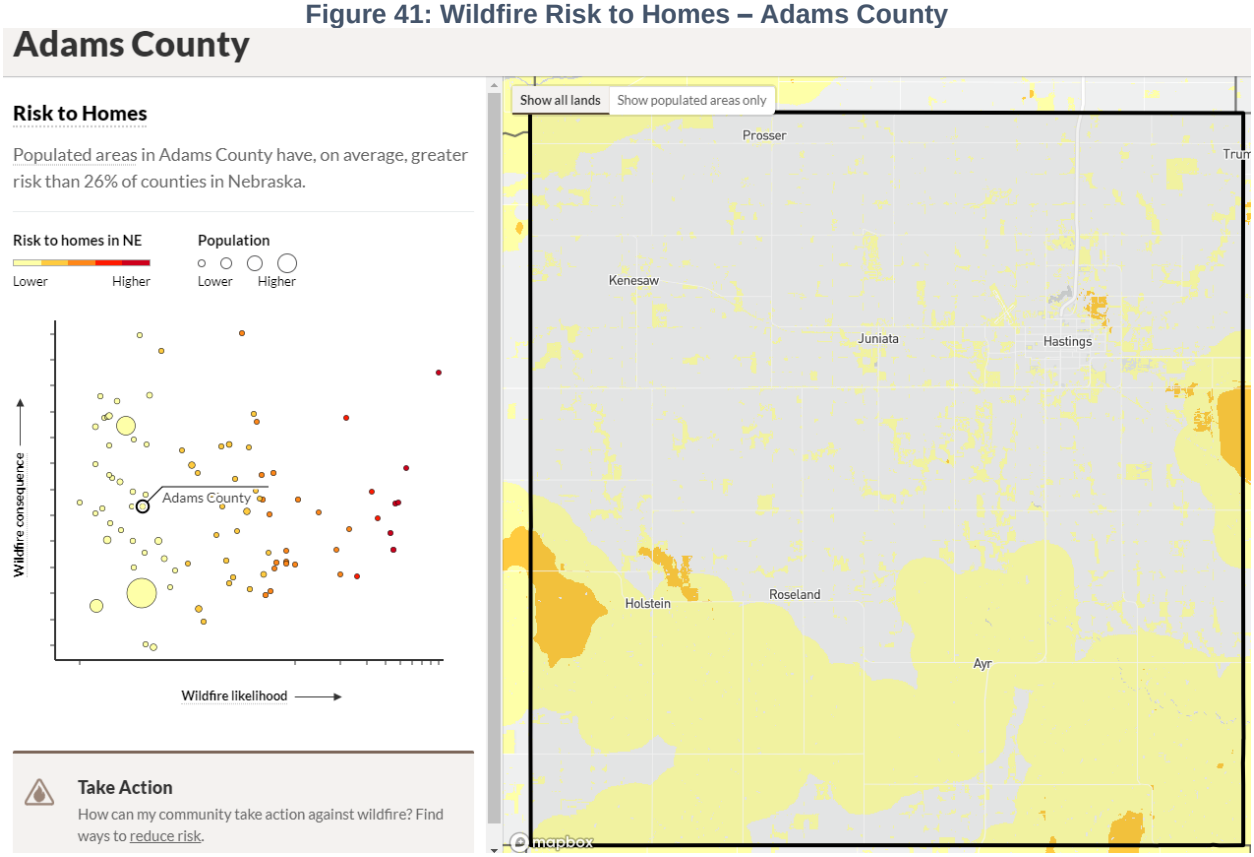
Figure 40: Little Blue District Wildland Urban Interface Map



Source: USDA, 2010[45]

The United States Department of Agriculture Forest Service created the interactive web resource *Wildfire Risk to Communities* to help communities and jurisdictions understand, explore, and reduce wildfire risk. The following figures show wildfire risk to homes per county in the planning area.

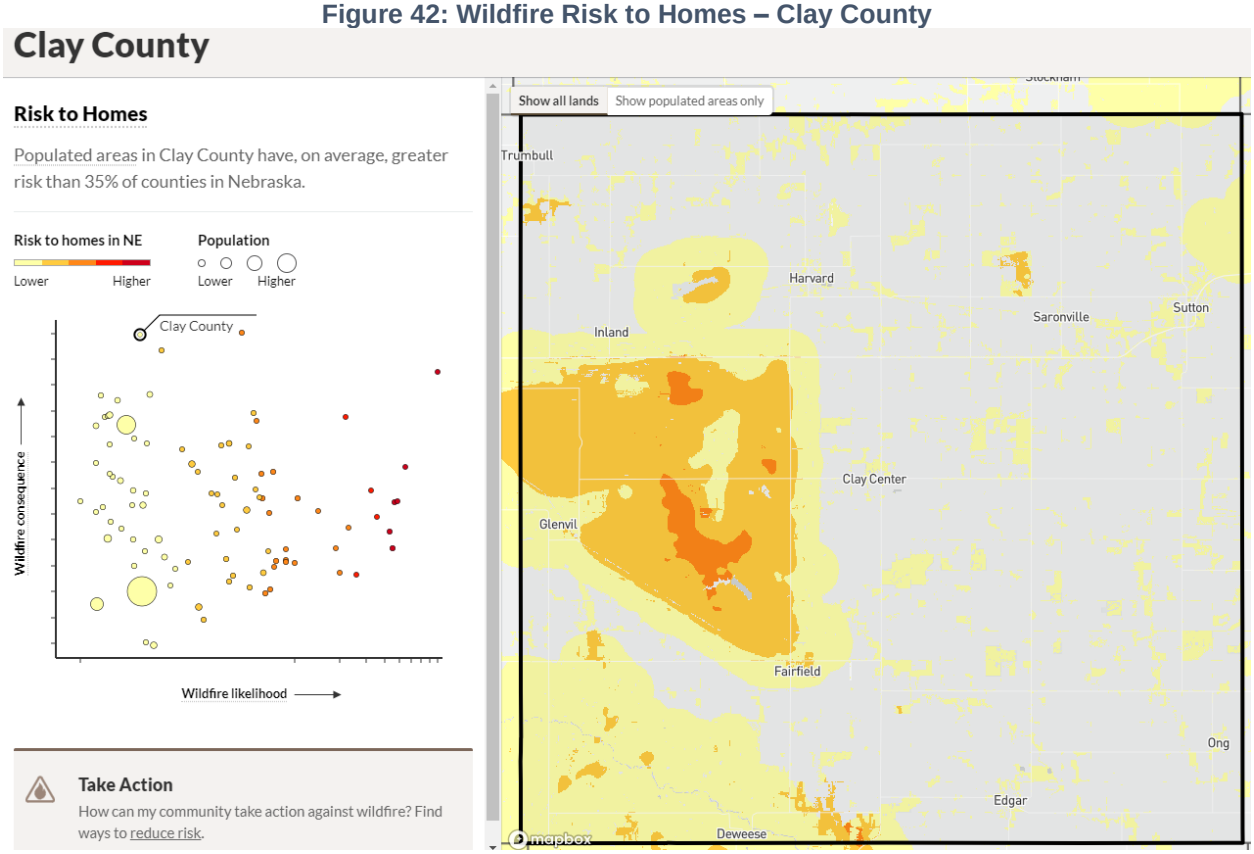
Figure 41: Wildfire Risk to Homes – Adams County



Source: Wildfire Risk to Communities

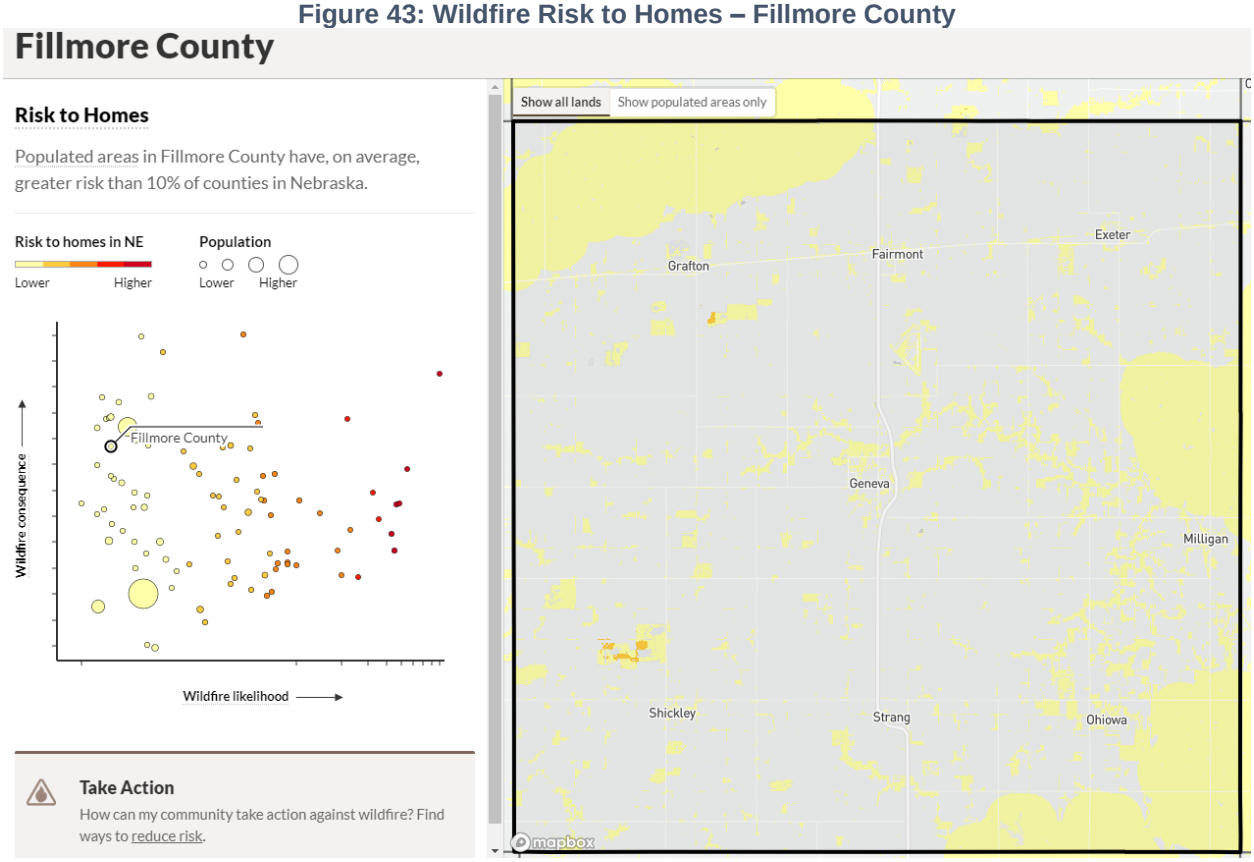
[45] USDA, USFS, & University of Wisconsin. 2010. "The 2010 Wildland-Urban Interface of the Conterminous United States." https://www.fs.fed.us/nrs/pubs/rmap/rmap_nrs8.pdf.

Figure 42: Wildfire Risk to Homes – Clay County



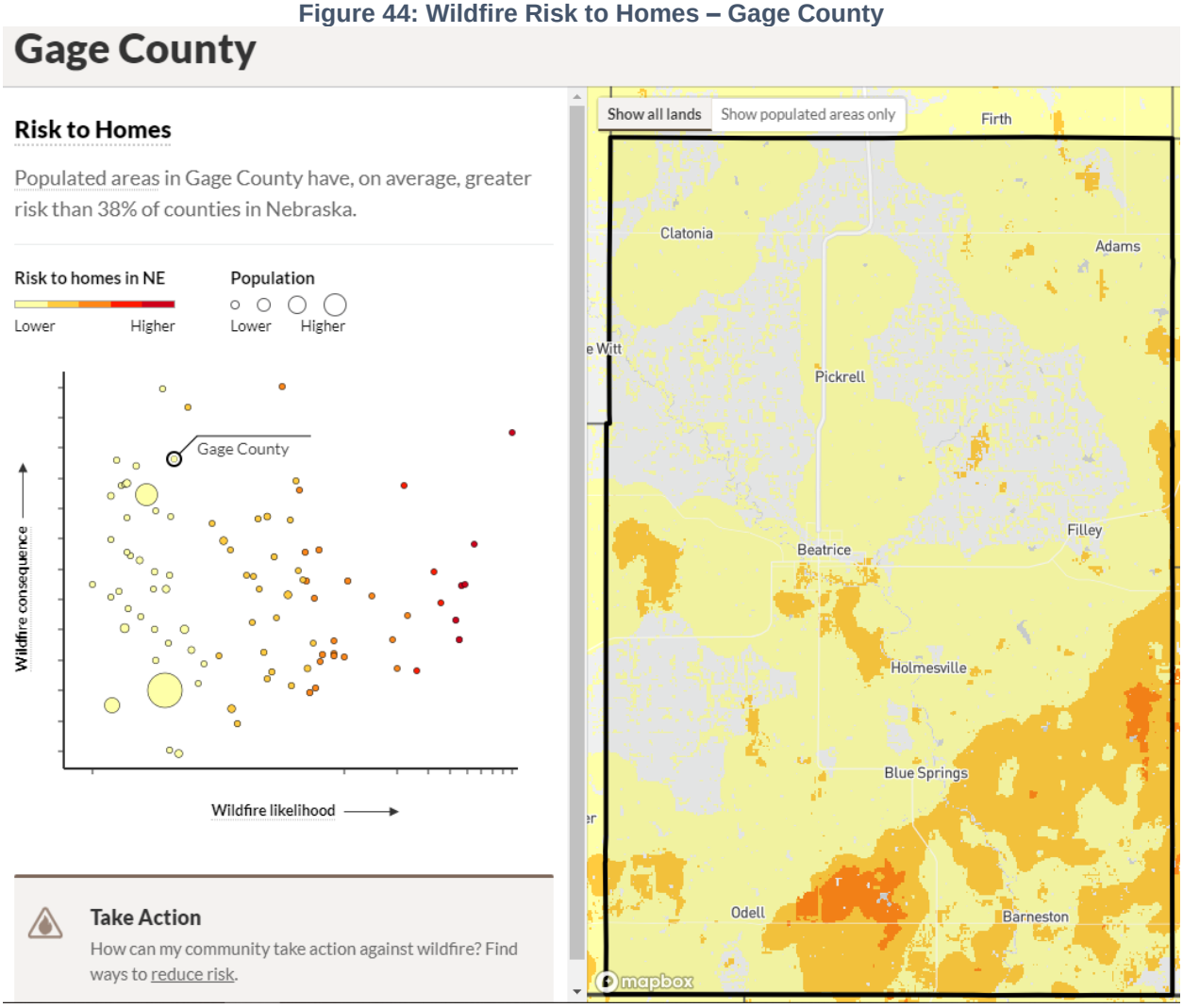
Source: Wildfire Risk to Communities

Figure 43: Wildfire Risk to Homes – Fillmore County



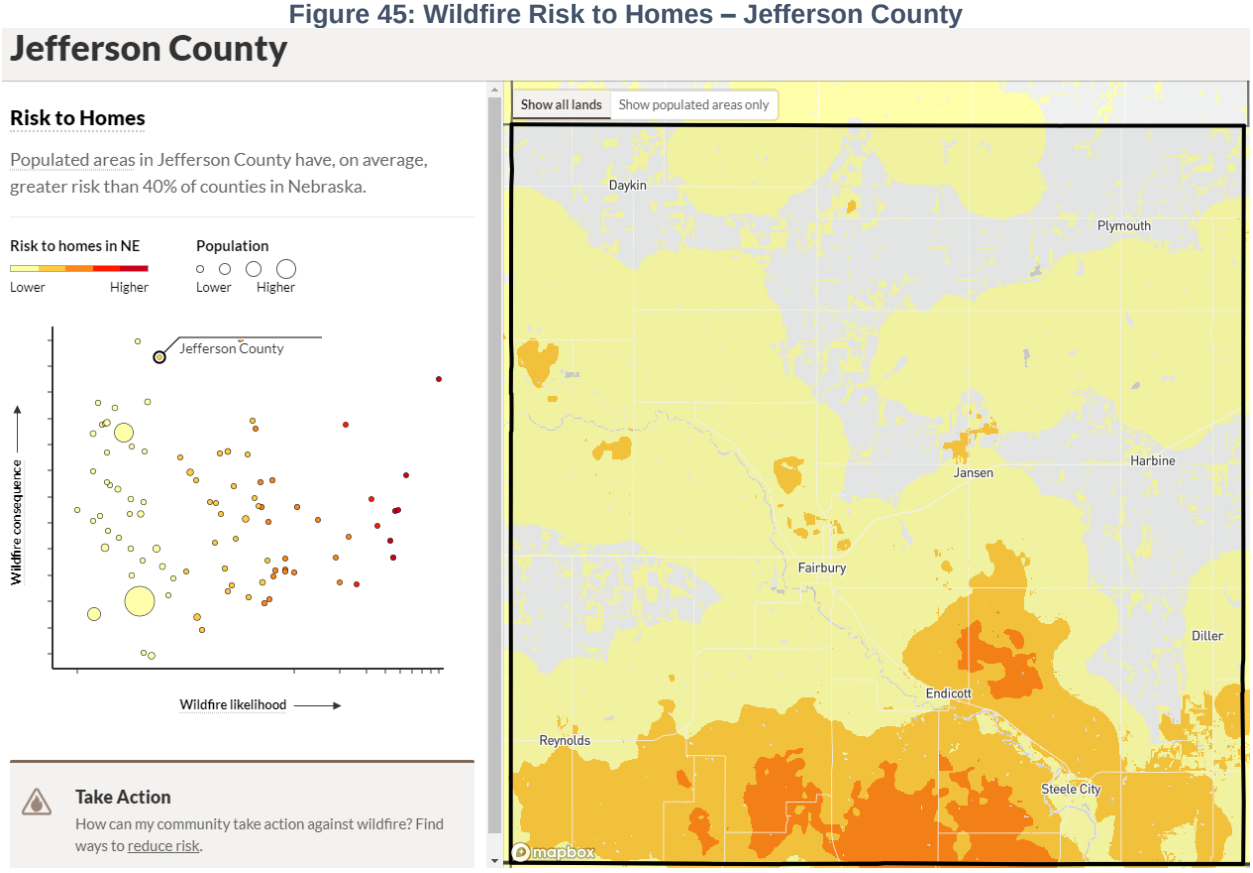
Source: Wildfire Risk to Communities

Figure 44: Wildfire Risk to Homes – Gage County



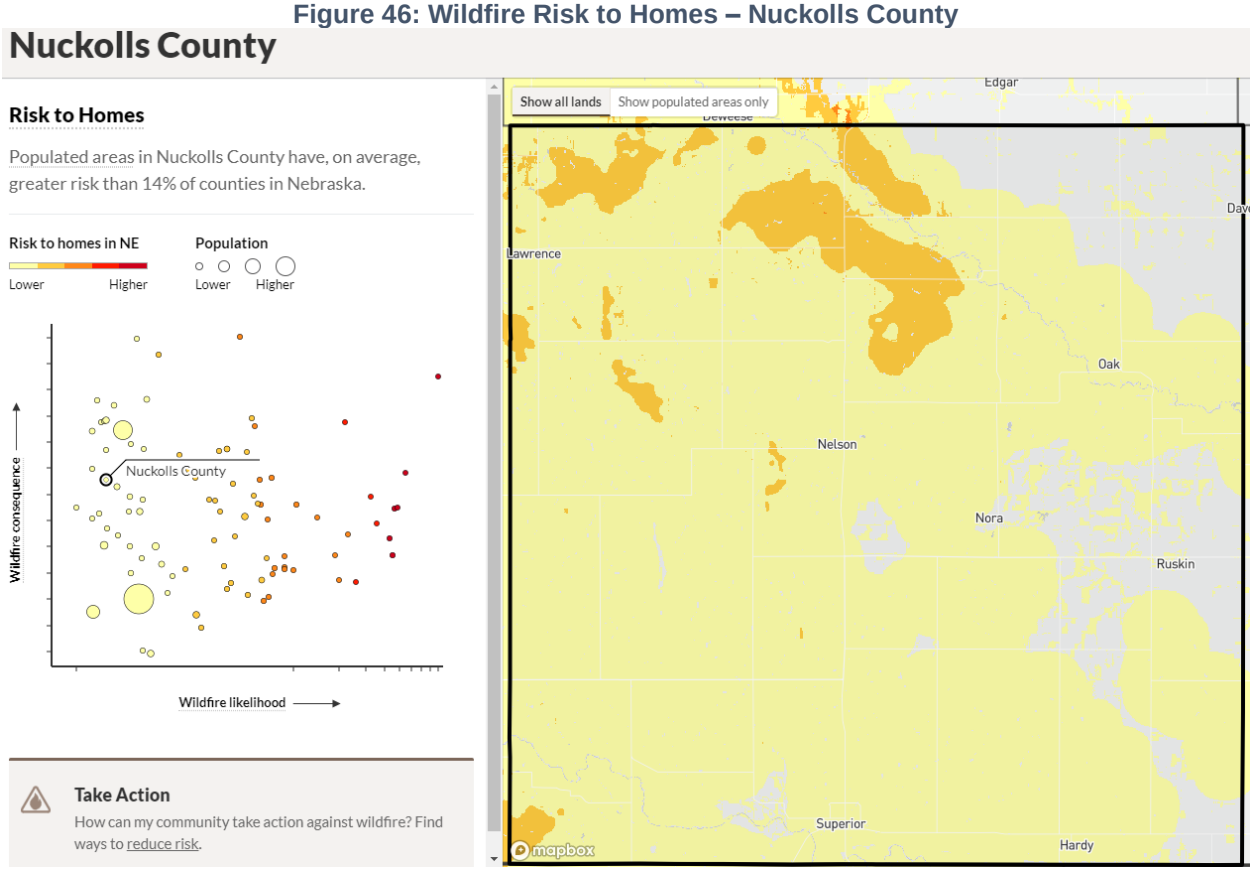
Source: Wildfire Risk to Communities

Figure 45: Wildfire Risk to Homes – Jefferson County



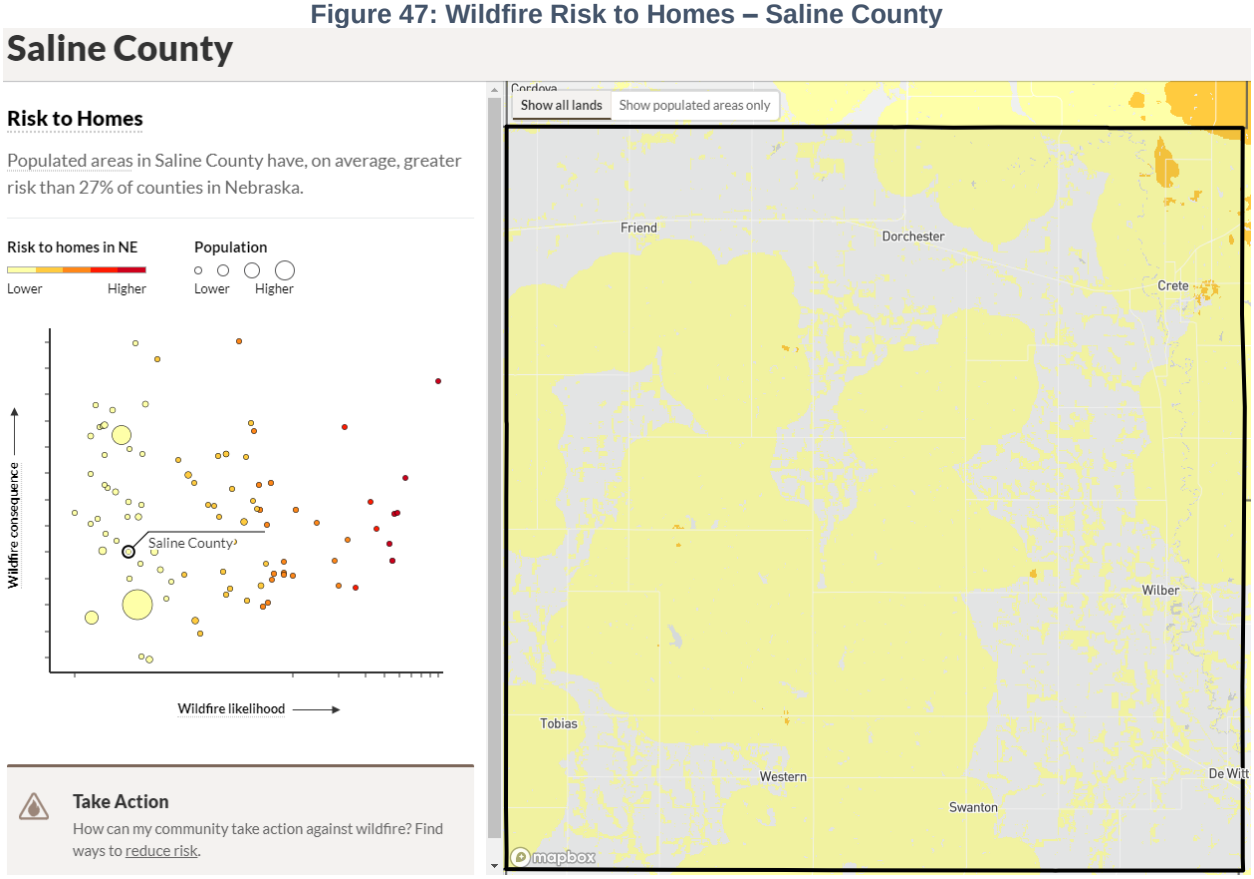
Source: Wildfire Risk to Communities

Figure 46: Wildfire Risk to Homes – Nuckolls County



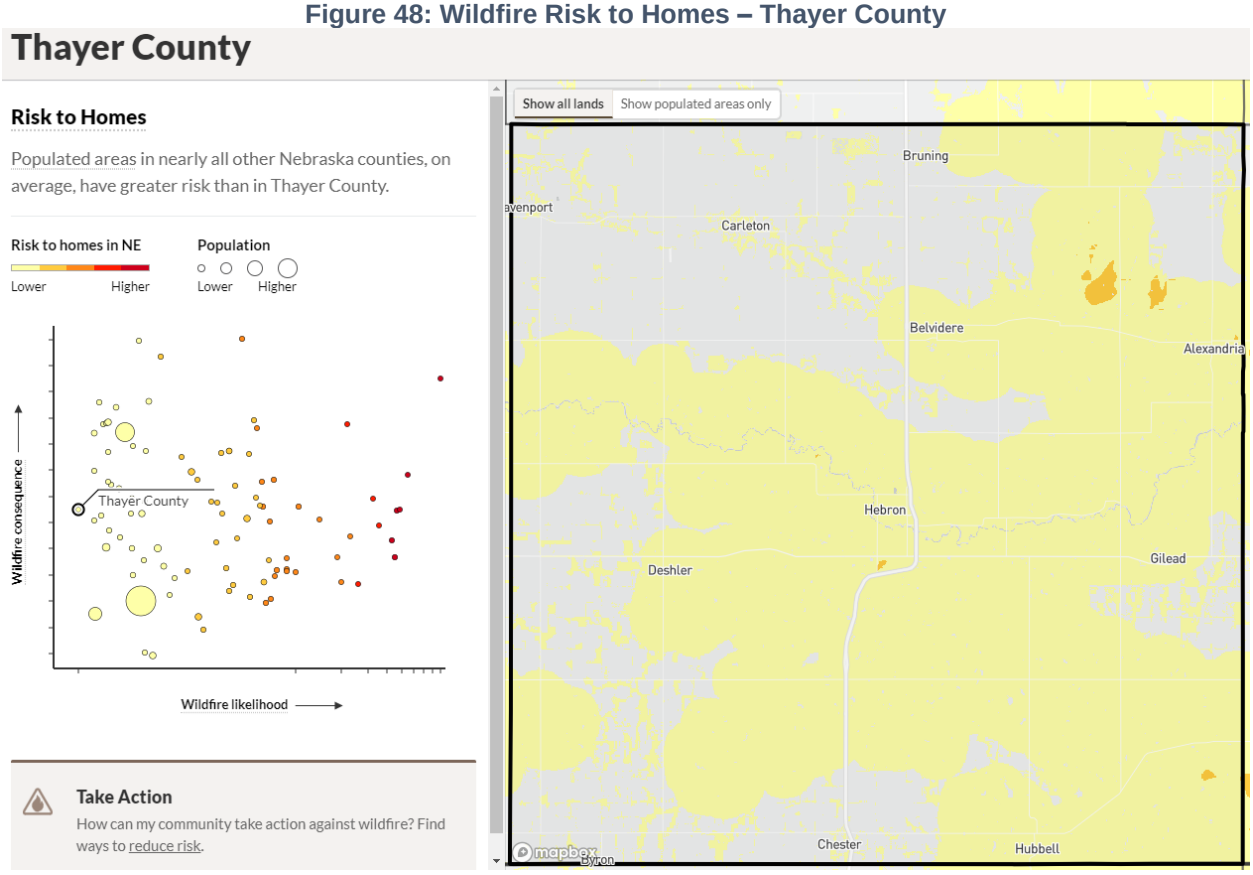
Source: Wildfire Risk to Communities

Figure 47: Wildfire Risk to Homes – Saline County



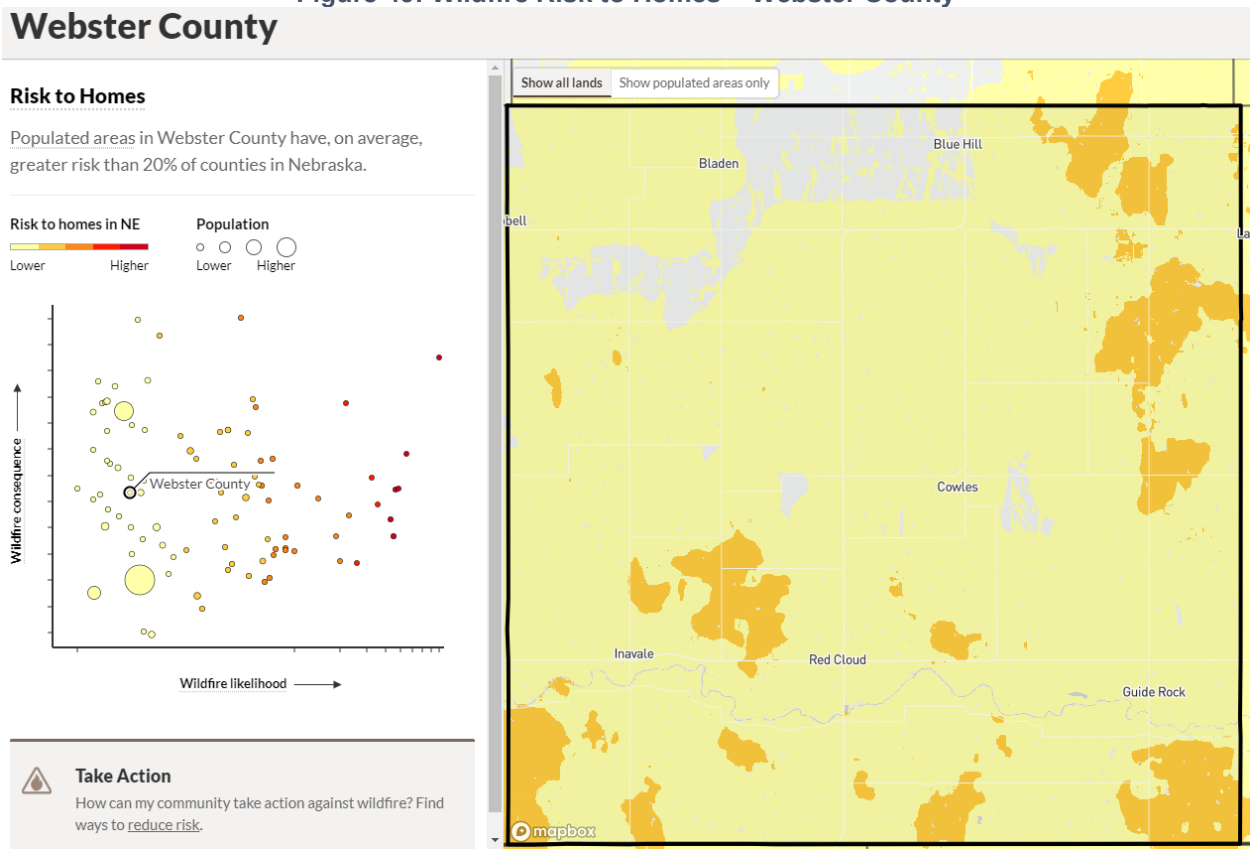
Source: Wildfire Risk to Communities

Figure 48: Wildfire Risk to Homes – Thayer County



Source: Wildfire Risk to Communities

Figure 49: Wildfire Risk to Homes – Webster County



Source: Wildfire Risk to Communities

According to the Southeast Nebraska Community Wildfire Protection Plan, specific concerns are located throughout Gage County. Locations of special concern include population centers adjacent to wildlands where topography is rough and woody fuels are dense in some areas, creating high fire hazard. The areas most at-risk from wildfire are located along the rivers and major creeks. All of Gage County's population centers, dispersed farms and ranches, and wooded areas along the rivers and streams lie within the boundaries of the WUI as defined in the CWPP. The previously single-jurisdictional 2019 HMP for the City of Beatrice noted a concern for wildfire throughout the city due to the high amount of WUI, particularly the riverfront, Southeast Community College campus, industrial park, the airport, Good Samaritan facility, and homes along the edges of city boundaries. The Beatrice fire chief identified locations throughout the city and edges of town, as well as many rural subdivisions, as at-risk WUI areas with multiple structures, difficult access, rough terrain, and heavy fuels. Specifically listed were the Covered Bridge area, Country Club Lane, Country Meadows, Flowing Springs area, Wildwood, Chester St., and Montgomery St. The Dewitt fire chief identified Turkey Creek and the Big Blue River as having difficult access.

Of the counties in the planning area, Jefferson County has the greatest risk of wildfire. The following tables describes other specific risks and vulnerabilities seen across the planning area.

Table 39: Wildfire Vulnerabilities by County

County	Risk To Homes (compared to NE Counties)	Exposure Type	Wildfire Likelihood (compared to NE Counties)
Adams	Greater risk than 26% of NE Counties	Directly Exposed (13%) Indirectly Exposed (2%) Not Exposed (85%)	Greater risk than 28% of NE Counties
Clay	Greater risk than 35% of NE Counties	Directly Exposed (24%) Indirectly Exposed (11%) Not Exposed (65%)	Greater risk than 26% of NE Counties
Fillmore	Greater risk than 10% of NE Counties	Directly Exposed (20%) Indirectly Exposed (2%) Not Exposed (78%)	Greater risk than 11% of NE Counties
Gage	Greater risk than 38% of NE Counties	Directly Exposed (25%) Indirectly Exposed (52%) Not Exposed (24%)	Greater risk than 34% of NE Counties
Jefferson	Greater risk than 40% of NE Counties	Directly Exposed (27%) Indirectly Exposed (60%) Not Exposed (13%)	Greater risk than 37% of NE Counties
Nuckolls	Greater risk than 14% of NE Counties	Directly Exposed (32%) Indirectly Exposed (62%) Not Exposed (6%)	Greater risk than 13% of NE Counties
Saline	Greater risk than 27% of NE Counties	Directly Exposed (28%) Indirectly Exposed (42%) Not Exposed (30%)	Greater risk than 22% of NE Counties
Thayer	Nearly all other NE counties have greater risk	Directly Exposed (27%) Indirectly Exposed (48%) Not Exposed (25%)	Nearly all other NE counties have greater risk
Webster	Greater risk than 20% of NE Counties	Directly Exposed (27%) Indirectly Exposed (46%) Not Exposed (27%)	Greater risk than 21% of NE Counties

Source: Wildfire Risk to Communities, 2020[46]

Table 40: Wildfire Vulnerable Populations by County

County	Families in Poverty	People with Disabilities	People over 65	Difficulty with English	Households with no Vehicle	Mobile Homes
Adams	597 (7.7%)	4,447 (14.2%)	5,438 (17.2%)	579 (2%)	705 (5.5%)	481 (3.8%)
Clay	119 (7%)	938 (15.3%)	1,220 (19.6%)	99 (1.7%)	49 (1.9%)	50 (1.9%)
Fillmore	141 (9%)	845 (15.8%)	1,298 (23.3%)	28 (0.5%)	60 (2.4%)	16 (0.6%)
Gage	291 (5.2%)	3,282 (15.4%)	4,399 (20.4%)	46 (0.2%)	414 (4.5%)	128 (1.4%)
Jefferson	120 (6.3%)	1,197 (16.9%)	1,665 (23.2%)	108 (1.6%)	149 (4.5%)	38 (1.2%)
Nuckolls	66 (5.7%)	713 (17%)	1,145 (26.8%)	39 (1%)	115 (6%)	49 (2.6%)

[46] United States Department of Agriculture, United States Forest Service. 2020. "Wildfire Risk to Communities." https://wildfirerisk.org/.

County	Families in Poverty	People with Disabilities	People over 65	Difficulty with English	Households with no Vehicle	Mobile Homes
Saline	358 (10.2%)	1,597 (11.4%)	2,027 (14.2%)	1,010 (7.6%)	80 (1.6%)	291 (5.7%)
Thayer	95 (6.4%)	752 (15.2%)	1,278 (25.1%)	16 (0.3%)	101 (4.4%)	36 (1.6%)
Webster	81 (8.7%)	539 (15.4%)	796 (22.3%)	0 (0%)	77 (5.1%)	30 (2%)

Source: Wildfire Risk to Communities, 2020[47]

Location

There were 66 local volunteer or rural fire districts identified in the planning area. The following table lists these fire districts by county.

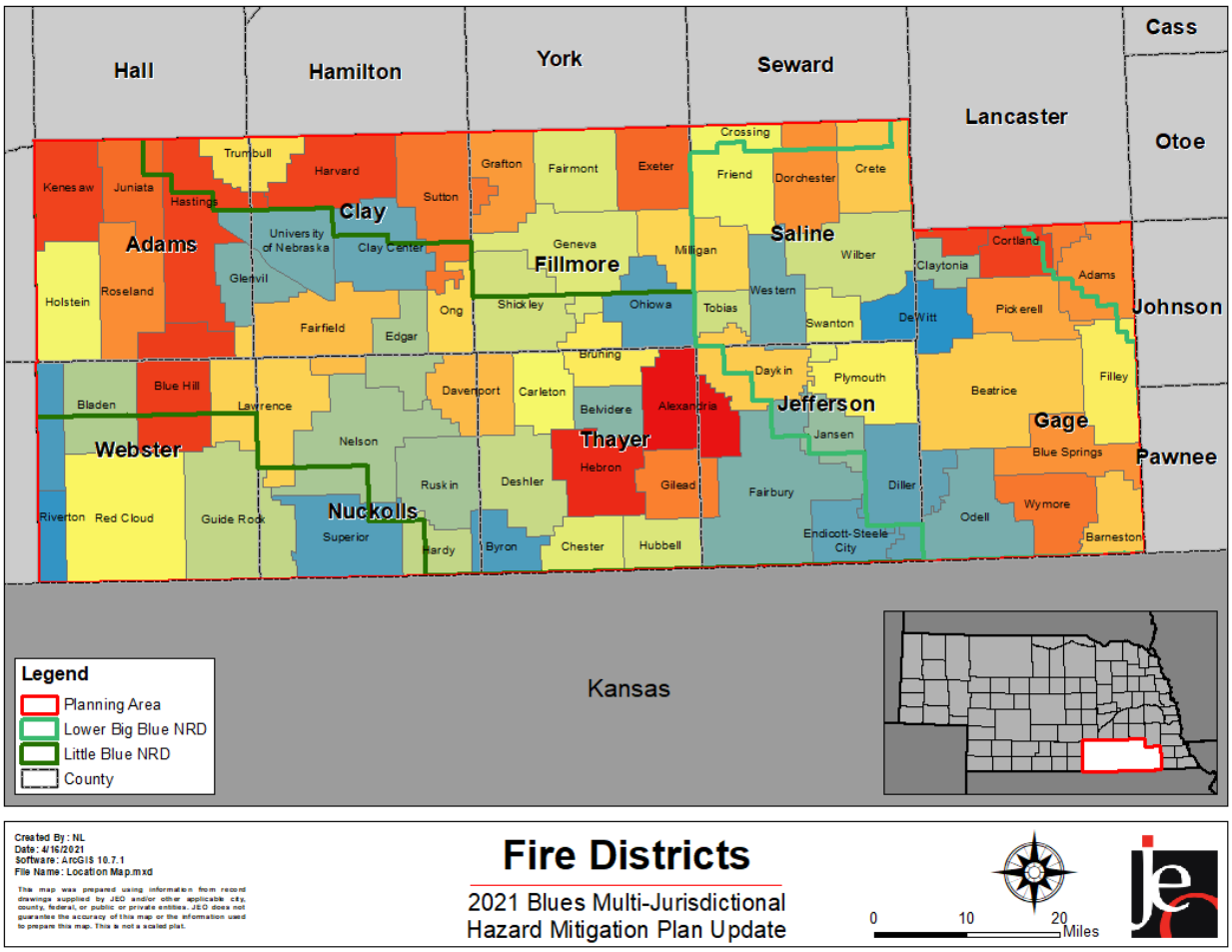
Table 41: Fire Districts in the Planning Area by County

County	Fire Districts	
Adams	Hastings Fire and Rescue	Juniata Rural Fire District
	Hastings Rural Fire District	Kenesaw Volunteer Fire Department
	Holstein Volunteer Fire Department	Roseland Volunteer Fire Department
Clay	Clay Center Volunteer Fire Department	Harvard Volunteer Fire Department
	Edgar Volunteer Fire Department	Sutton Volunteer Fire Department
	Fairfield Vol Fire & Rescue Dept	Trumbull Volunteer Fire Department
	Glenvil Fire & Rescue	
Fillmore	Exeter Volunteer Fire Department	Milligan Volunteer Fire Department
	Fairmont Volunteer Fire Department	Ohiowa Rural Fire Department
	Geneva Fire & Rescue	Shickley Volunteer Fire & Rescue
	Grafton Rural Fire Department	
Gage	Adams Rural Fire Department	Cortland Volunteer Fire Department
	Barneston Rural Fire Department	Filley Rural Fire Department
	Beatrice City Fire & Rescue	Odell Volunteer Fire Department
	Beatrice Rural Fire Department	Pickrell Volunteer Fire Department
	Blue Springs Volunteer Fire Department	Wymore Volunteer Fire & Rescue Department
	Clatonia Fire Department	
Jefferson	Daykin Volunteer Fire Department	Jansen Rural Fire District 9
	Diller Rural Fire Department	Plymouth Volunteer Fire Department
	Fairbury Rural Fire Department	Steele City Rural Volunteer Fire Department
	Fairbury Volunteer City Fire Department	
Nuckolls	Hardy Fire Department	Ruskin Fire Department
	Lawrence Volunteer Fire Department	Superior Volunteer Fire Department
	Nelson Volunteer Fire Department	
Saline	Crete Volunteer Fire & Rescue	Swanton Volunteer Fire Department
	Dewitt Volunteer Fire Department	Tobias Volunteer Fire Department
	Dorchester Volunteer Fire Department	Western Rural Fire Department
	Friend Volunteer Fire Department	Wilber Volunteer Fire Department
Thayer	Alexandria Volunteer Rural Fire	Davenport Volunteer Fire Department
	Belvidere Fire Department	Deshler Fire Department
	Bruning Fire Department	Gilead Volunteer Fire Department
	Byron Volunteer Fire Department	Hebron Volunteer Fire Department

[47] United States Department of Agriculture, United States Forest Service. 2020. "Wildfire Risk to Communities." https://wildfirerisk.org/.

County	Fire Districts	
	Carleton Volunteer Fire Department	Hubbell Volunteer Fire Department
	Chester Volunteer Fire Department	
Webster	Bladen Volunteer Fire Department	Guide Rock Volunteer Fire Department
	Blue Hill Volunteer Fire Department	Red Cloud Volunteer Fire Department

Figure 50: Fire Districts in the Planning Area



Historical Occurrences

For the planning area, 60 different fire departments reported a total of 2,059 wildfires between January 2000 and July 2020 according to the Nebraska Forest Service. The reported events burned 41,288 acres in total. While the RMA lists no damages from fire in the planning area, the NFS reported $613,319 in crop loss and $1,361,497 in property damages. Most fires occurred in 2006, 2000, and 2009 (Figure 51). The majority of wildfires were caused by Debris Burning or Miscellaneous causes (Figure 52). Wildfire events have ranged from less than one acre to 7,500 acres, with an average event burning 20 acres. 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.

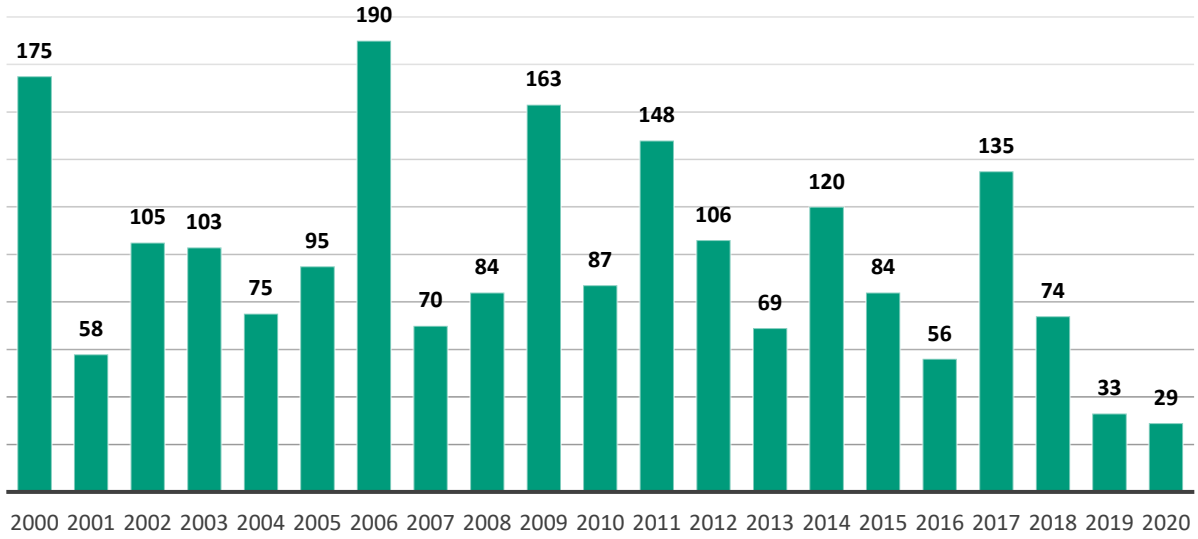
Wildfire count data was provided by the Nebraska Forest Service from January 2000 to July 2020. As the number of reported wildfires by the county indicates, wildfire events can occur in any county within the planning area. Gage County has reported the greatest number of fires and amount of acres burned.

Table 42: Reported Wildfires by County

County	Reported Wildfires	Acres Burned	Other Impacts
Adams	121	1,033	2 fatalities; 3 structures threatened
Clay	122	1,983	37 structures threatened; 5 structures destroyed
Fillmore	257	6,995	15 structures threatened; 11 structures destroyed
Gage	536	19,737	2 injuries; 17 structures threatened; 1 structures destroyed
Jefferson	235	3,502	18 structures threatened; 4 structures destroyed
Nuckolls	210	1,212	2 injuries; 28 structures threatened; 3 structures destroyed
Saline	243	2,477	3 injuries; 34 structures threatened; 3 structures destroyed
Thayer	237	2,807	6 injuries; 1 fatalities; 84 structures threatened; 17 structures destroyed
Webster	98	1,543	2 injuries; 9 structures threatened
Total	**2,059**	**41,288**	**15 injuries; 3 fatalities; 245 structures threatened; 44 structures destroyed**

Source: NFS, 2000-2020[48]

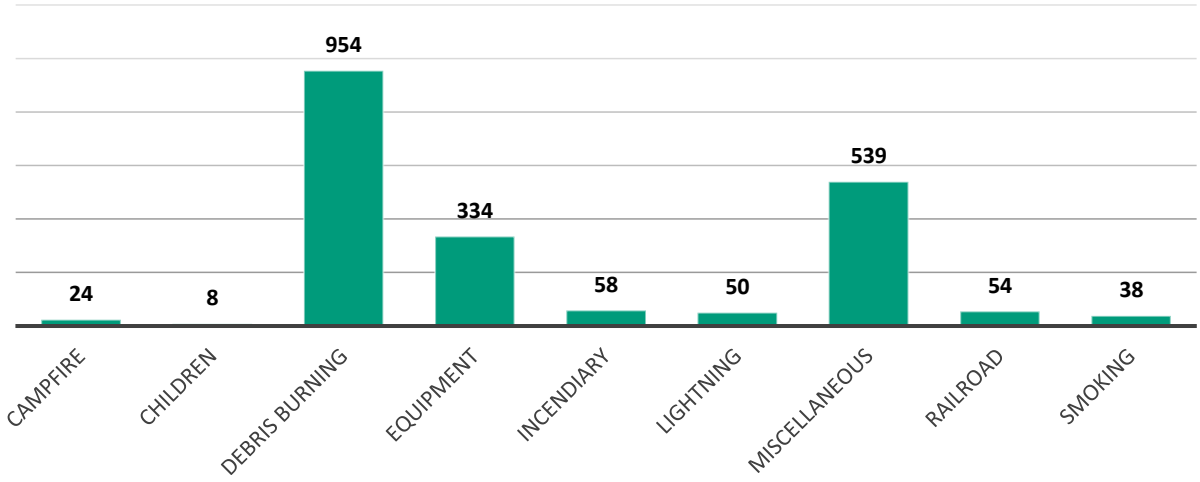
Figure 51: Wildfire Events by Year



Source: NFS, 2000-2020

[48] Nebraska Forest Service. 2020. "Fire Incident Type Summary." Data Files 2000-2018 provided by NFS.

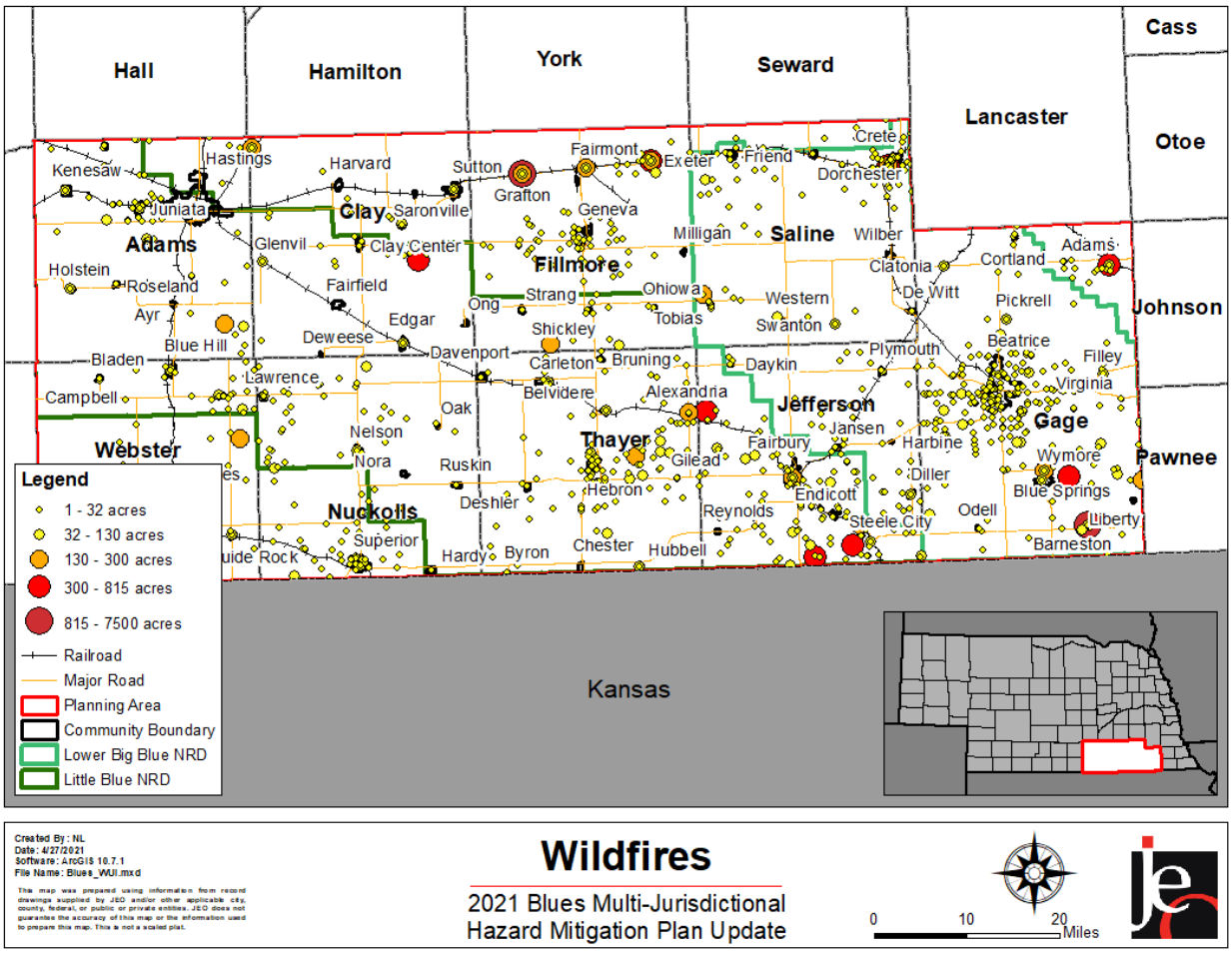
Figure 52: Wildfires by Cause in Planning Area



Source: NFS, 2000-2020

Figure 53 shows the location and general size of wildfires from 1990 to 2020.

Figure 53: Wildfire Occurrences in the Planning Area



Average Annual Losses

The average damage per event estimate was determined based upon records from the Nebraska Forest Service Wildfires Database from January 2000 to July 2020 and the number of historical occurrences. This does not include losses from displacement, functional downtime, economic loss, injury, or loss of life. During this 21-year period, 2,059 wildfires burned 41,288 acres and caused $613,319 crop and $1,361,497 property damages.

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 43: Wildfire Loss Estimation

Hazard Type	Number of Events	Events Per Year	Average Acres per Fire	Total Property Loss	Average Property Loss	Total Crop Loss	Average Annual Crop Loss
Grass/Wildfire	2,059	98	20.1	$613,319	$29,206	$1,361,497	$64,833

Source: NFS, 2000-2020

Table 44: Wildfire Event Impacts and Threats

Hazard Type	Injuries	Fatalities	Homes Threatened or Destroyed	Other Structures Threatened or Destroyed
Grass/Wildfire	15	3	129	160

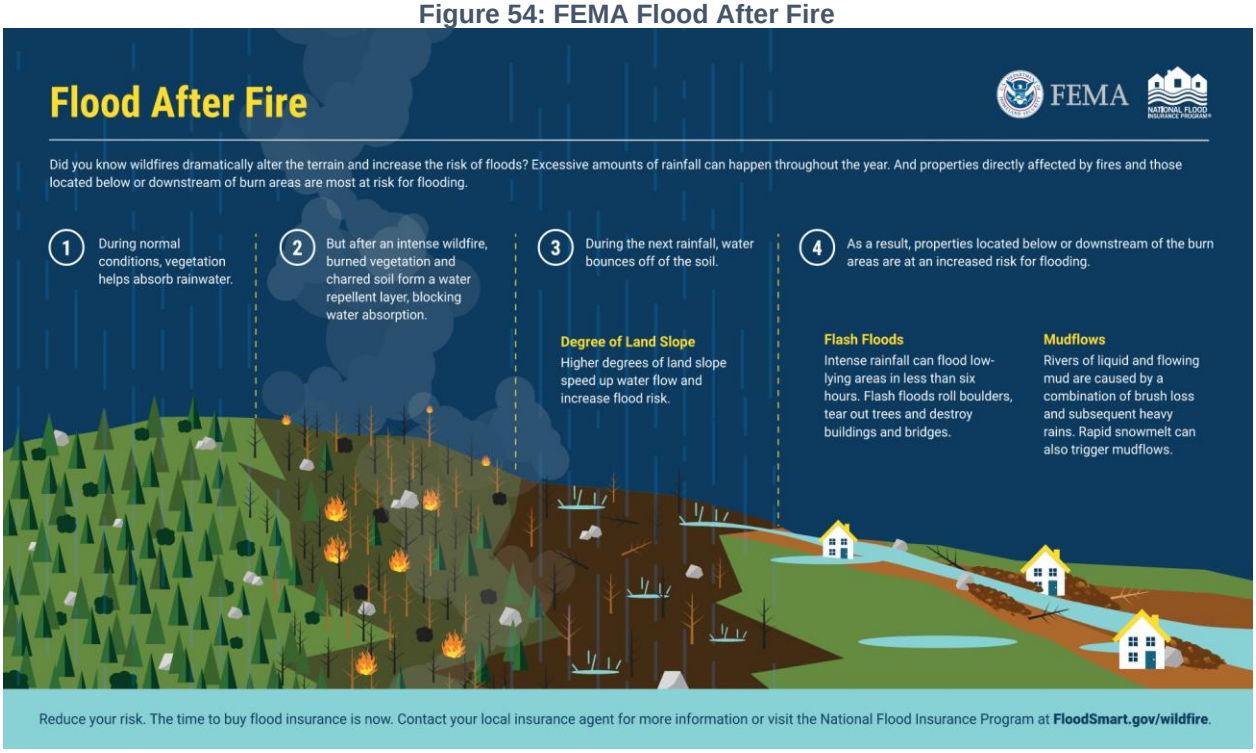
Source: NFS, 2000-2020

Extent

Overall, 2,059 wildfires were reported in the planning area and burned 41,288 acres in total. Of these, 58 fires burned 100 acres or more, with the largest wildfire burning 7,500 acres in Gage County in April 2000. The average area burned per wildfire was less than 21 acres indicating while many fires may occur, they are typically small in nature and easily contained.

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 54). 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 54: FEMA Flood After Fire

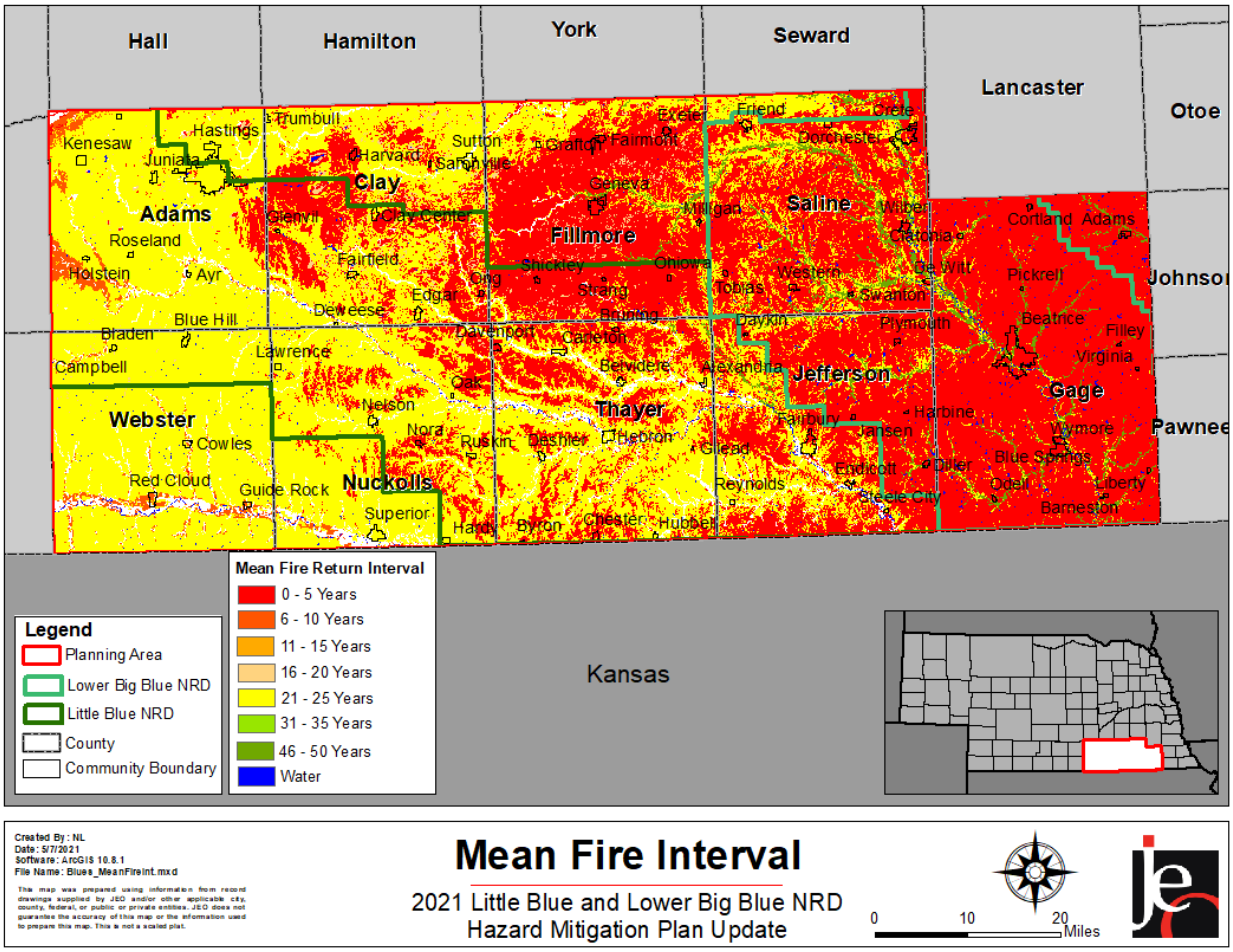


Source: FEMA, 2020[49]

Figure 55 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 in each area under natural conditions.

[49] 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 55: Mean Fire Return Interval



Probability

Probability of wildfire occurrence is based on the historic record provided by the Nebraska Forest Service and reported potential by participating jurisdictions. With a grass/wildfire occurring each reported year (Figure 51) there is a 100 percent annual probability of wildfires occurring in the planning area each year.

Community Top Hazard Status

The following table lists jurisdictions which identified Grass/Wildfire as a top hazard of concern:

Jurisdictions	
Clay County	Village of Chester
Fillmore County	Village of Davenport
Thayer County	Village of Glenvil
Beatrice Public Schools	Village of Ong
South Central USD 5 (Lawrence-Nelson-Sandy Creek)	Village of Ruskin
City of Blue Hill	Village of Western
City of Superior	

Regional Vulnerabilities

Periods of drought can occur throughout the year while extreme heat conditions during summer months greatly increase the potential for and magnitude of wildland fires. Drought has a high probability of occurring in the planning area and the planning area sees, on average, six days above 100°F. During a severe drought, dry conditions, and/or windy conditions, large wildfires can more easily spread.

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; including on tribal reservation lands. Wildfires can cause extensive damage to both urban and rural building stock and properties including critical facilities and infrastructure, as well as agricultural producers which support the local industry and economy. Damaged homes can educe available housing stock for residents, causing residents to leave the area. Additionally, fire events threaten the health and safety of residents and emergency response personnel. Recreation areas, timber and grazing land, wildlife habitat, and scenic views can also be threatened by wildfires.

Development across the planning area may be located within the WUI, particularly in large metropolitan areas with a large amount of intermix overlap such as the City of Beatrice. 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 following table provides information related to regional vulnerabilities; for jurisdictional-specific vulnerabilities, refer to *Section Seven: Community Profiles.*

Table 45: Regional Grass/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 -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	-Property damages
INFRASTRUCTURE	-Damage to power lines and utility structures
CRITICAL FACILITIES	-Risk of damages
CLIMATE	-Changes in seasonal temperature and precipitation normals can increase frequency and severity of wildfire events -Changes in climate can help spread invasive species, changing potential fuel loads in wildland areas
OTHER	-Increase chance of landslides, erosion, and land subsidence -May lead to poor water quality -Post fire, flash flooding events may be exacerbated

Hazardous Materials

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.*[50]

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.

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

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 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. For example, a train derailment in Crete, Nebraska in 1969 allowed anhydrous ammonia to leak from a rupture tanker. The resulting poisonous fog killed nine people and injured 53.

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 46 demonstrates the nine classes of hazardous material according to the 2012 Emergency Response Guidebook.

Table 46: 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[51]

[51] 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.

Location

There are 263 locations across the planning area that house hazardous materials according to the Tier II reports submitted to the Nebraska Department of Environment and Energy (NDEE) in 2019. These locations are shown in Figure 56. A listing of hazardous material storage sites can be found in *Section Seven: Community Profiles* for each jurisdiction.

Figure 56: Fixed Chemical Sites in the Planning Area

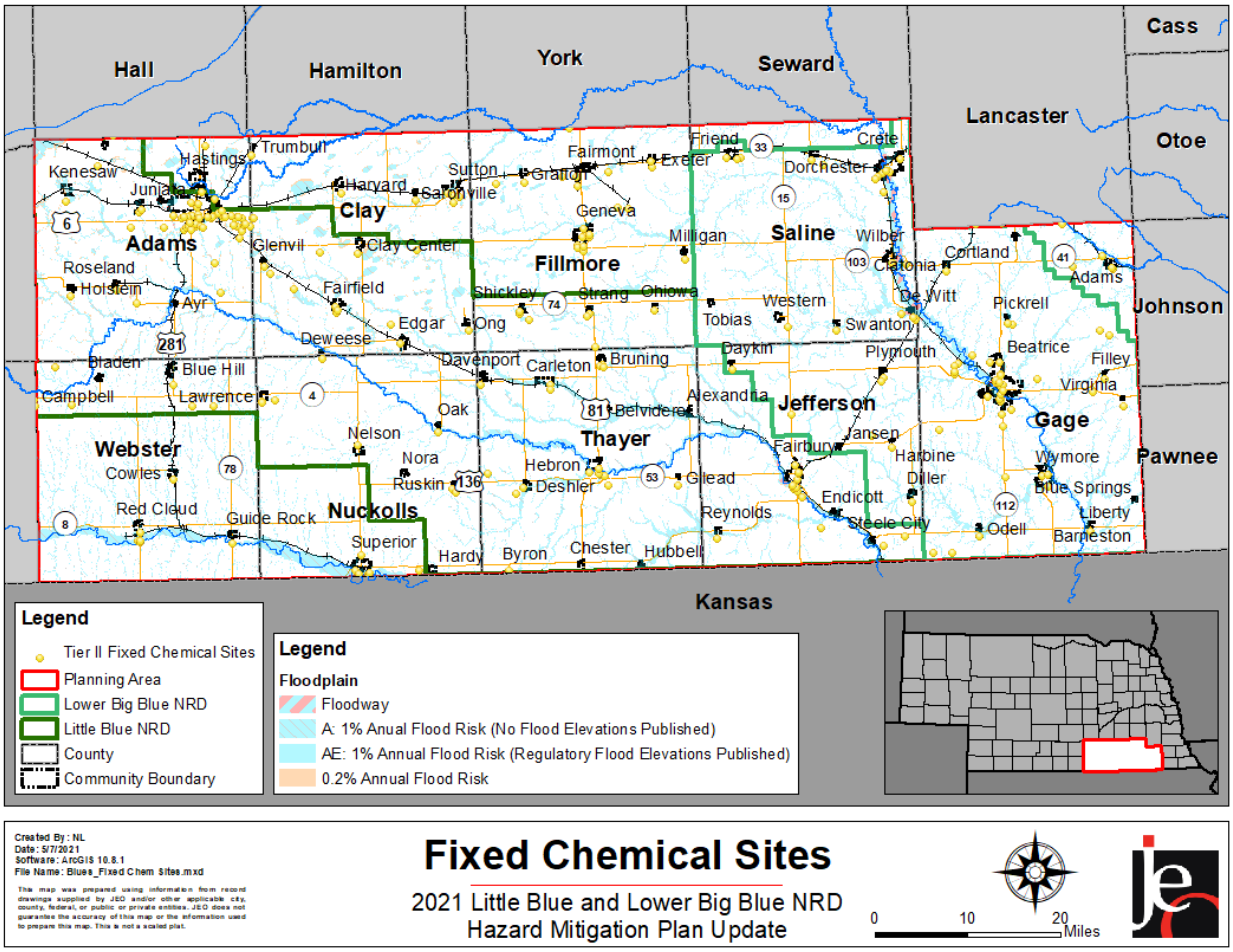
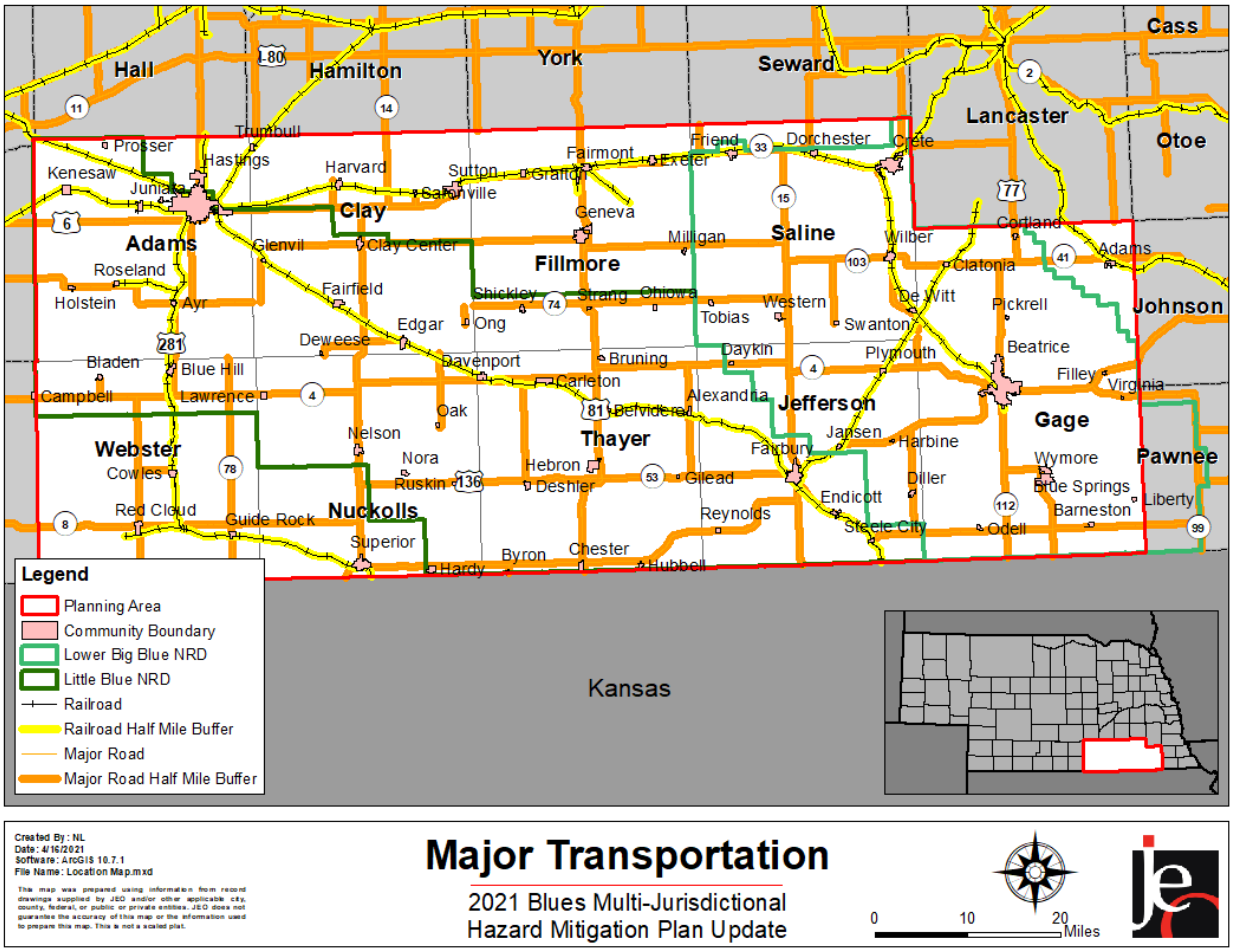


Figure 57: Major Transportation Corridors in the Planning Area



Hazardous materials releases during transportation primarily occur on major transportation routes as identified in Figure 57. Participating communities specifically reported transportation along railroads and highways as having the potential to impact their communities. Railroads providing service through the planning area have developed plans to respond to chemical releases along rail routes. A large number of spills also typically occur during the loading and unloading of chemicals for highway and pipeline chemical transport. The most heavily trafficked corridors in the planning are include US Route 34, which runs east to west through the northern part of the planning area, from Hastings to Fairmont to Crete; US Route 136, which is an east-west arterial running along the southern part of the planning area, from Red Cloud to Fairbury to Beatrice; and US Routes 281, 81, and 77, which are north-south arterials serving several of the planning area counties.

According to PHMSA, there are several gas transmission and hazardous liquid pipelines located in the planning area. Maps of pipelines and incidents from PHMSA for each of the nine counties in the planning area can be seen below (Figure 58 through Figure 66).[52]

[52] Pipeline and Hazardous Materials Safety Administration. 2020. "National Pipeline Mapping System." https://www.npms.phmsa.dot.gov/ .

Figure 58: Adams County Public Map Viewer Map

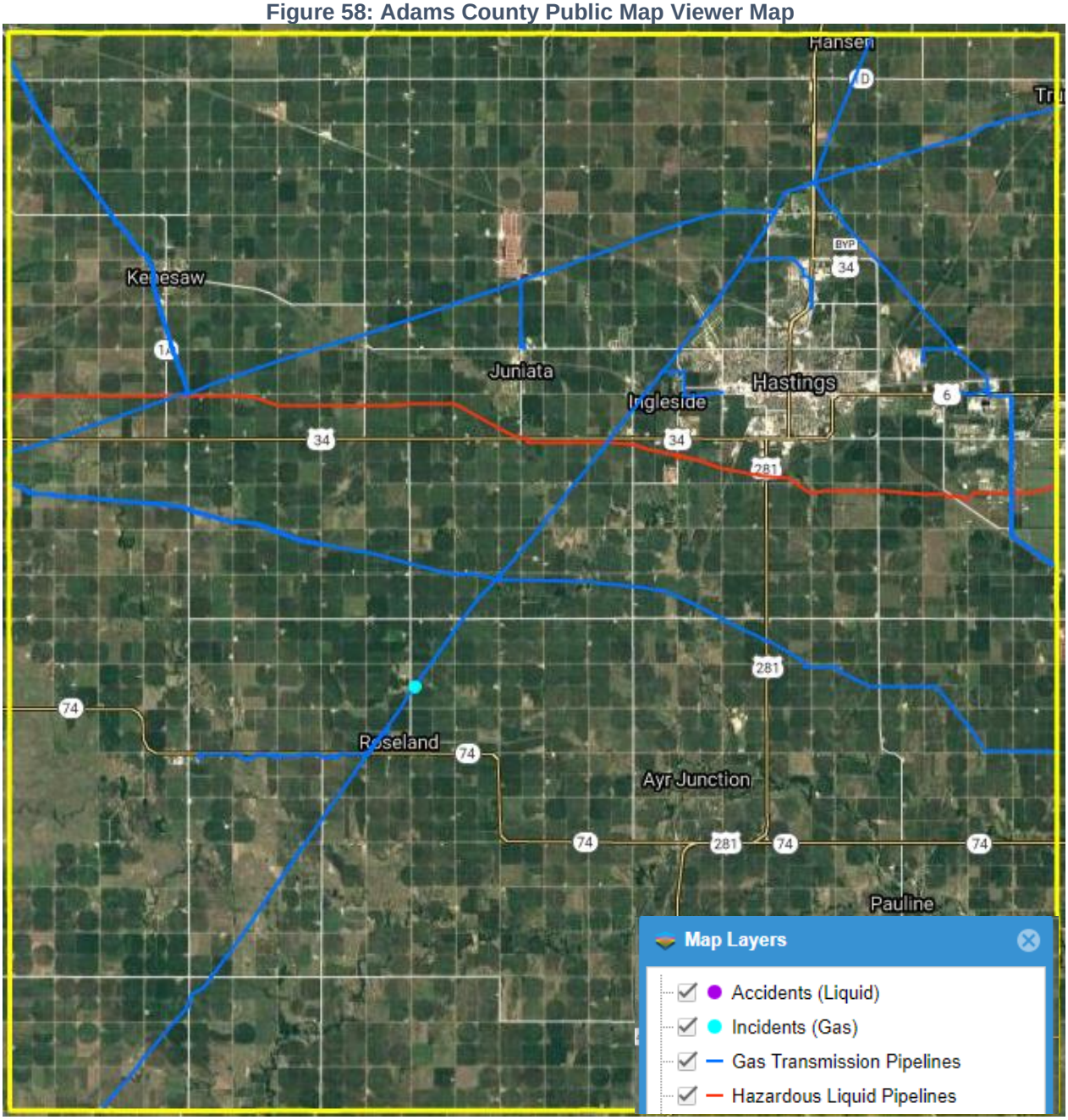


Figure 59: Clay County Public Map Viewer Map

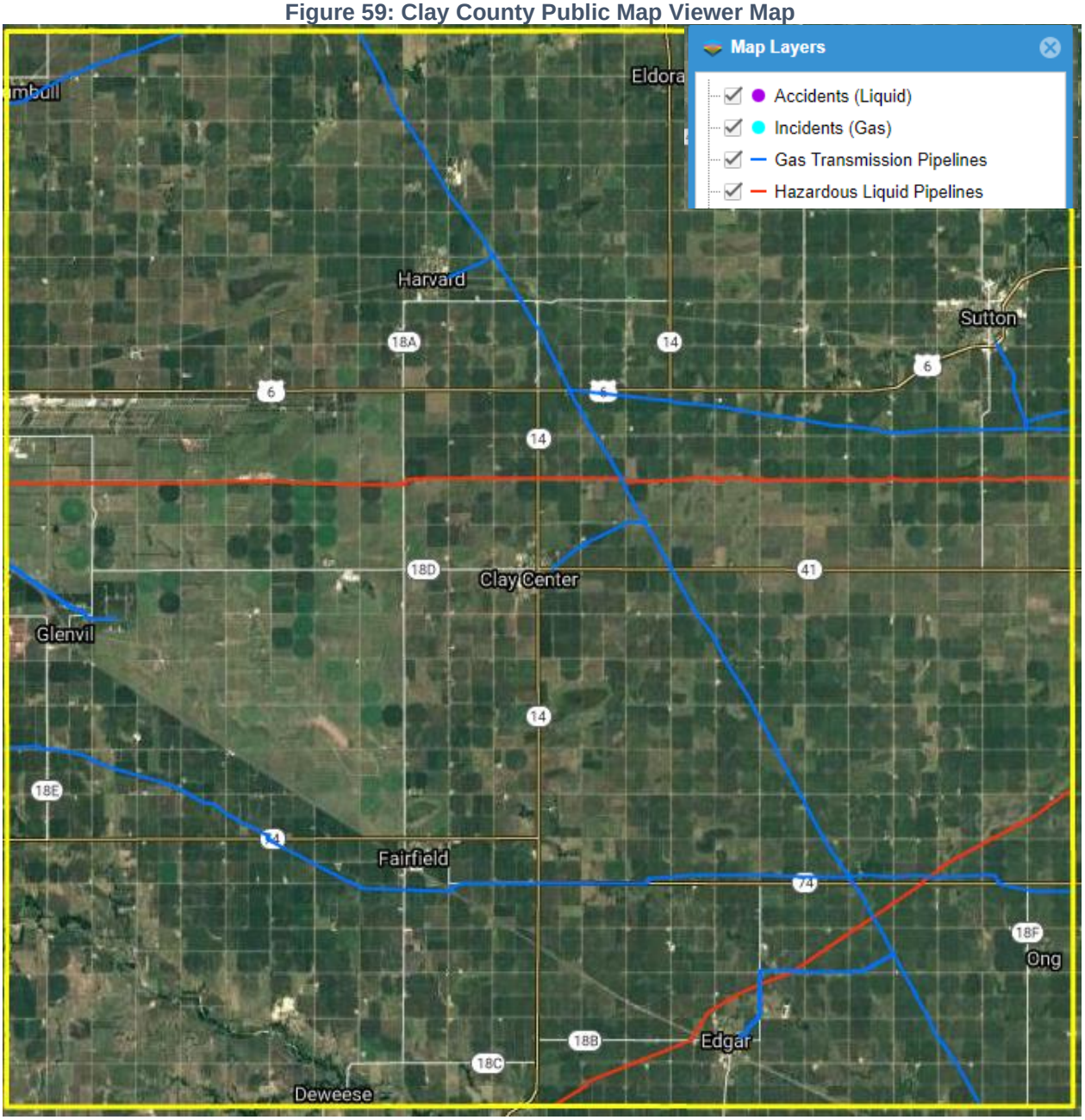


Figure 60: Fillmore County Public Map Viewer Map

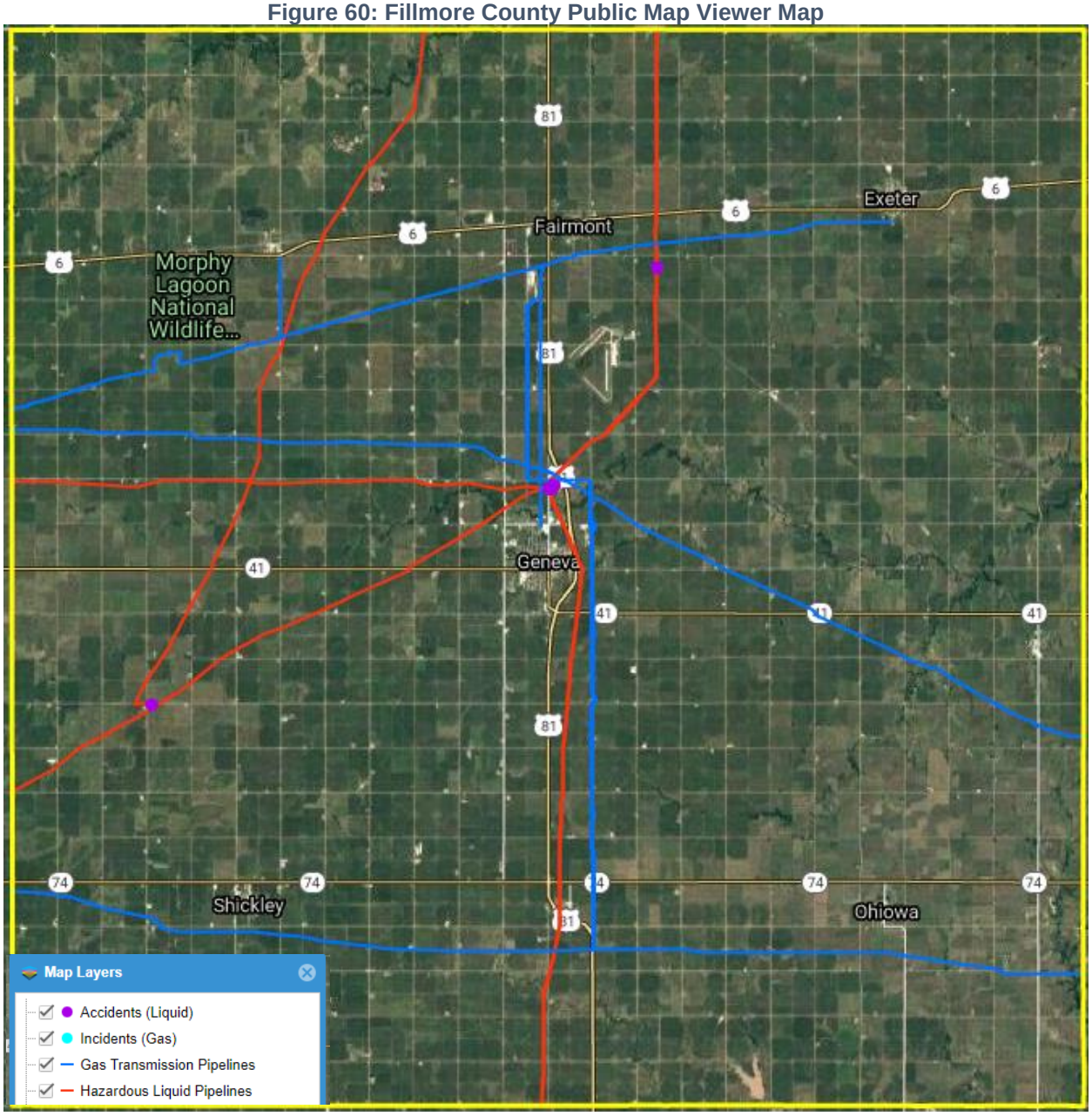


Figure 61: Gage County Public Map Viewer Map

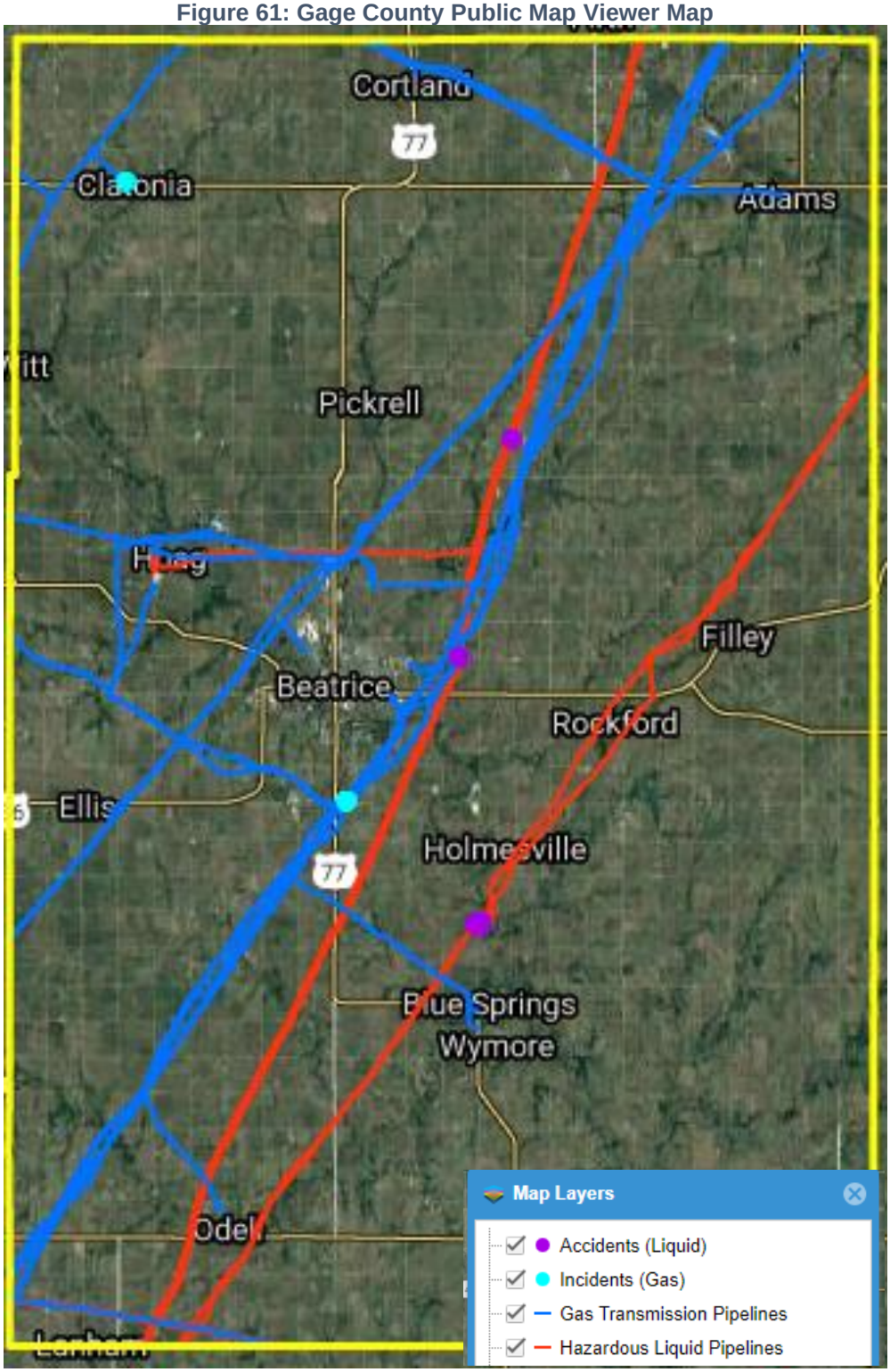


Figure 62: Jefferson County Public Map Viewer Map

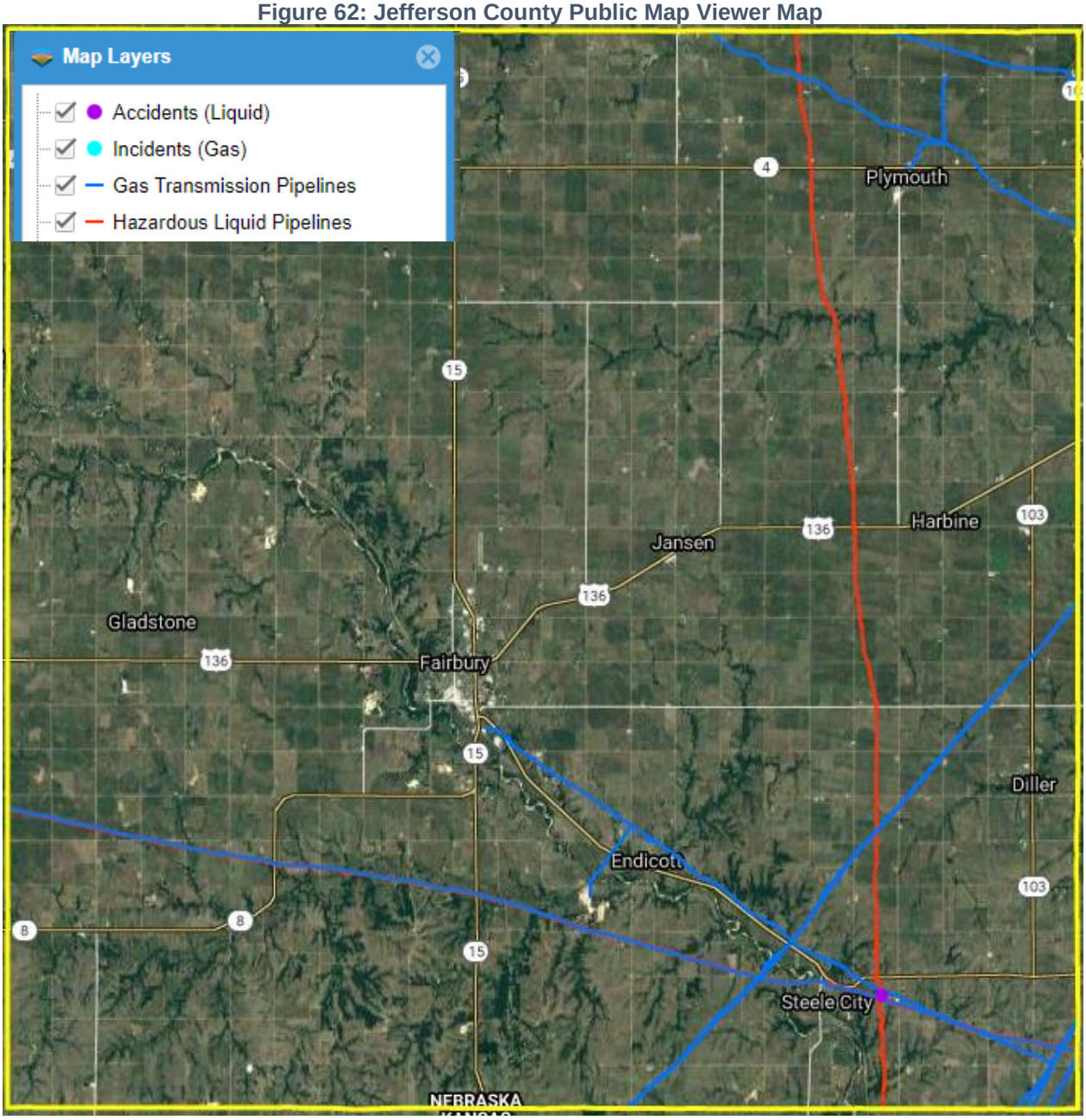


Figure 63: Nuckolls County Public Map Viewer Map

Figure 64: Saline County Public Map Viewer Map

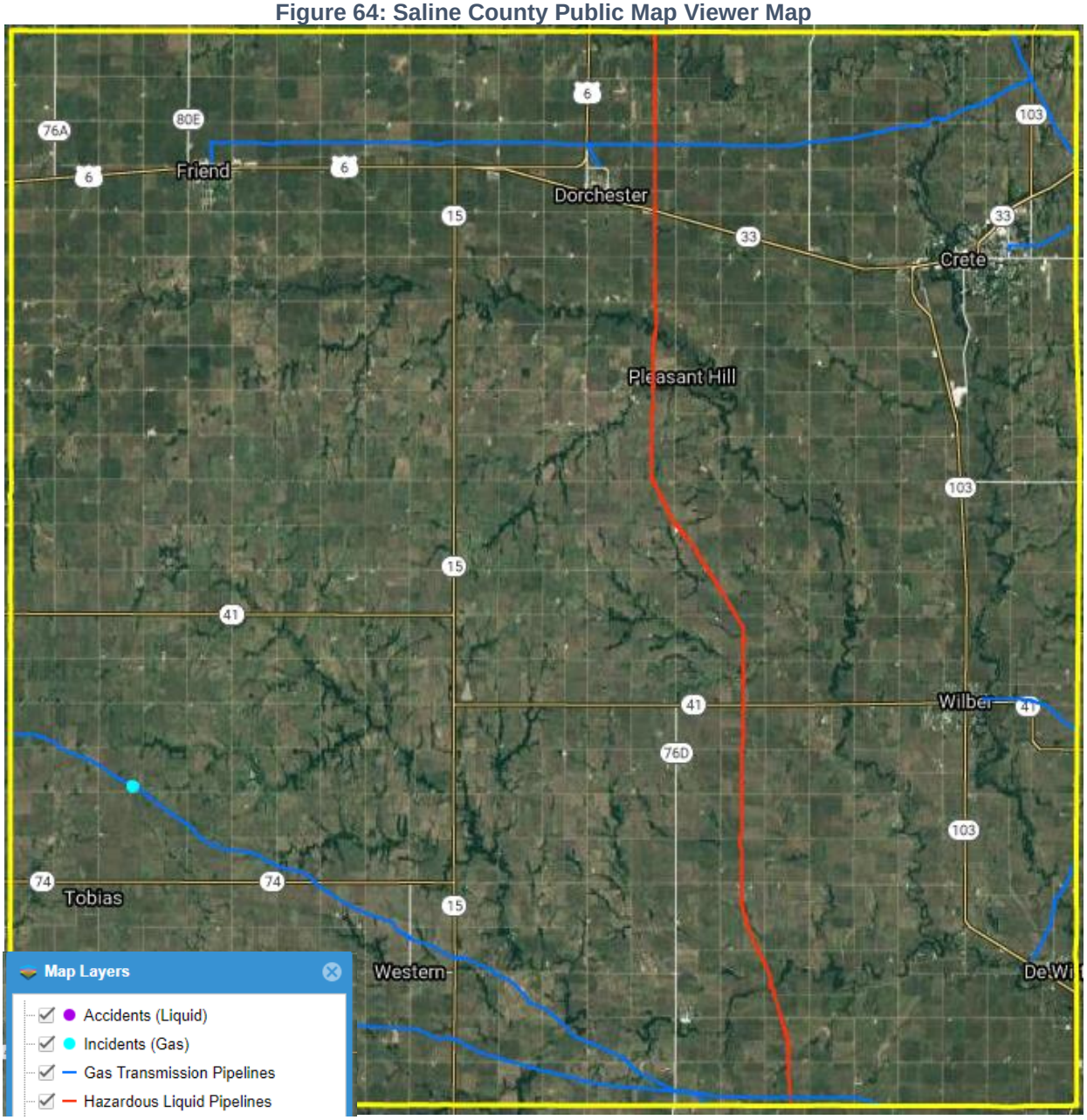


Figure 65: Thayer County Public Map Viewer Map

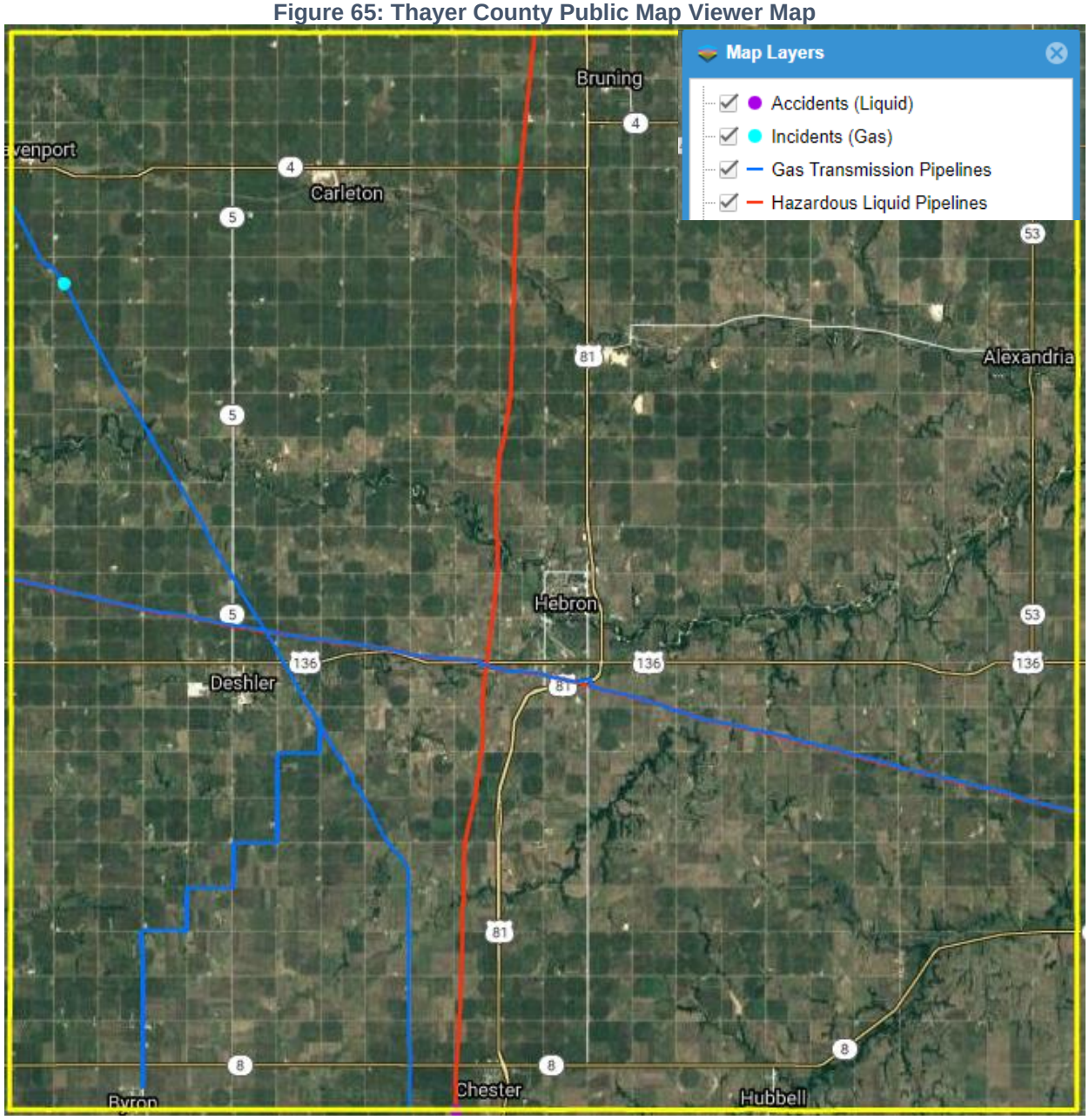
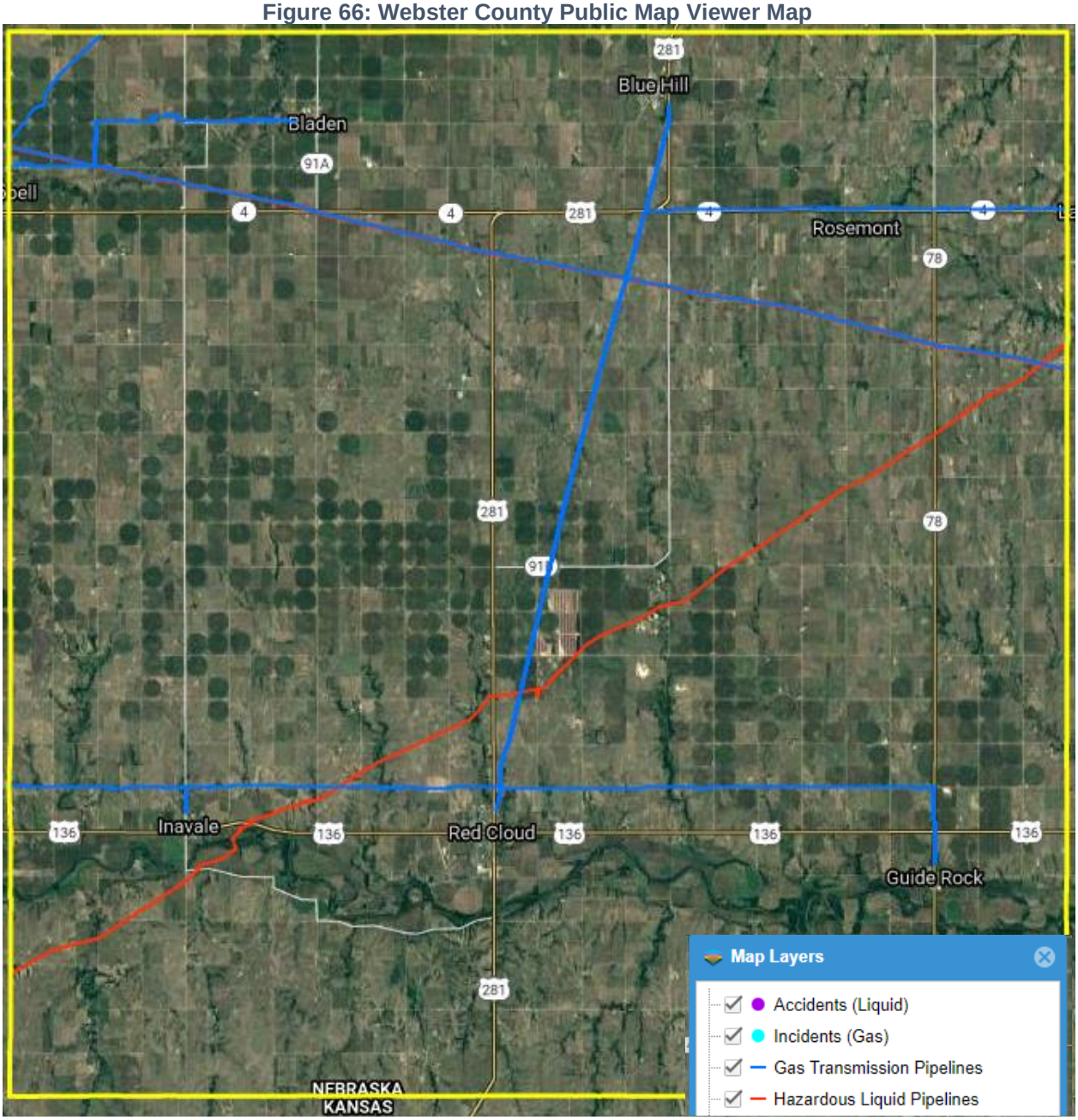


Figure 66: Webster County Public Map Viewer Map



Historical Occurrences

Fixed Site Spills

According to the NRC database, there have been 368 fixed site chemical spills between January 1990 and December 2019 in the planning area. The following table lists only those events with the largest quantity of material released (>2,000 gallons/pounds), incidents with injuries or evacuations, and reported property damages.

Table 47: Chemical Fixed Site Incidents

Year	Location of Release	Quantity Spilled	Material Involved	# injured	# evacuated	Property Damage
1998	Crete (Saline)	100 lbs	Anhydrous Ammonia	1	3	$0
1993	Crete (Saline)	1,000 gals	Anhydrous Ammonia	0	300	$0
2000	Hastings (Adams)	0	Anhydrous Ammonia	0	100	$0
2000	Beatrice (Gage)	150 lbs	Anhydrous Ammonia	0	35	$0
2012	Beatrice (Gage)	0	Anhydrous Ammonia	0	35	$0
1990	Hastings (Adams)	500 lbs	Anhydrous Ammonia	0	30	$0
2012	Hastings (Adams)	50 lbs	Anhydrous Ammonia	0	10	$0
2014	Geneva (Fillmore)	100 barrels	Automotive Gasoline	0	6	$0
2011	Beatrice (Gage)	12,364 lbs	Anhydrous Ammonia	0	0	$0
2009	Hebron (Thayer)	5,304 ppm	Ammonia	0	0	$0
2008	Geneva (Fillmore)	5,200 gals	Liquid Ammonia	0	0	$0
2018	Geneva (Fillmore)	3,120 gals	Ammonia Water	0	0	$0
1996	Ruskin (Nuckolls)	2,300 gals	Anhydrous Ammonia	0	0	$0
1999	Hastings (Adams)	2,200 lbs	Ammonia Thiosulfate	0	0	$0
1994	Beatrice (Gage)	2,000 lbs	Ammonium Nitrate	0	0	$0
1994	Odell (Gage)	2,000 gals	Fertilizer 7217	0	0	$0

Source: National Response Center, 1990-2019

Transportation Spills

According to the Pipeline and Hazardous Materials Safety Administration (PHMSA), 72 hazardous materials releases occurred during transportation in the planning area between 1990 and 2020. During these events, there were no injuries, no fatalities, and $1,206,459 in damages. The following table provides a list of the most significant historical transportation chemical spills, including the largest spills and most costly incidents.

Table 48: Historical Chemical Spills 1990-2020

Date of Event	Location of Release	Failure Description	Material Involved	Method of Transportation	Quantity Spilled	Total Damages
6/26/1990	Crete (Saline)	Rupture/Loose Closure	Phosphoric Acid Solution	Highway	950 LGA	$0
4/23/1991	Exeter (Gage)	Rail Derailment	Ferrous Chloride	Rail	10,000 LGA	$506,000
7/19/1991	Hastings (Adams)	Rupture	Acetylene	Highway	0	$88,975
12/24/1994	Beatrice (Gage)	Overfilled	Gasoline	Highway	500 LGA	$200
3/20/1995	Gilead (Thayer)	Defective Component	Anhydrous Ammonia	Highway	1,460 LGA	$1,045
4/29/2002	Geneva (Gage)	Accident	Gasoline	Highway	800 LGA	$85,000
1/16/2006	Strang (Gage)	Puncture	Isohexenes	Highway	1,000 LGA	$150,000
11/19/2009	Bruning (Thayer)	Accident/Leak	Liquified Petroleum Gas	Highway	1 LGA	$51,401
1/23/2017	Odell (Gage)	Accident	Liquified Petroleum Gas	Highway	2,600 LGA	$118,680

Source: PHMSA, 1990-2020

Average Annual Losses

There have been 368 chemical fixed site spills in the planning area reported from the NRC and 72 transportation spills as reported by PHMSA. Neither the NRC nor PHMSA track crop losses from chemical spills. These events reported $1,206,459 in property damages. This does not include losses from displacement, functional downtime, economic loss, injury, or loss of life.

Table 49: Chemical Fixed Site Losses

Hazard Type	Number of Events	Events per Year	Total Injuries	Total Evacuated	Total Loss	Average Annual Loss
Chemical Spills	368	11.9	1	519	$0	$0
Chemical Transportation	72	2.3	0	N/A	$1,206,459	$24,129

Source: NRC, 1990-2019; PHMSA, 1990-2020

Extent

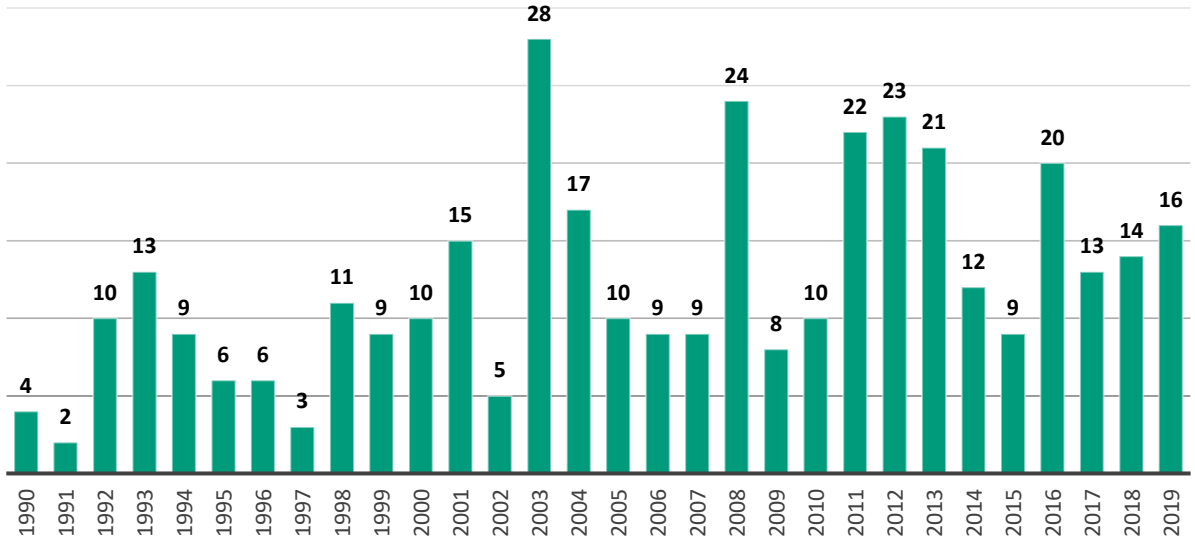
The extent of chemical spills at fixed sites varies and depends on the type of chemical that is released with a majority of events localized to the facility. The probable extent of chemical spills during transportation is difficult to anticipate and depends on the type and quantity of chemical released. There were 368 fixed site and 72 transportation chemical releases that have occurred in the planning area. Fixed chemical spills ranged from one to 12,364 pounds and transportation spills ranged from no material released to over 950 liquid gallons of material.

Of these events, nine spills led to evacuations and one spill event caused injuries. No spill events led to fatalities. 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.

Probability

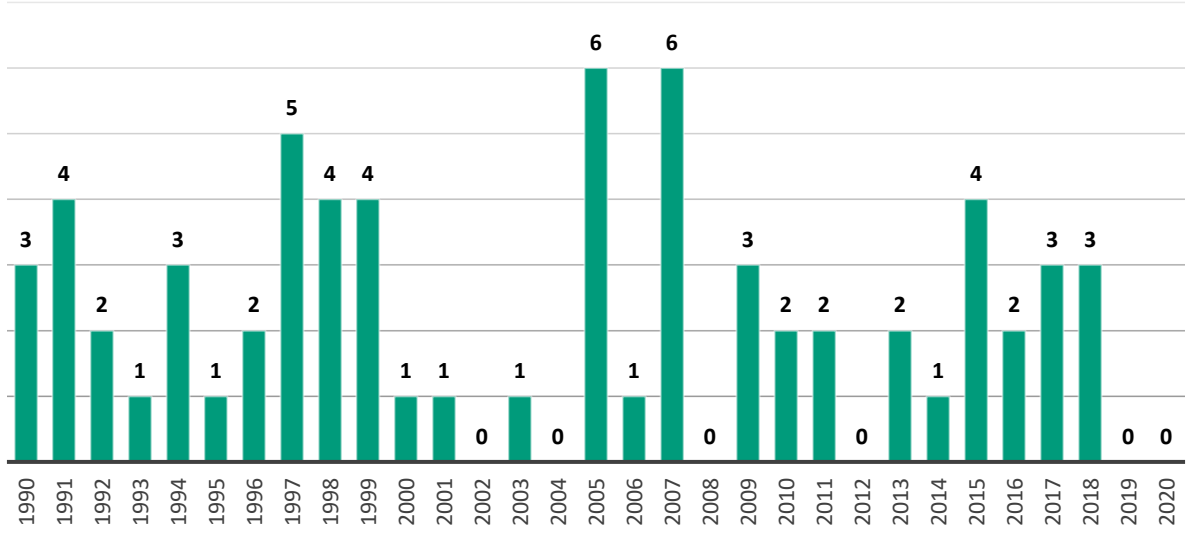
Given the historic record of occurrence for fixed chemical spill events (at least one chemical spill reported in all years), for the purposes of this plan, the annual probability of a fixed chemical spill is 100 percent. Given the historic record of occurrence for chemical transportation spill events (25 out of 31 years with a reported event), for the purposes of this plan, the annual probability of chemical transportation occurrence is 81%.

Figure 67: Chemical Fixed Site Events by Year



Source: NRC, 1990-2019

Figure 68: Chemical Transportation Events by Year



Source: PHMSA, 1990-2020

Community Top Hazard Status

The following table lists jurisdictions which identified Hazardous Materials as a top hazard of concern:

Jurisdictions	
Beatrice Public Schools	Village of Bruning
City of Crete	Village of Clatonia
City of Deshler	Village of Davenport
City of Edgar	Village of Daykin
City of Fairbury	Village of Diller

Jurisdictions	
City of Fairfield	Village of Dorchester
City of Hebron	Village of Filley
City of Superior	Village of Glenvil
City of Wilber	Village of Grafton
Clay County	Village of Hardy
Exeter Milligan Public Schools	Village of Jansen
Fillmore County	Village of Lawrence
Jefferson County	Village of Odell
Saline County	Village of Ong
South Central USD 5 (Lawrence-Nelson-Sandy Creek)	Village of Plymouth
South Heartland District Health Department	Village of Reynolds
Superior Public Schools	Village of Ruskin
Tri-County Public Schools	Village of Swanton
Village of Adams	Village of Tobias
Village of Alexandria	Village of Trumbull
Village of Barneston	Village of Western

Regional Vulnerabilities

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

Table 50: Regional Hazardous Materials 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
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
CRITICAL FACILITIES	-Risk of fire, explosion, or other damages -Risk of evacuation
CLIMATE	-More extreme weather events and flood events put sites at risk of flooding at greater risk

Levee Failure

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 to a breach and thus a levee failure.

Location

There is one federal levee located in Fairbury and three non-USACE levee systems located in the City of Beatrice as reported in USACE's National Levee Database.

Beyond the USACE's National Levee Database, there is no known comprehensive list of levees that exists in the planning area especially for private agricultural levees. Thus, it is not possible at this time to document the location of non-federal levees, the areas they provide flood risk reduction, nor the potential impact of these levees.

Table 51: USACE Levees in Planning Area

Name	Sponsor	Location	Length (miles)	Risk Level	Population in Leveed Area	Structures in Leveed Area	Property Value in Leveed Area
Fairbury NE	City of Fairbury	Fairbury (Jefferson County)	1.75	Low	645	581	$90,632,730

Source: USACE Levee Database

According to the USACE National Levee Database, the Fairbury project is a levee system that reduces the occurrence of flooding in Fairbury, Nebraska. The levee system includes 1.7 miles of earthen levee along the Little Blue River. The levee was designed and constructed by the U.S. Army Corps of Engineers (USACE) in 1970. After construction the project was then turned over to the local sponsor, the City of Fairbury, for operation and maintenance. The local sponsor now owns, operates and maintains the levee system.

Table 52: Non-USACE Levees in Planning Area

Name	Location	Length (miles)	Population in Leveed Area	Structures in Leveed Area	Property Value in Leveed Area
Indian Creek Levee – Beatrice, NE 2	Beatrice NE	0.45	2	2	$367,796.42
Big Blue River Levee – Beatrice NE	Beatrice NE	0.56	2	2	$367,796.42
Indian Creek Levee – Beatrice NE 1	Beatrice NE	0.17	0	0	$0

*Source: USACE Levee Database; *Note non-USACE levees are not screened for risk level*

Historical Occurrences

As there is no formal database of historical levee failures, the following sources were consulted: members of the Planning Team, local newspapers and media outlets, Little Blue NRD, Lower Big Blue NRD, and USACE. According to these resources no recorded instances of levee failure have occurred in the planning area.

Extent

Given the one federal levee in the planning area, the extent of federal levee failure is limited to the southwestern portion of Fairbury. If this levee were to fail, approximately 30-percent of the city would be inundated. The City of Beatrice noted that while here are non-credited, non-federal levees (Indian Creek Levee NE-1, Indian Creek Levee NE-2, and the Big Blue River Levee), these levees provide flood protection primarily to agricultural assets outside of the City boundaries. There are a number of agricultural levees in the planning area, however, these levees to do not protect people, and their failure would result in only minor crop damages.

USACE, who is responsible for federal levee oversite and inspection of levees, has three ratings for levee inspections. Any levee failure events in the planning area will fall within USACE's rating system; however, it is not currently possible to determine what level of damage each levee system will experience. Non-federal levees are not inspected and thus do not have ratings.

Table 53: 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 he established timeframe, not to exceed two years.

Source: USACE

As of March 2021, the Fairbury Levee System was classified as a Minimally Acceptable levee system.

Levee Improvements and FEMA Accreditation

In 2004, as it initiated work under the Flood Map Modernization Initiative (Map Mod), FEMA determined that analysis of the role of levees in flood risk reduction would be an important part of the mapping efforts. A report issued in 2005 noted that the status of the Nation's levees was not well understood and the condition of many levees and floodwalls had not been assessed since their original inclusion in the NFIP. As a result, FEMA established policies to address existing levees. As DFIRMs are developed, levees fall under one of the three following categories:

1) Accredited Levee - With the exception of areas of residual flooding (interior drainage), if the data and documentation specified in 44 CFR 65.10 is readily available and provided to FEMA, the area behind the levee will be mapped as a moderate-risk area. There is no mandatory flood insurance purchase requirement in a moderate-risk area, but flood insurance is strongly recommended.

2) Provisionally Accredited Levee (PAL) - If data and documentation is not readily available, and no known deficiency precludes meeting requirements of 44 CFR 65.10,

FEMA can allow the party seeking recognition up to two years to compile and submit full documentation to show compliance with 44 CFR 65.10. During this two-year period of provisional accreditation, the area behind the levee will be mapped as moderate-risk with no mandatory flood insurance purchase requirement.

3) De-Accredited Levees – If the information established under 44 CFR 65.10 is not readily available and provided to FEMA, and the levee is not eligible for the PAL designation, the levee will be de-accredited by FEMA. The area behind the levee will be mapped as a high risk area, subject to mandatory flood insurance purchase.

The Fairbury Levee System was a Provisionally Accredited Levee system as of March 2021. The City of Fairbury has expressed intent to improve flood protection provided by the levee and work through the accreditation process.

Probability

Given no historical occurrences of federal levee failure in the planning area, the annual probability of this event occurring is considered to be less than one-percent. While it is possible for levee failure to occur in the future, this is considered a low probability.

Community Top Hazard Status

The following table lists jurisdictions which identified Levee Failure as a top hazard of concern:

Jurisdictions	
Little Blue NRD	Village of Kenesaw
City of Sutton	

Regional Vulnerabilities

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

Table 54: Regional Levee Failure Vulnerabilities

SECTOR	VULNERABILITY
PEOPLE	-Those living in federal and non-federal levee protected areas -Residents with low mobility or with no access to a vehicle are move vulnerable during levee failure events -Those without adequate notification (text alerts, sirens, internet or cable access) may be at greater risk
ECONOMIC	-Businesses and industries protected by levees are at risk during failures
BUILT ENVIRONMENT	-All buildings within levee protected areas are at risk to damages
INFRASTRUCTURE	-Major transportation corridors and bridges at risk during levee failures
CRITICAL FACILITIES	-Critical facilities in levee protected areas are at risk
CLIMATE	-Changes in seasonal precipitation and temperature normals can increase strain on infrastructure

Public Health Emergency

According to the World Health Organization, a public health emergency is:

> "an occurrence or imminent threat of an illness or health condition, caused by bio terrorism, epidemic or pandemic disease, or (a) novel and highly fatal infectious agent or biological toxin, that poses a substantial risk of a significant number of human facilities or incidents or permanent or long-term disability" (WHO/DCD, 2001). The declaration of a state of public health emergency permits the governor to suspend state regulations, change the functions of state agencies.[53]

The number of cases that qualifies as a public health emergency depends on several factors including the illness, it's symptoms, ease in transmission, incubation period, and available treatments or vaccinations. With the advent of sanitation sewer systems and other improvements in hygiene since the 19th century, the spread of infectious disease has greatly diminished. Additionally, the discovery of antibiotics and the implementation of universal childhood vaccination programs have played a major role in reducing human disease impacts. Today, human disease incidences are carefully tracked by the Centers for Disease Control and Prevention (CDC) and state organizations for possible epidemics and to implement control systems. Novel illnesses or diseases have the potential to develop annually and significantly impact residents and public health systems.

Some of the best actions or treatments for public health emergencies are nonpharmaceutical interventions (NPI). These are readily available behaviors or actions and response measures people and communities can take to help slow the spread of respiratory viruses such as influenza or coronavirus. Understanding NPIs and increasing the capacity to implement them in a timely way, can improve overall community resilience during a pandemic. Using multiple NPIs simultaneously can reduce influenza transmission in communities even before vaccination is available.[54] Pandemics are global or national disease outbreaks. These types of illnesses, such as influenza, can spread easily person-to-person, cause severe illness, and are difficult to contain. An especially severe pandemic can lead to high levels of illness, death, social disruption, and economic turmoil. Past public health emergency events include:

- 1918 Spanish Flu: the H1N1 influenza virus spread world-wide during 1918 and 1919. It is estimated that at least 50 million people worldwide died during this pandemic with about 675,000 deaths alone in the United States. No vaccine was ever developed and control efforts included self-isolation, quarantine, increased personal hygiene, disinfectant use, and social distancing.
- 1957 H2N2 Virus: a new influenza A (H2N2) virus emerged in Eastern Asia and eventually crossed into coastal U.S. cities in summer of 1957. In total 1.1 million people worldwide died of the flu with 116,000 of those in the United States.
- 1968 H3N2 Virus: an influenza A virus discovered in the United States in September 1968 which killed over 100,000 citizens. The majority of deaths occurred in people 65 years and older.
- 2009 H1N1 Swine Flu: a novel influenza A virus discovered in the United States and spread quickly across the globe. This flu was particularly prevalent in young people while

[53] World Health Organization. 2008. Accessed April 2020. "Glossary of humanitarian Terms." https://www.who.int/hac/about/definitions/en/.
[54] U.S. Department of Health and Human Services. 2017. "Pandemic Influenza Plan: 2017 Update." https://www.cdc.gov/flu/pandemic-resources/pdf/pan-flu-report-2017v2.pdf

those over 65 had some antibody resistance. The CDC estimated the U.S. had over 60.8 million cases and 12,469 deaths.

- 2019 COVID-19: the coronavirus disease 2019 is a contagious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which originated in Wuhan China and spread globally. As of March 19, 2021 the CDC reported in the U.S. over 29,431,658 cases and 535,217 deaths attributed to COVID-19. Efforts to control and limit the virus included face coverings, self-isolation, quarantine, increased cleaning measures, and social distancing. Significant impacts to the national and global economy have been caused by COVID-19.

The State of Nebraska Department of Health and Human Services (DHHS) requires doctors, hospitals, and laboratories to report on many communicable diseases and conditions to monitor disease rates for epidemic events. Additionally, regional or county health departments monitor local disease outbreaks and collect data relevant to public health. The following health departments are found in the planning area[55]:

- South Heartland District Health Department
- Public Health Solutions District Health Department
- Clay County Health Department

Location

Human disease outbreaks can occur anywhere in the planning area. Public heath emergencies or pandemic threshold levels are dependent on the outbreak type, transmission vectors, location, and season. Normal infectious disease patterns are changing due to increasing human mobility and climate change. Rural populations are particularly at risk for animal-related diseases while urban areas are at greater risk from community spread type illnesses. All residents throughout the planning area are at risk during public health emergencies. All areas within the planning area experienced impacts from COVID-19 specifically during 2019-2021.

Historical Occurrences

Cases and fatalities associated with Public Health Emergencies vary between illness types and severity of outbreak. Past major outbreaks in Nebraska have specifically included the H1N1 Swine Flu in 2009, mumps outbreak in 2019, and COVID-19 in 2020.

- H1N1 Swine Flu (2009) – outbreaks were first reported in mid-April 2009 and spread rapidly. The new flu strand for which immunity was nonexistent in persons under 60 years old was similar in many ways to typical seasonal influenza. Symptoms of H1N1 included fever greater than 100F, cough, and sore throat. County specific counts of H1N1 are not available, however a total of 71 confirmed cases were reported by June 12, 2009.[56] Outbreaks in Nebraska were typically seen sporadically with occasional cluster outbreaks at summer camps for youth. The U.S. Public Health Emergency for the H1N1 Influenza outbreak expired on June 23, 2010. The CDC developed and encouraged all US residents to receive a yearly flu vaccination to protect against potential exposures. The H1N1 continues to appear annually and persons in the planning area are at risk of infection in the future.
- Mumps (2019) –In August 2019, 30 attendees at a Nebraska wedding developed mumps after being exposed to one asymptomatic patient. Transmission from this event resulted

[55] Nebraska Department of Health and Human Services. Accessed December 2020. "Local Health Departments." http://dhhs.ne.gov/Pages/Local-Health-Departments.aspx
[56] CDC. June 2009. "Novel H1N1 Flu Situation Update." https://www.cdc.gov/h1n1flu/updates/061209.htm.

in 31 secondary cases, 27 tertiary cases, and three quaternary cases. Isolation and a communitywide third-dose MMR vaccination campaign helped end the outbreak.[57] No reported cases of mumps were found in the planning area.

- COVID-19 (2020) – In January 2020 the CDC confirmed the first case of COVID-19 in the United States and it quickly spread across the country. By March 2020 the World Health Organization declared COVID-19 a pandemic and travel bans were instituted around the globe. Primary symptoms of the infection included cough, fever or chills, shortness of breath or difficulty breathing, fatigue, muscle and body aches, headache, loss of taste or smell, sore throat, and others.
  The first confirmed case of COVID-19 in the State of Nebraska was a 36-year old Omaha resident in early March. Counties and cities throughout the planning area have instituted mask mandates and other directed health measures to protect residents from the spread of COVID-19.

The table below displays COVID-19 confirmed cases and deaths as of December 3, 2020.

Table 55: COVID-19 in the Planning Area

County	Total Number of Tests	Confirmed Cases	Fatalities
Adams	11,877	2,771	38
Clay	2,545	674	11
Fillmore	2,116	475	10
Gage	9,637	2,119	19
Jefferson	3,438	627	1
Nuckolls	1,705	407	1
Saline	7,340	1,950	3
Thayer	2,173	480	4
Webster	1,244	322	4
Total	**42,075**	**9,825**	**91**

Source: Nebraska DHHS COVID-19 Dashboard, March 19, 2021

Average Annual Losses

The national economic burden of influenza medical costs, medical costs plus lost earnings, and total economic burden was $10.4 billion, $26.8 billion, and $87.1 billion respectively in 2007.[58] However, associated costs with pandemic response are much greater. As of December 2020, estimated costs for COVID-19 in the United States exceed $16 trillion. Estimated costs for the State of Nebraska or the 9-county planning area are unknown at this time. Specific costs do not include losses from displacement, functional downtime, economic loss, injury, or loss of life. The direct and indirect effects of significant health impacts are difficult to quantify and will vary depending on the type and spread of the virus.

Extent

Those most affected by public heath emergencies are typically the very young, the very old, the immune-compromised, the economically vulnerable, and the unvaccinated. Roughly 26% of the planning area's population is 19 years old or younger, and 19% of the planning area is 64 years old or older, while approximately 12% of the population lives below the poverty line. Current estimates for vaccination rates are not publicly available. As of January 2021, vaccine

[57] Donahue M, Hendrickson B, Julian D, et al. Multistate Mumps Outbreak Originating from Asymptomatic Transmission at a Nebraska Wedding — Six States, August–October 2019. MMWR Morb Mortal Wkly Rep 2020;69:666–669. DOI: http://dx.doi.org/10.15585/mmwr.mm6922a2external icon.

[58] Molinari, N.M., Ortega-Sanchez, I.R., Messonnier, M., Thompson, W.W., Wortley, P.M., Weintraub, E., & Bridges, C.B. April 2007. "The annual impact of seasonal influenza in the US: measuring disease burden and costs." DOI: 10.1016/j.vaccine.2007.03.046.

development for COVID-19 was in preliminary rollout to first responders, essential workers, and those over 80 years old in Nebraska.

These factors increase vulnerability to the impacts of pandemics. Refer to *Section Three: Planning Area Profile* for further discussion of age and economic vulnerability in the planning area. It is not possible to determine the extent of individual public health emergency events, as the type and severity of a novel outbreak cannot be predicted. However, depending on the disease type, a significant portion of residents may be at risk to illness or death.

The extent of a public health emergency is also closely tied to the proximity or availability of health centers. The following table identifies hospitals in the planning area.

Table 56: Hospitals in the Planning Area

County	Facility Name	Nearest Community	Total Licensed Beds
Adams	Mary Lanning Healthcare	Hastings	170
Fillmore	Fillmore County Hospital	Geneva	30
Gage	Beatrice Community Hospital & Health Center	Beatrice	25
Jefferson	Jefferson Community Health Center	Fairbury	17
Nuckolls	Brodstone Memorial Hospital	Superior	25
Saline	Crete Area Medical Center	Crete	24
Saline	Warren Memorial Hospital dba Friend Community Health	Friend	19
Thayer	Thayer County Health Services	Hebron	17
Webster	Webster County Community Hospital	Red Cloud	13

Source: Nebraska Department of Health and Human Services[59]

Immunodeficiency disorders (such as diabetes), obesity, or other pre-existing health complications reduce the ability of the body to fight infection. Diabetes prevalence per county and for the state are listed in the table below.[60]

Table 57: Diabetes Prevalence in the Planning Area (2017)

County	Diagnosed Diabetes Rate (Total Adults Age 20+)
Adams	10.8%
Clay	7.9%
Fillmore	10.7%
Gage	9.7%
Jefferson	6.9%
Nuckolls	5.6%
Saline	10.8%
Thayer	7.1%
Webster	8.1%
State of Nebraska	8.0% (2016 data)

Source: CDC, 2017

Nebraska state law (Title 173) requires all students have the following vaccinations: poliomyelitis, Diphtheria, pertussis, tetanus, measles, mumps, rubella, Hepatitis B, and varicella (chicken pox). The Vaccines for Children (VFC) program is a federally funded and state-operated vaccine supply

59 Department of Health and Human Services. September 2020. "Hospitals." http://dhhs.ne.gov/publichealth/Documents/Hospital%20Roster.pdf.
60 Centers for Disease Control and Prevention. 201y. "Diagnosed diabetes prevalence – Nebraska." https://gis.cdc.gov/grasp/diabetes/DiabetesAtlas.html.

program that provides free vaccines to children under 18 who are of American Indian or Alaska Native descent, enrolled in Medicaid, uninsured, or underinsured. Additionally, the HPV vaccination series is recommended for teenagers and influenza vaccinations are recommended yearly for those over six months old. Individuals without vaccinations are at greater risk of contracting diseases or carrying diseases to others.

Probability

There is no pattern as to when public health emergencies will occur. Based on historical records, it is likely that small-scale disease outbreaks will occur annually within the planning area. However, large scale emergency events (such as seen with COVID-19) cannot be predicted.

Community Top Hazard Status

The following table lists jurisdictions which identified Public Health Emergency as a top hazard of concern:

Jurisdictions	
Fillmore County	South Central USD 5 (Lawrence-Nelson-Sandy Creek)
Gage County	South Heartland District Health Department
City of Wilber	

Regional Vulnerabilities

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

Table 58: Regional Public Health Emergency Vulnerabilities

SECTOR	VULNERABILITY
PEOPLE	-Vulnerable populations include the very young, the very old, the unvaccinated, the economically vulnerable, and those with immunodeficiency disorders or other comorbidities. -Institutional settings such as prisons, dormitories, long-term care facilities or health care facilities, meat-packing plants, daycares, and schools are at higher risk to contagious diseases -Poverty, rurality, underlying health conditions, and drug or alcohol use increase chronic and infectious disease rates
ECONOMIC	-Large scale or prolonged events may cause businesses to close, which could lead to significant revenue loss and loss of income for workers
BUILT ENVIRONMENT	None
INFRASTRUCTURE	-Transportation routes may be closed if a quarantine is put in place -Healthcare facilities in the planning area may be overwhelmed quickly by widespread events
CRITICAL FACILITIES	-Healthcare facilities in the planning area may be overwhelmed quickly by widespread events -Critical facilities could see suspended action or reduced resources due to sick staff
CLIMATE	-Climate change impacts on extreme weather, air quality, transmission of disease via insects and pests, food security, and water quality increase threats of disease
OTHER	-Long-term public health emergencies can have negative impacts on resident's mental health

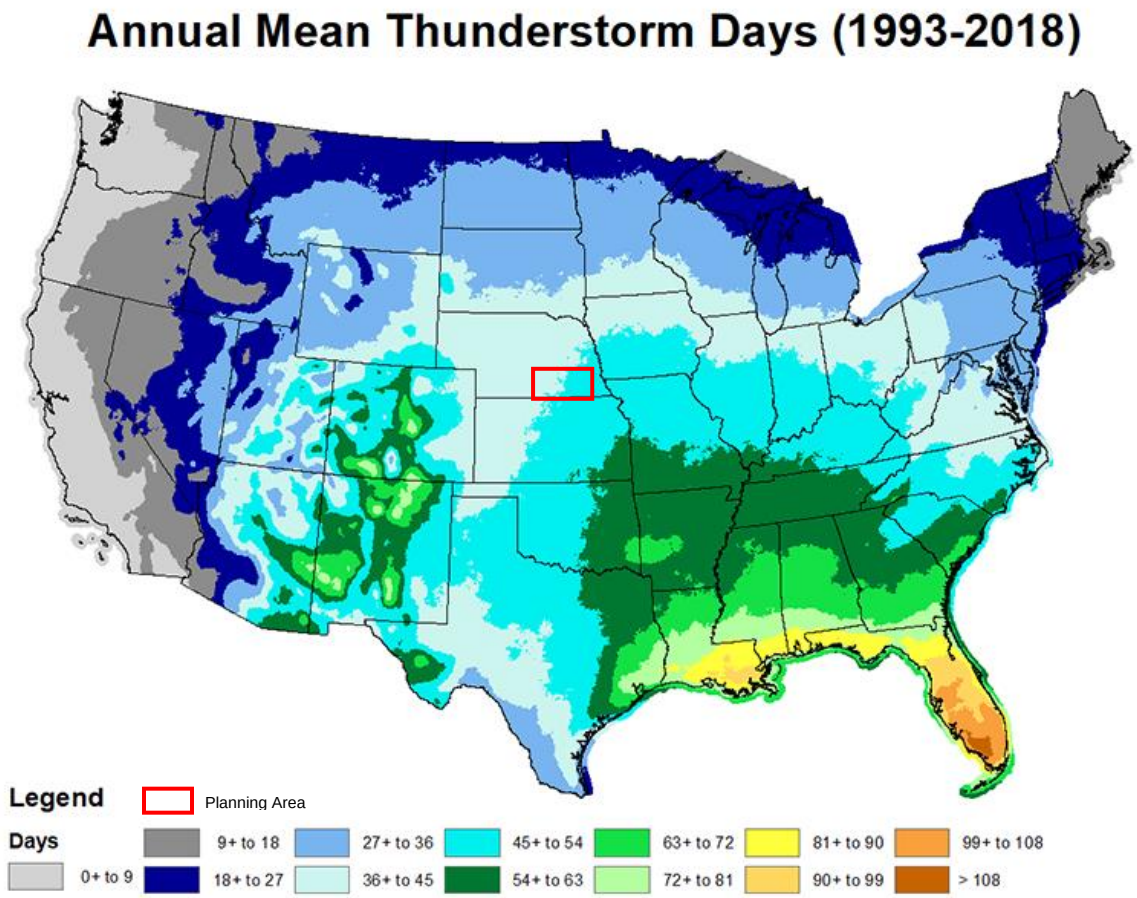
Severe Thunderstorms

Severe thunderstorms are common and unpredictable seasonal events throughout Nebraska. A thunderstorm is defined as a storm that contains lightning and thunder, which is caused by unstable atmospheric conditions. When the cold upper air sinks and the warm, moist air rises, storm clouds or “thunderheads” develop, resulting in thunderstorms. This can occur singularly, in clusters, or in lines.

Thunderstorms can develop in fewer than 30 minutes and can grow to an elevation of eight miles into the atmosphere. Lightning, by definition, is present in all thunderstorms and can cause harm to humans and animals, fires to buildings and agricultural lands, and electrical outages in municipal electrical systems. Lightning can strike up to 10 miles from the portion of the storm depositing precipitation. There are three primary types of lightning: intra-cloud, inter-cloud, and cloud to ground. While intra and inter-cloud lightning are more common, communities are potentially impacted when lightning comes in contact with the ground. Lightning generally occurs when warm air mixes with colder air masses resulting in atmospheric disturbances necessary for polarizing the atmosphere.

Economically, thunderstorms are generally beneficial in that they provide moisture necessary to support Nebraska’s largest industry, agriculture. The majority of thunderstorms do not cause damage, but when they escalate to severe storms, the potential for damages increases. Damages can include: crop losses from wind and hail; property losses due to building and automobile damages from hail; high wind; flash flooding; and death or injury to humans and animals from lightning, drowning, or getting struck by falling or flying debris. Figure 69 displays the average number of days with thunderstorms across the country each year. The planning area experiences an average of 36 to 54 thunderstorms over the course of one year.

Figure 69: Average Annual Thunderstorms



Source: NWS, 2018[61]

Location

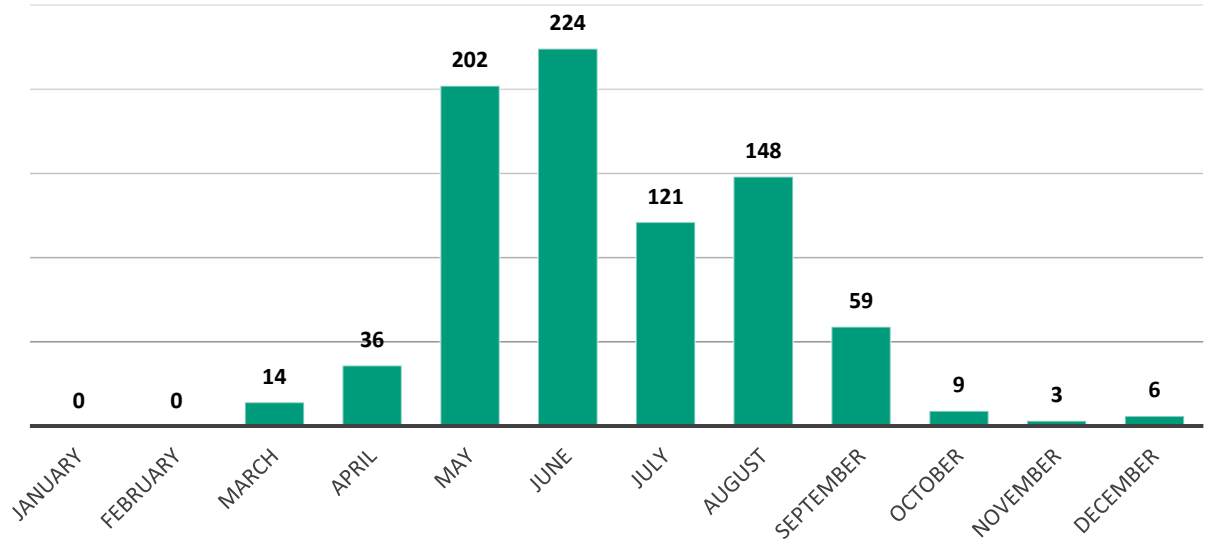
The entire nine-county planning area is at risk to thunderstorms and associated damages from heavy rain, lightning, hail, and thunderstorm level winds.

Historical Occurrences

Severe thunderstorms in the planning area usually occur in the afternoon and evening during the summer months.

[61] National Weather Service. 2020. "Global Weather: Introduction to Thunderstorms." https://www.weather.gov/jetstream/tstorms_intro#:~:text=It%20is%20estimated%20that%20there,its%20share%20of%20thunderstorm%20occurrences.

Figure 70: Thunderstorm Wind Events by Month



Source: NCEI, 1996-2020

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

The NCEI reports a total of 822 thunderstorm wind, 196 heavy rain, 25 lightning, and 1,712 hail events in the planning area from January 1996 to April 2020. In total these events were responsible for $158,896,200 in property damages. The USDA RMA data does not specify severe thunderstorms as a cause of loss, however heavy rains and hail which may be associated with severe thunderstorms caused $134,205,021 in crop damages. There were nine injuries and two fatalities reported in association with these storm events.

Average Annual Losses

The average damage per event estimate was determined based upon recorded damages from NCEI Storm Events Database since 1996 and number of historical occurrences. This does not include losses from displacement, functional downtime, economic loss, injury, or loss of life. Severe thunderstorms cause an average of $6,355,848 per year in property damages.

Table 59: High Winds and 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
Hail	1,712	68.5	$83,647,000	$3,345,880	$104,307,459	$4,967,022
Heavy Rain	196	7.8	$1,097,000	$43,880	$29,897,562	$1,423,693
Lightning	25	1	$20,335,000	$813,400	N/A	N/A
Thunderstorm Winds	822	32.9	$53,817,200	$2,152,688	N/A	N/A
Totals	**2,755**	**110.0**	**$158,896,200**	**$6,355,848**	**$134,205,021**	**$6,360,715**

Source: 1 NCEI (1996-April 2020), 2 USDA RMA (2000-2020)

Extent

The geographic extent of a severe thunderstorm event may be large enough to impact the entire planning area (such as in the case of a squall line, derecho, or long-lived supercell) or just a few square miles, in the case of a single cell that marginally meets severe criteria. The NWS defines a thunderstorm as severe if it contains hail that is one inch in diameter or capable of winds gusts of 58 mph or higher. The Tornado and Storm Research Organization (TORRO) scale is used to classify hailstones and provides some detail related to the potential impacts from hail. Table 64 outlines the TORRO Hail Scale.

Table 60: TORRO Hail Ranking

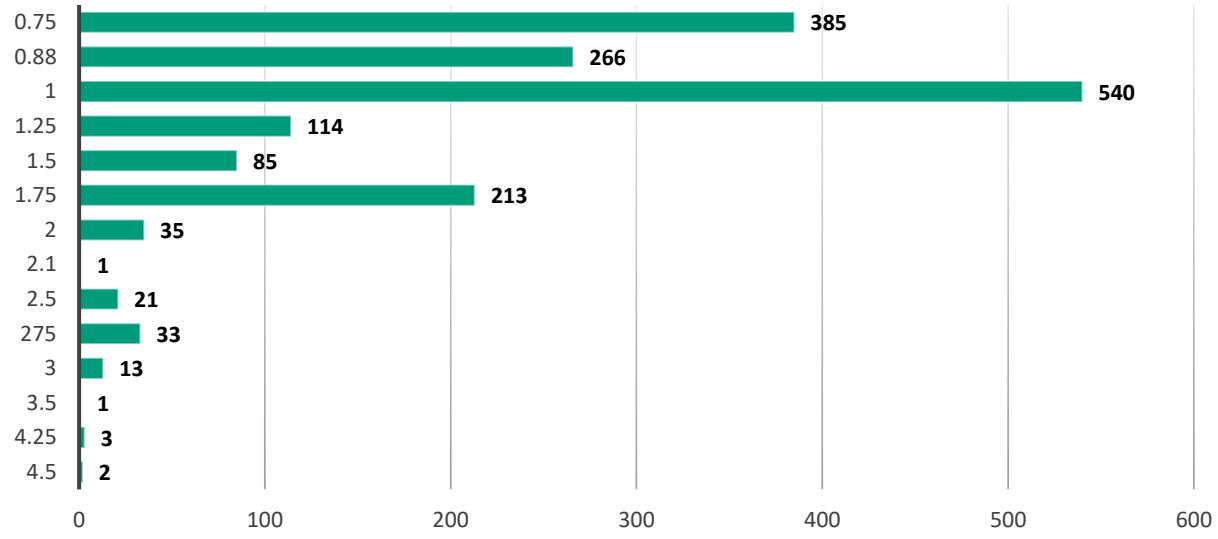
Class	Type of Material	Divisions
H0: Hard Hail	5 mm; 0.2 in (pea size)	No damage
H1: Potentially Damaging	5-15 mm; 0.2-0.6in (marble)	Slight general damage to plants and crops
H2: Significant	10-20 mm; 0.4-0.8 in (grape)	Significant damage to fruit, crops, and vegetation
H3: Severe	20-30 mm; 0.8-1.2 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[62]

The NCEI reported 1,712 individual hail events across the planning area. As the NCEI reports events per county, this value overestimates the total amount of thunderstorm events. The average hailstone size was 1.16 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 planning area. In addition, it is reasonable, based on the number of occurrences, to expect larger hailstones to occur in the planning area annually. The planning area has endured five H10 hail events (>4.0 inches) during the period of record. Figure 34 shows hail events based on the size of the hail.

[62] Tornado and Storm Research Organization. 2017. "Hail Scale." http://www.torro.org.uk/hscale.php.

Figure 71: Hail Events by Magnitude



Source: NCEI, 1996-2020

For the planning area it is reasonable to expect spring (March, April and May) and summer (June, July and August) to have the highest rainfall totals. Using data provided by the High Plains Regional Climate Center the spring months could have an average of 23 days with at least trace amounts of precipitation. Eleven days will receive precipitation totals greater than one tenth of an inch; approximately three days will have more than one half an inch of precipitation; and approximately one day will report rainfall totals equal to or greater than one inch. During the summer months the planning area can expect to receive at least trace amounts of precipitation on 26 days. More than 16 days will report totals greater than or equal to one tenth of an inch; five days will report rainfall totals of at least one half an inch; and two days will report precipitation totals of at least one inch.

Probability

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

Community Top Hazard Status

The following table lists jurisdictions which identified Severe Thunderstorms as a top hazard of concern:

Jurisdictions	
Little Blue NRD	Village of Chester
Lower Big Blue NRD	Village of Clatonia
Adams County	Village of Cortland
Clay County	Village of Cowles
Gage County	Village of Daykin
Jefferson County	Village of Deweese
Nuckolls County	Village of DeWitt
Saline County	Village of Diller
Thayer County	Village of Dorchester

Jurisdictions	
Webster County	Village of Endicott
Barneston Rural Fire Dept	Village of Exeter
Beatrice Public Schools	Village of Fairmont
Exeter Milligan Public Schools	Village of Filley
Meridian Public Schools	Village of Grafton
SCC - Beatrice Campus	Village of Harbine
South Central USD 5 (Lawrence-Nelson-Sandy Creek)	Village of Hardy
Superior Public Schools	Village of Holstein
Tri-County Public Schools	Village of Hubbell
City of Beatrice	Village of Jansen
City of Blue Hill	Village of Juniata
City of Blue Springs	Village of Lawrence
City Of Clay Center	Village of Liberty
City of Edgar	Village of Milligan
City of Fairbury	Village of Odell
City of Fairfield	Village of Ong
City of Friend	Village of Prosser
City of Geneva	Village of Reynolds
City of Hastings	Village of Saronville
City of Sutton	Village of Steele City
City of Wilber	Village of Strang
City of Wymore	Village of Tobias
Village of Ayr	Village of Trumbull
Village of Barneston	Village of Virginia
Village of Belvidere	Village of Western
Village of Bruning	

Regional Vulnerabilities

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

Table 61: Regional Severe Thunderstorm Vulnerabilities

SECTOR	VULNERABILITY
PEOPLE	-Elderly citizens with decreased mobility may have trouble evacuating or seeking shelter -Mobile home residents are at risk of injury and damage to their property if the mobile home is not properly anchored -Injuries can occur from: not seeking shelter, standing near windows, and shattered windshields in vehicles
ECONOMIC	-Damages to buildings and property can cause significant losses to business owners and employees
BUILT ENVIRONMENT	-Buildings are at risk to hail damage -Downed trees and tree limbs -Roofs, siding, windows, gutters, HVAC systems, etc. can incur damage
INFRASTRUCTURE	-High winds and lighting can cause power outages and down power lines -Roads may wash out from heavy rains and become blocked from downed tree limbs
CRITICAL FACILITIES	-Power outages are possible -Critical facilities may sustain damage from hail, lightning, and wind
CLIMATE	-Changes in seasonal precipitation and temperature normals can increase frequency and magnitude of severe storm events
OTHER	-High winds, hail, lightning, heavy rain, and possibly tornadoes can occur with this hazard

Severe Winter Storms

Severe winter storms are an annual occurrence in Nebraska. Winter storms can bring extreme cold, freezing rain, heavy or drifting snow, and blizzards. Blizzards are particularly dangerous due to drifting snow and the potential for rapidly occurring whiteout conditions which greatly inhibit vehicular traffic. Generally, winter storms occur between eh months of November and March, but may occur as early as October and as late as April. Heavy snow is usually the most defining element of a winter storm. Large snow events can cripple an entire jurisdiction by hindering transportation, knocking down tree limbs and utility lines, and structurally damaging buildings. Extreme cold, freezing rain, and blizzards also occur alongside many severe 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 planning area, the coldest months of the year are January, February, and December. The average low temperature for these months are all below freezing (average low for the three months in the planning area is 16.2°F). The average high temperatures for the months of January, February, and December are near 38.51°F in the planning area.[63]

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.

Blizzards

Blizzards are particularly dangerous due to drifting snow and the potential for rapidly occurring whiteout conditions, which greatly inhibits vehicular traffic. Heavy snow is usually the most defining element of a winter storm. Large snow events can cripple an entire jurisdiction for several days by hindering transportation, knocking down tree limbs and utility lines, structurally damaging buildings, and injuring or killing crops and livestock.

Location

The entire planning area is a risk of severe winter storms.

Historical Occurrences

Due to the regional scale of severe winter storms, the NCEI reports events as they occur in each county. According to the NCEI, there were a combined 766 severe winter storm events for the planning area from January 1996 to April 2020. These recorded events caused a total of $34,546,000 in property damages and $12,156,696 in crop damages.

The most damaging event was a winter storm in Adams County on October 25, 1997 which caused a reported $15,000,000 in property damages.

[63] High Plains Regional Climate Center. 2020. "Monthly Climate Normals 1981-2010." http://climod.unl.edu/.

Average Annual Losses

The average damages per event estimate was determined based upon NCEI Storm Events Database since 1996 and includes aggregated 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. Severe winter storms have caused an average of $919,542 per year in property damage for the planning area.

Table 62: 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	79	3.2	$105,000	$4,200	$12,156,696	$578,890
Extreme Cold	25	1	$0	$0		
Heavy Snow	41	1.6	$5,500,000	$220,000		
Ice Storm	51	2.0	$12,464,000	$498,560		
Winter Storms	379	15.2	$16,382,000	$655,280		
Winter Weather	191	7.64	$95,000	$3,800		
Totals	**766**	**30.6**	**$34,546,000**	**$1,381,840**	**$12,156,696**	**$578,890**

Source: 1 NCEI (1996-2020), 2 USDA RMA (2000-2020)

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. Ice Storm Warnings are issued when accumulation of at least 0.25 inches is expected from a storm, which controlling for high winds, would tend to classify ice storms in Nebraska as SPIA Level 2 or higher. The most common accumulation during ice storms was a quarter of an inch. The following figure shows the SPIA index.

Figure 72: 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[64]

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.

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

Figure 73: 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

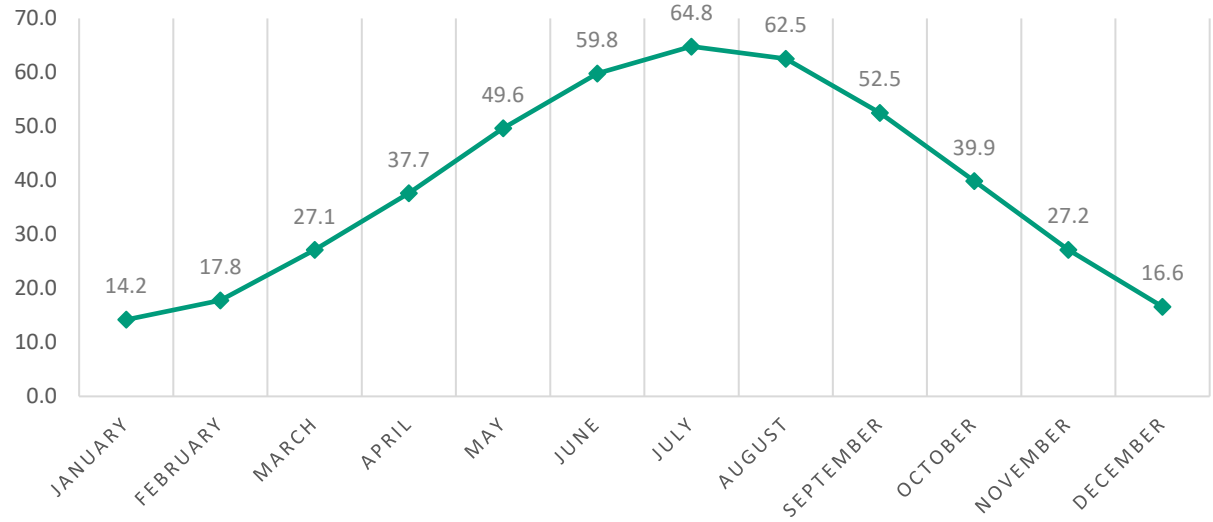
Frostbite Times: 30 Minutes, 10 MInutes, 5 Minutes

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

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

Source: NWS

Figure 74: Monthly Climate Normals Min Temperature (1981-2010)

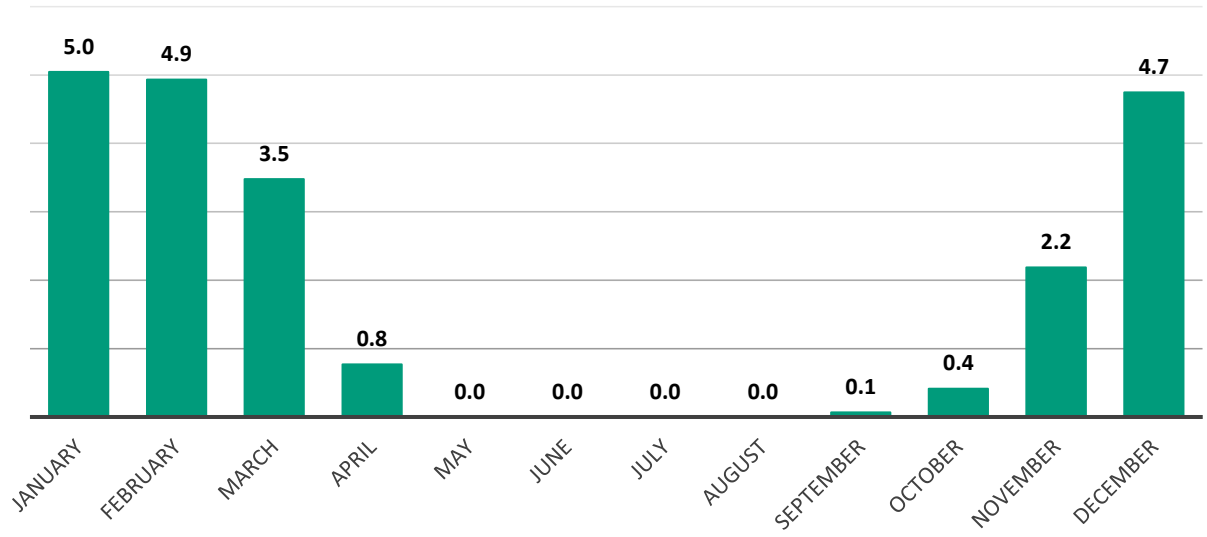


Source: NCEI

Record lows for most reporting weather stations within the planning area monitored by the High Plains Regional Climate Center occurred in the month of January and were recorded at or near a -17°F recorded in 1940.

Average monthly snowfall for the planning area is shown in Figure 75, which shows the snowiest months are between December and February. A common snow event (likely to occur annually) will result in accumulation totals between one and five inches. Often these snow events are accompanied by high winds. 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 75: Monthly Normal Snowfall in Inches (1981-2010)



Source: High Plains Regional Climate Center

Probability

Based on historical records and reported events, severe 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.

Community Top Hazard Status

The following table lists jurisdictions which identified Severe Winter Storms as a top hazard of concern:

Jurisdictions	
Little Blue NRD	Village of Chester
Adams County	Village of Clatonia
Clay County	Village of Davenport
Fillmore County	Village of Daykin
Gage County	Village of Deweese
Jefferson County	Village of DeWitt
Nuckolls County	Village of Diller
Saline County	Village of Dorchester
Thayer County	Village of Exeter

Jurisdictions	
Barneston Rural Fire Dept	Village of Fairmont
Beatrice Public Schools	Village of Filley
Exeter Milligan Public Schools	Village of Grafton
Meridian Public Schools	Village of Guide Rock
SCC - Beatrice Campus	Village of Harbine
South Central USD 5 (Lawrence-Nelson-Sandy Creek)	Village of Hardy
South Heartland District Health Department	Village of Holstein
Superior Public Schools	Village of Juniata
Tri-County Public Schools	Village of Kenesaw
City of Beatrice	Village of Lawrence
City of Blue Springs	Village of Liberty
City of Crete	Village of Milligan
City of Deshler	Village of Odell
City of Fairbury	Village of Ong
City of Friend	Village of Pickrell
City of Hastings	Village of Plymouth
City of Red Cloud	Village of Prosser
City of Superior	Village of Ruskin
City of Wilber	Village of Saronville
City of Wymore	Village of Shickley
Village of Adams	Village of Strang
Village of Alexandria	Village of Tobias
Village of Barneston	Village of Trumbull
Village of Belvidere	Village of Western
Village of Bruning	

Regional Vulnerabilities

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

Table 63: Regional Severe Winter Storm Vulnerabilities

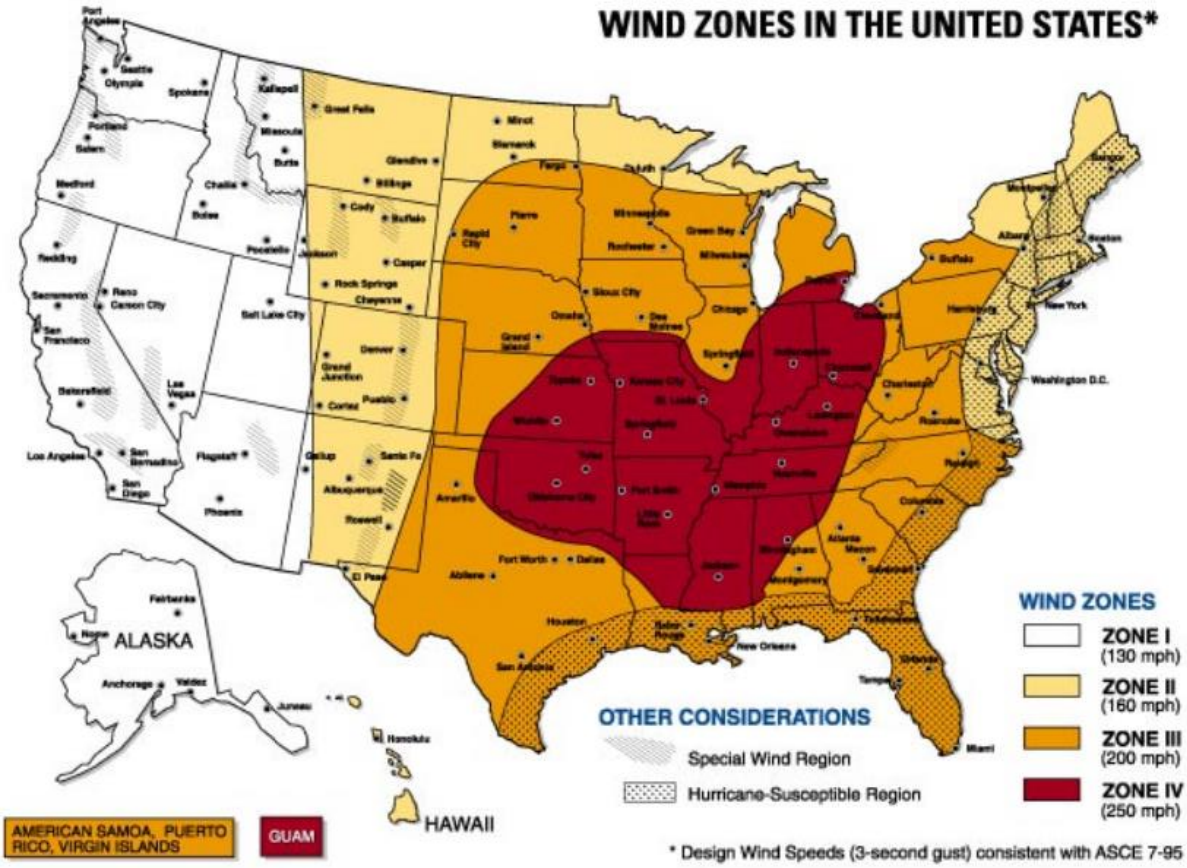
SECTOR	VULNERABILITY
PEOPLE	-Elderly citizens are at higher risk to injury or death, especially during extreme cold and heavy snow accumulations -Citizens without adequate heat and shelter at higher risk of injury or death
ECONOMIC	-Closed roads and power outages can cripple a region for days, leading 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
CRITICAL FACILITIES	-Emergency response and recovery operations, communications, water treatment plans, and others at risk to power outages, impassable roads, and other damages
CLIMATE	-Changes in seasonal precipitation and temperature normals can increase frequency and magnitude of severe storm events.

Tornadoes and High Winds

High 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 significant property damage including to trees and center-pivot irrigation systems.

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.[65] The NWS issues High Wind Advisories when there are sustained winds of 25 to 39 miles per hour and/or gusts to 57 mph. F shows the wind zones in the United States. The wind zones are based on the maximum wind speeds that can occur from a tornado or hurricane event. The planning area is located primarily in Zone III which has maximum winds of 200 mph equivalent to an EF4/5 tornado.

Figure 76: Wind Zones in the U.S.



Source: FEMA

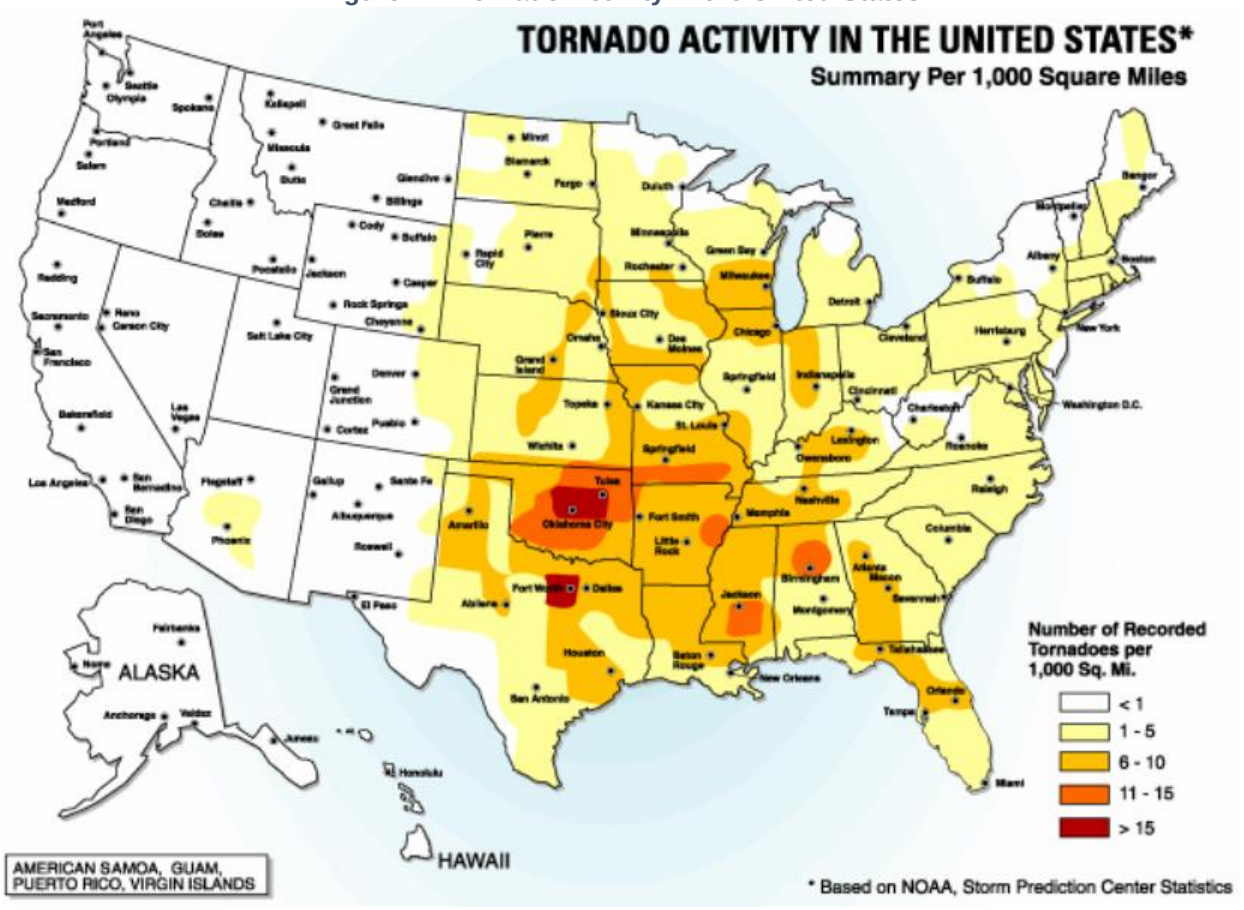
[65] National Weather Service. 2017. "Glossary." http://w1.weather.gov/glossary/index.php?letter=h.

High winds are a critical component of tornado formation. A tornado is typically associated with a supercell thunderstorm. 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." Approximately 1,250 tornadoes are reported annually in the contiguous United States. 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. Nationally, the tornado season typically occurs between April and July. On average, 80 percent of tornadoes occur between noon and midnight. In Nebraska, 77 percent of all tornadoes occur in the months of May, June, and July.

Figure 77: Tornado Activity in the United States



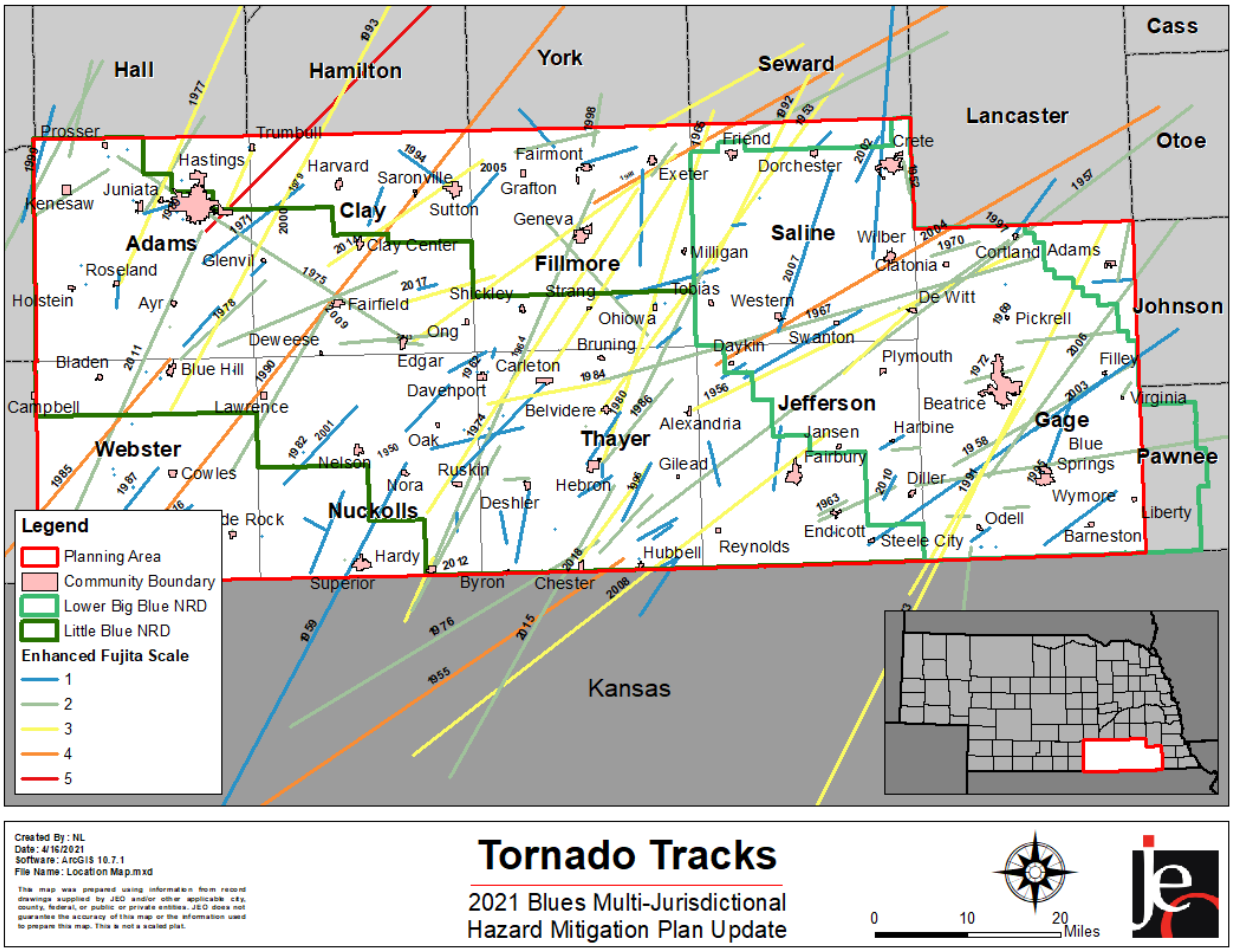
Source: FEMA

Nebraska is ranked fifth in the nation for tornado frequency with an annual average of 57 tornadoes between 1991 and 2010.[66]

Location

High winds and tornadoes can occur throughout the planning area. The impacts would be greater in more densely populated areas, such as in the City of Beatrice or City of Fairbury. The following map shows the historical track locations across the region according to the Midwestern Regional Climate Center. Few significant tornado events have directly impacted communities located in the planning area, but touchdowns and tornado events can occur anywhere within the nine-county planning area.

Figure 78: Tornado Tracks in the Planning Area



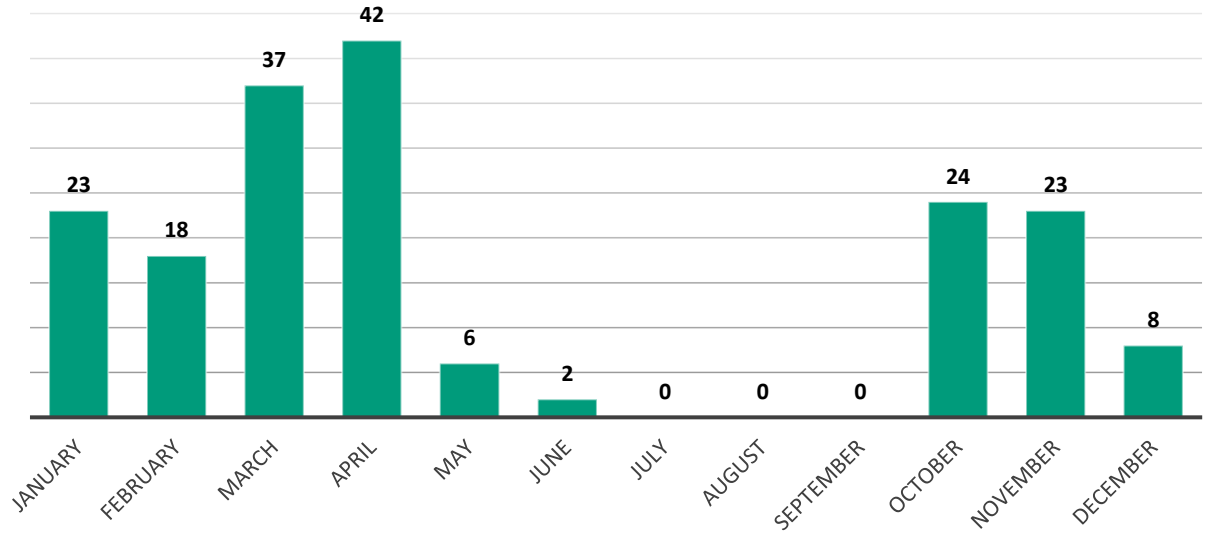
Historical Occurrences

Due to the regional scale of high winds, the NCEI reports events as they occur in each county. While a single event can affect two or more counties at a time, the NCEI reports them as separate events. There were 183 high wind events that occurred between January 1996 and April 2020 and 148 tornadic events ranging in magnitude from EF/F0 to EF/F4. These events were responsible for $127,088,580 in property damages (NCEI) and $10,915,489 in crop damages (RMA). As seen in the following figures, the majority of high wind events occur in the spring and

[66] National Centers for Environmental Information. 2013. "U.S. Tornado Climatology." https://www.ncdc.noaa.gov/climate-information/extreme-events/us-tornadoclimatology.

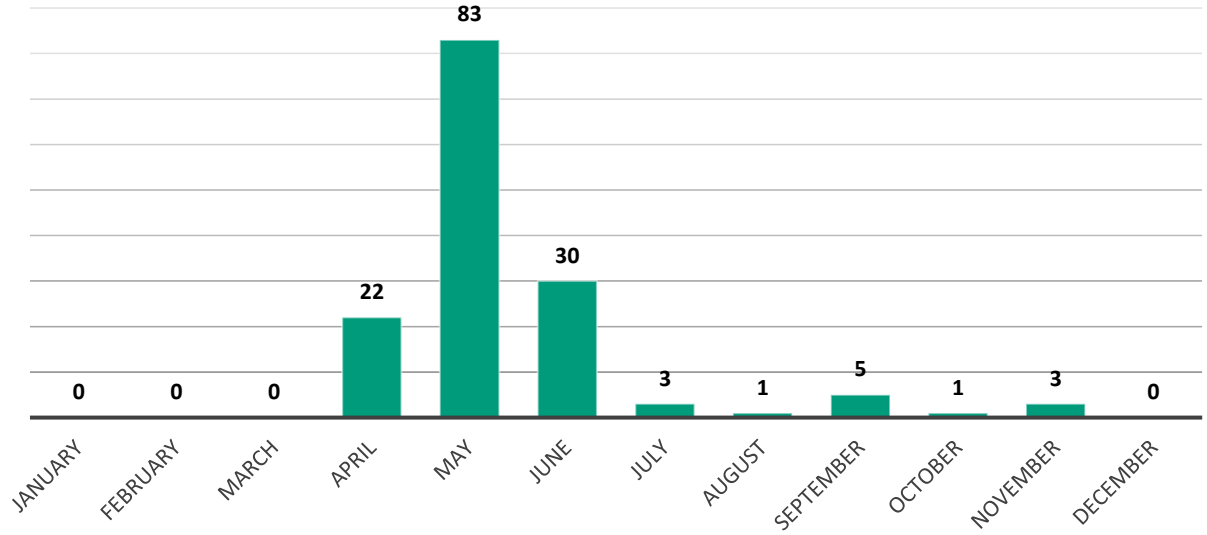
winter months, while most tornado events occur in the late spring/early summer. Significant hazard events with direct impacts to communities are discussed in more detail in the applicable *Community Profiles.*

Figure 79: High Wind Events by Month



Source: NCEI, 1996-2020

Figure 80:Tornadoes by Month in the Planning Area



Source: NCEI, 1996-2019

Several events led to either fatalities and/or injuries. Event descriptions from NCEI for the most damaging events (those including injuries, fatalities, or greatest property damage estimates) are provided below.

- **6/22/2003 Tornado –** one fatality and seven injuries. *"A strong tornado set down on the southeast side of Deshler near the fairgrounds and moved west through the south side of Deshler. The slow-moving tornado lifted a couple of miles west of town. Thunderstorms*

erupted during the evening in south-central Nebraska. One storm near Aurora produced very large hail. One stone measured by an NWS Storm Survey team was determined to be the largest sized stone to fall in the United States. It measured 7 inches in diameter and 18.75 inches in circumference. Given the lack of wind, damage was limited to roofs, a few windows and some crop land near town. The storm also produced a couple of brief small tornadoes as it slowly moved through northern Hamilton county. At nearly the same time, another very slow moving storm produced several tornadoes, hail and extremely heavy rains in Thayer county. One tornado moved through the town of Deshler going from the southeast side of town to the west. One man was killed in his garage before he was able to get to shelter. Over 400 homes in Deshler were damaged with four being completely demolished. Nearly 100 homes were moderately to severely damaged. Six businesses in town were considered a complete loss and 25 others reportedly suffered moderate to severe damage. Seven people were injured, most were minor and were from broken glass. Despite ongoing drought conditions, widespread flooding was reported in Thayer and southern Fillmore counties. The flash flood along the Rose Creek at Hubbell provided some of the worst damage. Water was flowing into houses and businesses on main street to the tune of up to 5 feet deep. Boats were the only mode of travel through the business district. Up to 15 residents had to be evacuated by the local Dive and Rescue team using jet skis. The flooding was caused by extremely heavy rainfall in nearby Republic County, Kansas. Flooding and flash flooding was also a problem throughout Thayer county. Rainfall of over 12 inches was reported about 5 miles north of Deshler. Residents reported nearly 5 hours of constant, wind-driven rain. Windows were blown out and the rain just poured into homes. Widespread agricultural damage was done due to the rain. The runoff in the Snake and Spring creeks ravaged Deshler, the town which had already been hammered by tornadoes that evening. Flooding was concentrated in the southern part of town and most widespread near the park and fairgrounds. Major river flooding was reported along the Little Blue River from just west of Hebron to the Jefferson county line. One man at his farmstead near Gilead had to be air lifted to safety by the National Guard as flooding waters rose on his property. Dozens of county roads and bridges were damaged or destroyed. U. S. Highway 81 was restricted to one lane travel at Hebron due to the high water on the road. Portions of Highways 81, 136 and 9 were closed for a time due to high water. The Big Sandy Creek flowed out of its banks at Alexandria and crested at 14.5 feet. Water was flowing over the highway near town and filling back into the town's sewer drains. In all, several million dollars in damage was done by the flooding alone. Some locals said this was the worst flooding in the area in 55 years."

- **5/8/1996 Tornado –** 15 injuries with $12,000,000 in property damages. *"The beginning of the tornado started 4 1/2 miles west northwest of downtown Beatrice, just north of the Homestead National Monument. The storm damaged trees just north of state highway 4 when it struck several homes, primarily lifting the roofs off of them. The tornado was rated F1 at that point. Around 1/2 mile to the east, the tornado struck a subdivision. The damage was more severe, with collapsed outer walls and roofs off homes. The tornado damage was rated as a strong F2 in this area. The tornado, continuing to move in an east southeast direction, nearly paralleling highway 4, struck a church. Part of the roof was lost off the church. After striking the church, the tornado hit several more homes and barns before entering the heart of the city. The damage path width of the tornado was 1/4 to 1/2 mile wide, with damaging thunderstorms winds out to 11/2 mile. The main tornado path remained 1/4 to 1/2 mile wide north of U.S. highway 136, with much of the damage south of highway 136 due to thunderstorm downburst winds. The tornado strength weakened when entering the city, with an F-scale strength between F0-F1. Although much of the damage in the central city area was due to falling trees and large tree limbs, other damage noted was roofing torn off of several buildings and a*

collapsed 200 foot communication tower. After the storm exited the city, it regained strength. The tornado also began curving to the northeast. The storm maintained about F1 strength from about 1 mile east of downtown Beatrice to the storm's dissipation, approximately 3 miles northeast of the city. The strong F2 tornado's path was 9.5 miles long."

- **5/22/2004 Tornado –** tornado with eight injuries. *"This long tracked tornado is often referred to as the Hallam tornado. It initially touched down 3 miles west of Daykin in northern Jefferson county. The tornado was rated an F0 or F1 in Jefferson County damaging farm outbuildings, grain bins and trees. From there the tornado crossed into Saline County southwest of Western and remained an F0 or F1 until it struck the southern portion of Wilber where it strengthened to F2. Roofs were blown off of homes just southeast of Wilber. The tornado traveled from Wilber into Gage County, crossing the county line west of Clatonia where it grew to its most intense stage, F4. The tornado remained nearly at this strength as it crossed into Lancaster county near Hallam with a damage path of around 2 1/2 miles. Many well-built homes were demolished from Clatonia to Hallam, along with grain bins, farm sheds, and outbuildings. Many trees were destroyed or uprooted. In total the tornado was on the ground for around 54 miles with a maximum intensity of f4. Besides the fatality, 38 people sustained injuries, 158 homes were leveled and 57 others were seriously damaged. The dollar amount of damage was estimated at 160 million, with 60 million of that agricultural including 100 cattle and 50 hogs lost. Some 150,000 acres of crop land sustained significant damage. The 5 counties were declared national disaster areas by FEMA."*
- **4/11/2001 Tornado –** tornado with two injuries. *"A tornado caused extensive damage in Virginia with most of the damage occurring along a 4 block long and 1 block wide stretch through the center of town. One house was almost completely destroyed causing minor injuries to 2 people living there. Six other homes and businesses sustained extensive damage, and trees and other debris were scattered all over the community."*

Average Annual Losses

The average damage per event estimate was determined based upon NCEI Storm Events Database since 1996 and number of historical occurrences. This does not include losses from displacement, functional downtime, economic loss, injury or loss of life. It is estimated that high wind events can cause an average of $91,383 per year in property damages and $501,271 per year in crop damages. Tornadoes have caused an average of over $4 million per year in property damages; however, damages from tornadoes vary greatly depending on the severity or magnitude of each event.

Table 64: High Winds and 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
High Winds	183	7.3	$2,284,580	$91,383	$10,526,687	$501,271
Tornadoes	148	5.9	$124,804,000	$4,992,160	$388,802	$18,514

Source: 1 NCEI (1996-April 2020), 2 USDA RMA (2000-Aug 2020)

Extent

The Beaufort Wind Scale can be used to classify wind strength while the magnitude of tornadoes is measured by the Enhanced Fujita Scale. 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.

Table 65: 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, 2017[67]

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. According to a recent report from the National Institute of Science and Technology on the Joplin Tornado, tornadoes rated EF3 or lower account for around 96 percent of all tornado damages.[68]

Table 66: 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

[67] Storm Prediction Center: National Oceanic and Atmospheric Administration. 1805. "Beaufort Wind Scale." http://www.spc.noaa.gov/faq/tornado/beaufort.html.
[68] Kuligowski, E.D., Lombardo, F.T., Phan, L.T., Levitan, M.L., & Jorgensen, D.P. March 2014. "Final Report National Institute of Standards and Technology(NIST) Technical Investigation of the May 22, 2011, Tornado in Joplin, Missouri."

			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 67: 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

Using the NCEI reported events, the most common high wind event in the planning area is a level 9 on the Beaufort Wind Ranking scale. The reported high wind events ranged from 35 mph to 70

mph, with an average speed of 50 mph. Based on the historical record, it is most likely that tornadoes that occur within the planning area will be of EF0 strength. Of the 148 reported tornado events, 87 were EF/F0, 38 were EF/F1, 18 were EF/F2, four were EF3/F3, and one was a F4 event. High winds and tornadoes are likely to occur annually in the planning area.

Probability

Given the historic record of occurrence for high wind events (21 out of 25 years with reported events), for the purposes of this plan, the annual probability of agricultural animal disease occurrence is 84 percent. However, high wind events may be more common than presented here but have simply not been reported in past years.

Given the historic record of occurrence for tornado events (24 out of 25 years with reported events), for the purposes of this plan, the annual probability of agricultural plan disease occurrence is 96%. However, it is worth noting that data utilized during this analysis only encompassed through April 2020. Tornado events in 2020 were likely experienced in the planning area but were not reflected here.

Community Top Hazard Status

The following table lists jurisdictions which identified Tornadoes and High Winds as a top hazard of concern:

Jurisdictions	
Little Blue NRD	Village of Chester
Adams County	Village of Clatonia
Fillmore County	Village of Cortland
Gage County	Village of Davenport
Jefferson County	Village of Daykin
Nuckolls County	Village of Deweese
Saline County	Village of DeWitt
Thayer County	Village of Diller
Webster County	Village of Dorchester
South Central USD 5 (Lawrence-Nelson-Sandy Creek)	Village of Exeter
South Heartland District Health Department	Village of Fairmont
Beatrice Public Schools	Village of Filley
Exeter Milligan Public Schools	Village of Glenvil
Meridian Public Schools	Village of Grafton
SCC - Beatrice Campus	Village of Guide Rock
Superior Public Schools	Village of Harbine
Tri-County Public Schools	Village of Hardy
Barneston Rural Fire Dept	Village of Holstein
City of Beatrice	Village of Hubbell
City of Blue Hill	Village of Jansen
City of Blue Springs	Village of Juniata
City of Clay Center	Village of Kenesaw
City of Crete	Village of Lawrence
City of Deshler	Village of Liberty
City of Edgar	Village of Milligan
City of Fairbury	Village of Odell
City of Fairfield	Village of Ohiowa

Jurisdictions	
City of Friend	Village of Ong
City of Geneva	Village of Pickrell
City of Hastings	Village of Plymouth
City of Hebron	Village of Prosser
City of Red Cloud	Village of Reynolds
City of Superior	Village of Ruskin
City of Sutton	Village of Saronville
City of Wilber	Village of Shickley
City of Wymore	Village of Steele City
Clay County	Village of Strang
Village of Adams	Village of Swanton
Village of Alexandria	Village of Tobias
Village of Ayr	Village of Trumbull
Village of Barneston	Village of Virginia
Village of Belvidere	Village of Western
Village of Bruning	

Regional Vulnerabilities

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

Table 68: Regional Tornadoes and High Winds 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 -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, especially at night
ECONOMIC	-Agricultural losses to both crops and livestock -Damages to businesses and prolonged power outages can cause significant impacts to the local economy, especially with EF3 tornadoes or greater
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
CRITICAL FACILITIES	-All critical facilities are at risk to damages and power outages
CLIMATE	-Changes in seasonal precipitation and temperature normals can increase frequency and magnitude of events

Terrorism

According to the Federal Bureau of Investigation (FBI), there is no single, universally accepted definition of terrorism. Terrorism is defined in the Code of Federal Regulations as "the unlawful use of force and violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof in furtherance of political or social objectives" (28 C.F.R. Section 0.85).

The FBI further describes terrorism as either domestic or international, depending on the origin, base, and objectives of the terrorist organization. For the purpose of this report, the following definitions from the FBI will be used:

- Domestic terrorism is the unlawful use, or threatened use, of force or violence by a group or individual based and operating entirely within the United States or Puerto Rico without foreign direction committed against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof in furtherance of political or social objectives.
- International terrorism involves violent acts or acts dangerous to human life that are a violation of the criminal laws of the United States or any state, or that would be a criminal violation if committed within the jurisdiction of the United States or any state. These acts appear to be intended to intimidate or coerce a civilian population, influence the policy of a government by intimidation or coercion, or affect the conduct of a government by assassination or kidnapping. International terrorist acts occur outside the United States or transcend national boundaries in terms of the means by which they are accomplished, the persons they appear intended to coerce or intimidate, or the locale in which their perpetrators operate or seek asylum.

There are different types of terrorism depending on the target of attack which are:

- Political Terrorism, Bio-terrorism, Cyber-terrorism, Eco-terrorism, Nuclear-terrorism, Narco-terrorism, and Agro-terrorism.

Terrorist activities are also classified based on motivation behind the event (such as ideology: i.e. religious fundamentalism, national separatist movements, and social revolutionary movements). Terrorism can also be random with no ties to ideological reasoning. The FBI also provides clear definitions of a terrorist incident and prevention:

- A terrorist *incident* is a violent act or an act dangerous to human life, in violation of the criminal laws of the United States, or of any state, to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives.
- Terrorism *prevention* is a documented instance in which a violent act by a known or suspected terrorist group or individual with the means and a proven propensity for violence is successfully interdicted through investigative activity.

Note: the FBI investigates terrorism-related matters without regard to race, religion national origin, or gender. Reference to individual members of any political, ethnic, or religious group in this report is not meant to imply that all members of that group are terrorists. Terrorists represent a small criminal minority in any larger social context.

Primarily, threat assessment, mitigation and response to terrorism are federal and state directives and work primarily with local law enforcement. The Office of Infrastructure Protection within the Federal Department of Homeland Security is a component within the National Programs and Protection Directorate.

The Office of Infrastructure Protection leads the coordinated national program to reduce and mitigate risk within 18 national critical infrastructure and key resources (CIKR) sectors from acts of terrorism and natural disasters and to strengthen sectors' ability to respond and quickly recover from an attack or other emergency. This is done through the National Infrastructure Protection Plan (NIPP).

Under the NIPP, a Sector-Specific Agency (SSA) is the federal agency assigned to lead a collaborative process for infrastructure protection for each of the 18 sectors. The NIPP's comprehensive framework allows the Office of Infrastructure Protection to provide the cross-sector coordination and collaboration needed to set national priorities, goals, and requirements for effective allocation of resources. More importantly, the NIPP framework integrates a broad range of public and private CIKR protection activities.

The SSAs provide guidance about the NIPP framework to state, tribal, territorial and local homeland security agencies and personnel. They coordinate NIPP implementation within the sector, which involves developing and sustaining partnerships and information-sharing processes, as well as assisting with contingency planning and incident management.

The Office of Infrastructure Protection has SSA responsibility for six of the 18 CIKR sectors. Those six are: Chemical; Commercial Facilities; Critical Manufacturing; Dams; Emergency Services; Nuclear Reactors, Materials and Waste.

SSA responsibility for the other 12 CIKR sectors is held by other Department of Homeland Security components and other federal agencies. Those 12 are:

- Agriculture and Food – Department of Agriculture; Food and Drug Administration
- Banking and Finance – Department of the Treasury
- Communications – Department of Homeland Security
- Defense Industrial Base – Department of Defense
- Energy – Department of Energy
- Government Facilities – Department of Homeland Security
- Information Technology – Department of Homeland Security
- National Monuments and Icons – Department of the Interior
- Postal and Shipping – Transportation Security Administration
- Healthcare and Public Health – Department of Health and Human Services
- Transportation Systems – Transportation Security Administration; U.S. Coast Guard
- Water – Environmental Protection Agency

The NIPP requires that each SSA prepare a Sector-Specific Plan, review it annually, and update it as appropriate.

The Department of Homeland Security and its affiliated agencies are responsible for disseminating any information regarding terrorist activities in the country. The system in place is the National Terrorism Advisory System (NTAS). NTAS replaced the Homeland Security Advisory

System (HSAS) which was the color coded system put in place after the September 11th attacks by Presidential Directive 5 and 8 in March of 2002. NTAS replaced HSAS in 2011.

NTAS is based on a system of analyzing threat levels and providing either an imminent threat alert or an elevated threat alert. An *Imminent Threat Alert* warns of a credible, specific and impending terrorist threat against the United States. An *Elevated Threat Alert* warns of a credible terrorist threat against the United States.

The Department of Homeland Security, in conjunction with other federal agencies, will decide whether a threat alert of one kind or the other should be issued should credible information be available. Each alert provides a statement summarizing the potential threat and what, if anything should be done to ensure public safety. The NTAS Alerts will be based on the nature of the threat: in some cases, alerts will be sent directly to law enforcement or affected areas of the private sector, while in others, alerts will be issued more broadly to the American people through both official and media channels.

An individual threat alert is issued for a specific time period and then automatically expires. It may be extended if new information becomes available or the threat evolves. The sunset provision contains a specific date when the alert expires as there will not be a constant NTAS Alert or blanket warning that there is an overarching threat. If threat information changes for an alert, the Secretary of Homeland Security may announce an updated NTAS Alert. All changes, including the announcement that cancels an NTAS Alert, will be distributed the same way as the original alert.

Location

Terrorist attacks can occur throughout the entire planning area. In rural areas, concerns are primarily related to agro-terrorism and tampering with water supplies. In urban areas, concerns are related to political unrest, activist groups, and others that may be targeting businesses, police, and federal buildings. Urban areas, schools, and government buildings are more likely to see terroristic activity. However, water systems of any size could be vulnerable as well as computer systems from cyber-terrorism.

Historical Occurrences

Previous accounts of terrorism in the planning area were gathered from the Global Terrorism Database, maintained by the University of Maryland and the National Consortium for the Study of Terrorism and Responses to Terrorism (START). This database contains information for over 140,000 terrorist attacks. According to the database, one event was reported in two counties in the planning area between 1970-2017.[69] These events caused no property damages, one death, and seven injuries within the planning area.

Table 69: High Winds and Tornado Losses

Date	Location	Perpetrator Group	Fatalities	Injuries	Target Type	Property Damage
5/4/2002	Fillmore and Thayer County	Anti-government extremists	0	0	Civilians	$0

Source: START, 1970-2017

According to the START Database, these events occurred:

[69] National Consortium for the Study of Terrorism and Responses to Terrorism (START). 2016. Global Terrorism Database [Data file]. Retrieved from https://www.start.umd.edu/gtd.

Between the dates of May 3-7, 2002, eighteen pipe bombs were found in rural mailboxes in five Midwestern states in the U.S.A., collectively causing seven injuries and leading to widespread panic in the region. Most of the explosives came with typewritten notes that bemoaned the power of the government and threatened more attacks. In the incidents that occurred on May 4-5, 2002, seven bombs were found in mailboxes in the southern and central counties of Nebraska. None of these bombs detonated and no injuries were suffered. On May 7, 2002, the FBI and Nevada state authorities arrested Luke Helder, a 21-year-old college student, who confessed to being responsible for all of the bombs.

Threat assessment, mitigation, and response to terrorism are federal and state directives that work in conjunction with local law enforcement. Terroristic events are addressed at the federal level by the U.S. Department of Homeland Security and at the state level by the Nebraska Emergency Management Agency.

Average Annual Losses

The average damage per event estimate was determined based upon the START Global Terrorism Database information since 1970. This does not include losses from displacement, functional downtime, or economic loss. If a terrorist event were to occur in the planning area, damages can range from minimal (in rural areas, <$1 million) to significant (in metropolitan areas, >$10 million).

Table 70: Terrorism Incident 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
Terrorism	2	0.04	$0	$0	N/A	N/A

Source: 1 NCEI (1996-2019), 2 USDA RMA (2000-2019)

Extent

Terrorist attacks can vary greatly in scale and magnitude, depending on the location, method, and target of the attack. Previous terrorist attacks in the planning area have been limited to pipe bombs in mailboxes; however, local concerns have also been identified for community computer systems, rural water supplies, and equipment.

Probability

Given one year with a reported incident over the 48 years, the annual probability for terrorism in the planning area is stated as less than 1% annually. This does not indicate that a terrorist event will occur with that frequency within the planning area as terrorist events are typically clustered in timeframe due to extenuating circumstances.

Community Top Hazard Status

The following table lists jurisdictions which identified Severe Winter Storms as a top hazard of concern:

Jurisdictions	
City of Wilber	Superior Public Schools
South Central USD 5 (Lawrence-Nelson-Sandy Creek)	Tri-County Public Schools

Regional Vulnerabilities

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

Table 71: Regional Terrorism Vulnerabilities

SECTOR	VULNERABILITY
PEOPLE	-Police officers and first responders at risk of injury or death -Media personnel at risk
ECONOMIC	-Damaged businesses can cause loss of revenue and loss of income for workers -Agriculture attacks could cause significant economic losses for the region
BUILT ENVIRONMENT	-Targeted buildings may sustain heavy damage
INFRASTRUCTURE	-Water supply, power plants, utilities all at risk of damage
CRITICAL FACILITIES	-Police stations and governmental offices are at higher risk
CLIMATE	-Activism pertaining to climate can place first responders and residents at risk