# Wyoming Region 1

## Campbell County

## Crook County

## Johnson County

## Sheridan County

## Weston County

**Regional**
**Hazard Mitigation Plan**
**September 2018**

Developed by Campbell County, Crook County, Johnson County, Sheridan County and Weston County

With professional planning assistance from

Wood Environment & Infrastructure Solutions, Inc.
Hazard Mitigation and Emergency Management Program

# TABLE OF CONTENTS

## Chapters

## Jurisdictional Annexes



## Appendixes

# EXECUTIVE SUMMARY

This plan is the product of a 2017-2018 planning process undertaken by the five counties in Wyoming Office of Homeland Security Region 1 – Campbell, Crook, Johnson, Sheridan, and Weston Counties. The purpose is to meet the requirements of the Disaster Mitigation Act of 2000 (PL 106-390), and thereby maintain continued eligibility for certain Hazard Mitigation – or disaster loss reduction – programs from the Federal Emergency Management Agency (FEMA). This plan updates existing hazard mitigation plans for Campbell, Crook, Johnson, and Sheridan counties, and serves as a new hazard mitigation plan for Weston County.

The process followed a methodology that adheres to FEMA guidance for local hazard mitigation plans. It consisted of two levels of planning teams; a steering committee/coordinating planning team comprised of the Emergency Management Coordinators and local Hazard Mitigation Planning Committees for each county. Every municipality within each county was invited to participate.

The planning process examined the recorded history of losses resulting from natural hazards, and analyzed the future risks posed to each county by these hazards. A hazard identification and risk assessment was updated for the following hazards: dam failure, drought, earthquake, expansive soils, flood, hailstorm, hazardous materials, high winds, landslide, lightning, mine subsidence, tornadoes, severe winter storms and wildfire. Where applicable, these profiles were built on existing information found in the previous hazard mitigation plans. The hazards were assessed for geographic extent, potential magnitude probability, vulnerability and given a rating for overall significance. Drought, wildfire, floods and winter storms tend to cause the most damage or economic loss in the Region.

The plan's mitigation strategy includes goals for each county in the planning area. The plan also puts forth county-specific recommendations for mitigation, based on the risk assessment, that are designed to reduce future losses in each county and the Region. Lastly, the plan includes an implementation strategy to ensure the plan is carried out in practice.

# CHAPTER 1 INTRODUCTION

## 1.1 Purpose

Wyoming Region 1, encompassing Campbell, Crook, Johnson, Sheridan, and Weston Counties and their municipalities, prepared this regional hazard mitigation plan to guide hazard mitigation planning and to better protect the people and property of the planning area from the effects of hazard events. This plan demonstrates the region's commitment to reducing risks from hazards and serves as a tool to help decision makers direct mitigation activities and resources. This plan also maintains the eligibility of participating jurisdictions in the planning area for certain federal disaster assistance under the Federal Emergency Management Agency's (FEMA) Hazard Mitigation Assistance (HMA) grant programs.

## 1.2 Background and Scope

Each year in the United States, disasters take the lives of hundreds of people and injure thousands more. Nationwide, taxpayers pay billions of dollars annually to help communities, organizations, businesses, and individuals recover from disasters. These monies only partially reflect the true cost of disasters, because additional expenses to insurance companies and nongovernmental organizations are not reimbursed by tax dollars. Many disasters are predictable, and much of the damage caused by these events can be alleviated or even eliminated.

Hazard mitigation is defined by FEMA as "any sustained action taken to reduce or eliminate long-term risk to human life and property from a hazard event." The results of a three-year, congressionally mandated independent study to assess future savings from mitigation activities provides evidence that mitigation activities are highly cost-effective. On average, each dollar spent on mitigation saves society an average of $4 in avoided future losses in addition to saving lives and preventing injuries (National Institute of Building Science Multi-Hazard Mitigation Council 2005). An update to this report in 2017 (Natural Hazard Mitigation Saves: 2017 Interim Report) indicates that mitigation grants funded through select federal government agencies, on average, can save the nation $6 in future disaster costs for every $1 spent on hazard mitigation.

Hazard mitigation planning is the process through which hazards that threaten communities are identified, likely impacts of those hazards are determined, mitigation goals are set, and appropriate strategies to lessen impacts are developed, prioritized, and implemented. This plan documents the planning region's hazard mitigation planning process, identifies relevant hazards and risks, and identifies the strategies that each participating jurisdiction will use to decrease vulnerability and increase resiliency and sustainability.

This plan was prepared pursuant to the requirements of the Disaster Mitigation Act of 2000 (Public Law 106-390) and the implementing regulations set forth by the Interim Final Rule published in the *Federal Register* on February 26, 2002 (44 CFR §201.6) and finalized on October 31, 2007 (hereafter, these requirements and regulations will be referred to collectively as the Disaster Mitigation Act (DMA)). While the act emphasized the need for mitigation plans and more coordinated mitigation planning and implementation efforts, the regulations established the requirements that local hazard mitigation plans must meet in order for a local jurisdiction to be eligible for certain federal disaster assistance and hazard mitigation funding under the Robert T. Stafford Disaster Relief and Emergency Act (Public Law 93-288). Because the planning area is subject to many kinds of hazards, access to these programs is vital.

Information in this plan will be used to help guide and coordinate mitigation activities and decisions for local land use policy in the future. Proactive mitigation planning will help reduce the cost of disaster response and recovery to communities and property owners by protecting critical community facilities, reducing liability exposure, and minimizing overall community impacts and disruption. The jurisdictions in the planning area have been affected by hazards in the past and are thus committed to reducing future disaster impacts and maintaining eligibility for federal funding.

## 1.3 Plan Organization

The Wyoming Region 1 Regional Hazard Mitigation Plan is organized in alignment with the DMA planning requirements and the FEMA plan review crosswalk:

- Chapter 1: Introduction
- Chapter 2: Community Profile
- Chapter 3: Planning Process
- Chapter 4: Risk Assessment
- Chapter 5: Mitigation Strategy
- Chapter 6: Plan Adoption, Implementation, and Maintenance
- County Annexes
- Appendices

### *County Annexes*

Each of the five counties has its own annex, which provides a more detailed assessment of that jurisdiction's unique risks as well as their mitigation strategy to reduce long-term losses. Each annex contains the following:

- Community profile summarizing geography and climate, history, economy, and population
- More detailed hazard vulnerability information and unique risks by jurisdiction, where applicable, for geographically specific hazards
- Hazard map(s) at an appropriate scale for the jurisdiction, if available
- Number and value of buildings, critical facilities, and other community assets located in hazard areas, if available

- A capability assessment describing existing regulatory, administrative, and technical resources
- Mitigation actions specific to the county and municipalities

## 1.4 Multi-Jurisdictional Planning

This plan was prepared as a regional, multi-jurisdictional plan. The planning region is comprised of five counties in Wyoming Region 1 (region), as established by the Wyoming Office of Homeland Security (WOHS); the region includes Campbell, Crook, Johnson, Sheridan, and Weston Counties. All local units of government in each county were invited to participate in the planning process; the decision whether or not to participate in this process was a local decision, based on local community needs. Communities have the option to not prepare a plan, to prepare a stand-alone plan for their jurisdiction, or to participate in a multi-jurisdiction or county-wide plan. Four of the five counties in the region had previous county-wide hazard mitigation plans prior to the development of this Regional Plan; Weston County was the only one that did not have a previous hazard mitigation plan. The following table lists counties and their local governments that have opted to participate in this effort and are seeking FEMA approval of the 2018 version of this plan. Changes in participation since the original planning updates are noted. Additional details about participation can be referenced in Chapter 3 and the county annexes.

**Table 1-1 Multi-Jurisdictional Participation 2018**

| Jurisdiction | Participation Status |
|---|---|
| **Campbell County** | Participated in 2016 plan and 2018 update |
| City of Gillette | Participated in 2016 plan and 2018 update |
| Town of Wright | Participated in 2016 plan and 2018 update |
| **Crook County** | |
| City of Sundance | Participated in 2013 plan and 2018 update |
| Town of Hulett | Participated in 2013 and 2018 update |
| Town of Moorcroft | Participated in 2013 and 2018 update |
| Town of Pine Haven | Participated in 2013 and 2018 update |
| **Johnson County** | |
| City of Buffalo | Participated in 2013 and 2018 update |
| Town of Kaycee | Participated in 2013 and 2018 update |
| **Sheridan County** | |
| City of Sheridan | Participated in 2014 and 2018 update |
| Town of Clearmont | Participated in 2014and 2018 update |
| Town of Dayton | Participated in 2014 and 2018 update |
| Town of Ranchester | Participated in 2014 and 2018 update |
| **Weston County** | No Previous plan - Participated in 2018 plan creation |
| City of Newcastle | No Previous plan - Participated in 2018 plan creation |

| Jurisdiction | Participation Status |
| --- | --- |
| Town of Upton | No Previous plan - Participated in 2018 plan creation |

# CHAPTER 2 COMMUNITY PROFILE

This section provides a brief overview of the geography of the planning area. Additional geographic profiles of the participating jurisdictions are provided in the annexes.

## 2.1 Geography and Climate

Wyoming Region 1 is comprised of five counties in the northeast corner of the state; the five counties are Campbell, Crook, Johnson, Sheridan and Weston. The region stretches from the Big Horn Mountains eastward to the Black Hills along the South Dakota border. It is bordered in the north by the State of Montana; in the east by the State of South Dakota; in the south by Wyoming's Converse, Natrona, and Niobrara counties (Region 2), and in the west by Wyoming's Big Horn and Washakie Counties (Region 6).

The region covers 16,773 square miles (10,734,556 acres). The highest point in the region is Cloud Peak in the Big Horn Mountains on the western edge of Johnson County, at 13,171 feet; the region's lowest point is 3,099 feet in the northeast corner of Crook County where the Belle Fourche River flows into South Dakota, which is also the lowest point in the state. Most of the area between those two extremes consists of rolling grasslands between 3,000 and 4,500 feet.

The major rivers in the region include the Tongue River, Powder River, Belle Fourche River, and Little Missouri River. Major highways include Interstates 25 and 90; US Highways 14, 16, 85 and 212; and state highways 50, 59, 24, 112, 116, 387, 450, and 585. Multiple rail lines cross the region as well.

Overall the region averages 31 days per year with temperatures above 90°F; during summer months, the average maximum temperature is 83.4°F, with a record high of 108°F. Growing season typically lasts 120-140 days a year. By contrast, the region averages 188 days a year with temperatures below 32°F; during winter months, the average minimum temperature is 10.4°F, with a record low of -46°F. The region averages 17.14 inches of precipitation per year, 71% of which falls in April through September. The average seasonal snowfall is 65 inches.

A base map of the planning region is illustrated in Figure 2-1. Details of land type and ownership can be found in Table 2-1 through Table 2-3.

## Figure 2-1 Wyoming Region 1

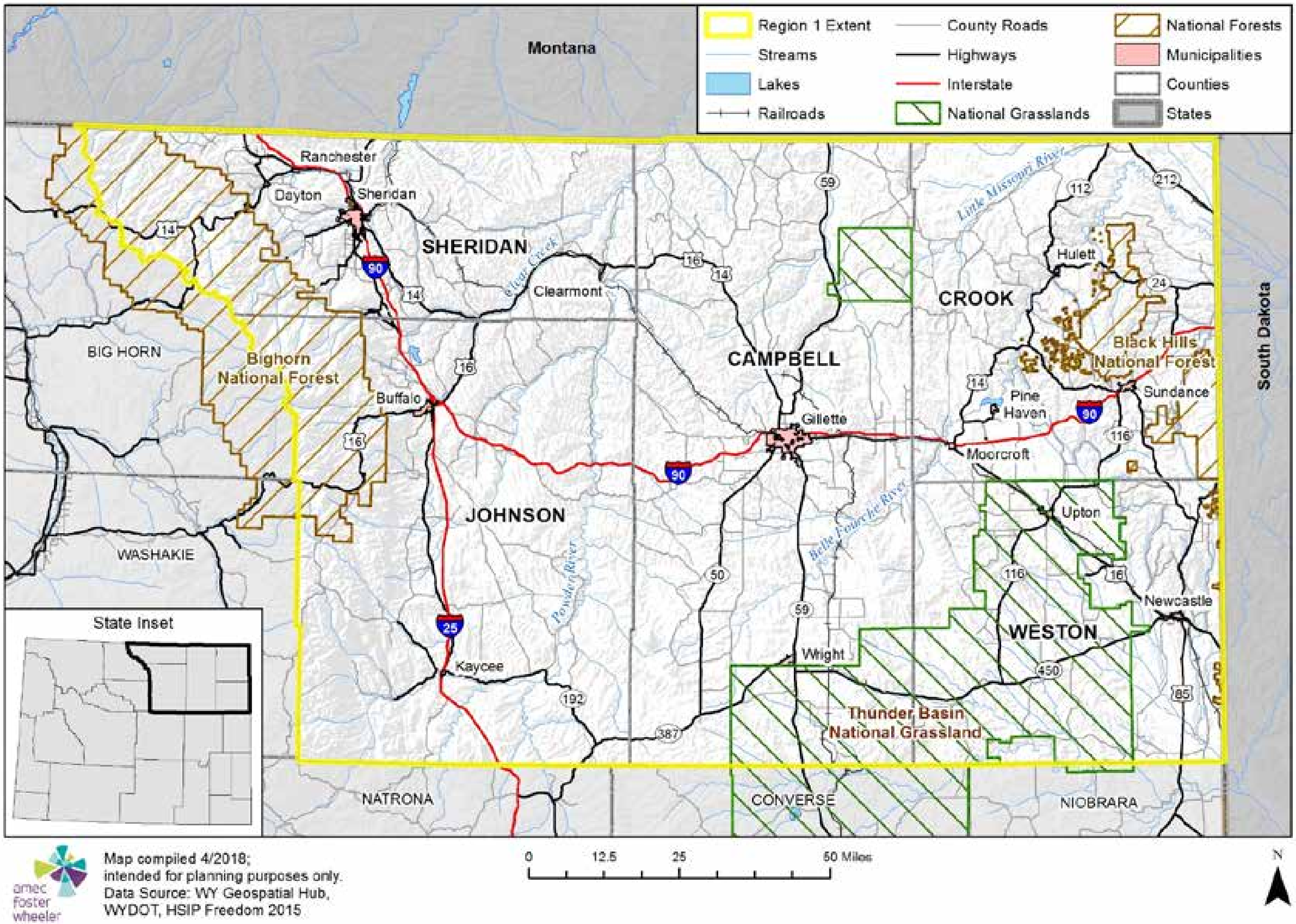


**Table 2-1 Region 1 Land Types**

| Land Type | Acreage | Percentage |
|---|---:|---:|
| Total Acres (2006) | 10,734,556 | |
| Grassland | 8,592,028 | 80.0% |
| Forest | 804,323 | 7.5% |
| Shrubland | 721,173 | 6.7% |
| Mixed Cropland | 360,123 | 3.4% |
| Other | 41,808 | 0.4% |
| Water | 9,868 | 0.1% |
| Urban | 3,705 | 0.0% |

Source: NASA MODIS Land Cover Type Yearly L3 Global 1km MOD12Q1, 2006.

**Table 2-2 Region 1 Land Ownership**

| Land Ownership | Acreage | Percentage |
|---|---:|---:|
| Total Acres | 10,734,556 | --- |
| Private Lands | 7,695,711 | 71.7% |
| *Conservation Easement* | *93,351* | *0.9%* |
| Federal Lands | 2,257,290 | 21.0% |
| *Forest Service* | *1,300,082* | *12.1%* |
| *BLM* | *940,016* | *8.8%* |
| *National Park Service* | *1,348* | *0.0%* |
| *Military* | *0* | *0.0%* |
| *Other Federal* | *15,844* | *0.1%* |
| State Lands | 778,548 | 7.3% |
| *State Trust Lands** | *750,196* | *7.0%* |
| *Other State* | *28,352* | *0.3%* |
| Tribal Lands | 53 | 0.0% |
| City, County, Other | 2,954 | 0.0% |

Source: U.S. Geological Survey, Gap Analysis Program. 2016. Protected Areas Database of the United States (PADUS)

**Table 2-3 Region 1 Residential Land Use**

| Residential Land | 2000 | 2010 | % increase |
|---|---:|---:|---:|
| Total Residential (acres) | 56,895 | 83,758 | 47% |
| Urban/Suburban | 9,590 | 12,513 | 30% |
| Exurban | 47,304 | 71,243 | 51% |

Source: Theobald, DM. 2013. Land use classes for ICLUS/SERGoM v2013. Unpublished report, Colorado State University.

## 2.2 Population

Table 2-4 describes the population distribution and change for the region and its individual counties. 47% of the region's population lives in Campbell County, 30% in Sheridan County, and the remaining 23% distributed between the other three counties. Table 2-5shows how the region's population has changed since the 2010 Census. As a whole, the Region increased in population by 1%, below the state's overall growth of 3%. However, this rate varies widely across the region, with Crook County experiencing 5% growth, while Weston County lost an estimated 4% of their population. Moreover, the region experienced an overall growth of 4% from 2010 through 2015, after which the population declined to its current level.

## Table 2-4 Region 1 Population Distribution

| Jurisdiction | 2017 Estimated Population | % of Region Total |
|---|---|---|
| Campbell County | 46,242 | 47% |
| Crook County | 7,410 | 7% |
| Johnson County | 8,476 | 9% |
| Sheridan County | 30,210 | 30% |
| Weston County | 6,927 | 7% |
| **Region 1 Total** | **99,265** | **---** |

Source: US Census Bureau

## Table 2-5 Region 1 Population Change 2010-2017

| Jurisdiction | 2010 Census | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | % change |
|---|---|---|---|---|---|---|---|---|---|
| Campbell County | 46,133 | 46,560 | 47,861 | 48,051 | 48,192 | 49,293 | 48,800 | 46,242 | 0% |
| Crook County | 7,083 | 7,123 | 7,141 | 7,153 | 7,245 | 7,432 | 7,497 | 7,410 | 5% |
| Johnson County | 8,569 | 8,645 | 8,637 | 8,637 | 8,584 | 8,616 | 8,496 | 8,476 | -1% |
| Sheridan County | 29,116 | 29,254 | 29,528 | 29,735 | 29,888 | 29,940 | 30,049 | 30,210 | 4% |
| Weston County | 7,208 | 7,141 | 7,074 | 7,136 | 7,142 | 7,181 | 7,198 | 6,927 | -4% |
| **Region 1 Total** | **98,109** | **98,723** | **100,241** | **100,712** | **101,051** | **102,462** | **102,040** | **99,265** | **1%** |

Source: US Census Bureau

## Table 2-6 Region 1 Demographic Profile

| | |
|---|---|
| ***Population*** | |
| Population estimate, 2017 | 99,265 |
| ***Age and Sex*** | |
| Median Age (US median age is 37.7) | 43.1 |
| Percent of population under 18 | 25.0% |
| Percent of population 18-34 | 21.6% |
| Percent of population 35-44 | 12.8% |
| Percent of population 45-64 | 27.7% |
| Percent of population 65 and over | 13.0% |
| Percent of population male | 51% |
| Percent of population female | 49% |
| **Race and Ethnicity** | |
| White alone | 94.5% |
| Black or African American alone | 0.7% |
| American Indian alone | 1.4% |
| Asian alone | 0.9% |
| Native Hawaiian & Other Pacific Islander alone | 0.0% |
| Some other race alone | 0.8% |
| Two or more races | 1.8% |
| White alone, not Hispanic or Latino | 90.2% |
| Hispanic or Latino (of any race) | 5.6% |
| ***Education*** | |
| High school graduate or higher, age 25 years+ | 92.8% |

| | |
|---|---|
| Bachelor's degree or higher, age 25 years+ | 23.2% |
| **Vulnerable Populations** | |
| Percent of population under 5 years old | 6.8% |
| Percent of population 80 years and older | 1.6% |
| Percent of population that speak English "not well" | 0.8% |
| Percent of population with disabilities | 11.2% |
| Percent of population without health insurance | 11.1% |
| Percent of population in poverty | 8.3% |
| Percent of population in deep-poverty (<1/2 federal poverty level) | 3.9% |
| Percent of population over 65 and in poverty | 1.0% |

Source: U.S. Census Bureau, American Factfinder, https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml

*Hispanic or Latino is considered an ethnicity, not a race. People who identify as Hispanic or Latino can belong to one or more races. Therefore, the total percentage can be greater than 100%.

## 2.3 Economy

Region 1 has a diverse economy: 50% of workers in the region are employed in the service sector, led by the retail trade; accommodation and food services; real estate; and health care. 26.1% of workers are employed in non-service jobs, with mining being the largest employer, followed by construction. The remaining 23.9% work in government sector jobs, primarily city and county government.

The number of jobs in the region grew by 138% from 1970 to 2000, and by another 32% since 2000. The largest increases were in construction; retail trade; finance, insurance and real estate; and mining jobs. Both mining and construction jobs, however, have declined sharply since 2010.

On average, job growth has kept pace with the region's population growth. The last few decades saw the region's unemployment rate decline gradually from 4.9% in 1990 to 2.5% in 2008; the Great Recession sent the county's unemployment rate as high as 6.3%. In the years since then, unemployment has dropped to 4.4%, the same as the national average.

The region's per capita income is $49,176, slightly below the national average of $50,280. Overall, per capita income grew by 64% from 1970 to 2000, and by another 19.5% from 2000 to 2016. Income from non-labor sources such as rents, dividends, or retirement income is 35.9% of total, which is close to the national average of 36.8%. 8.3% of county's population is below the poverty level, slightly below the national average of 15.1%.

**Table 2-7 Region 1 Economic Profile**

| Characteristic | Region 1 | Campbell County | Crook County | Johnson County | Sheridan County | Weston County |
|---|---|---|---|---|---|---|
| EMPLOYMENT | | | | | | |
| Total Employment, 2016 | 69,985 | 34,568 | 4,552 | 6,095 | 20,698 | 4,072 |
| Unemployment Rate, as of 2017 (US average: 4.4%) | 4.4% | 5.0% | 3.5% | 4.2% | 3.9% | 4.0% |
| Per capita income, 2016 (US average is $50,280) | $49,176 | $49,526 | $41,498 | $44,359 | $53,384 | $42,828 |
| Average earning per job, 2016 (US average: $59,598) | $53,816 | $66,148 | $38,438 | $35,681 | $44,195 | $42,359 |

| Characteristic | Region 1 | Campbell County | Crook County | Johnson County | Sheridan County | Weston County |
|---|---|---|---|---|---|---|
| Population % change, 1970-2016 (US ave: 58.6%) | 116.0% | 274.0% | 64.8% | 51.2% | 69.0% | 15.5% |
| Employment % change, 1970-2016 (US ave: 112.2%) | 215.8% | 473.6% | 118.4% | 130.9% | 144.7% | 38.0% |
| Personal Income % change, 1970-2016 (US ave: 201.1%) | 323.5% | 733.5% | 206.7% | 192.9% | 211.9% | 106.5% |
| Persons in poverty (US average is 15.1%) | 8.3% | 8.1% | 6.1% | 5.9% | 8.2% | 14.7% |
| Families in poverty (US average is 11.0%) | 5.7% | 5.5% | 5.2% | 2.2% | 5.1% | 13.3% |
| | | | | | | |
| EMPLOYERS | | | | | | |
| Total employer establishments, 2016 | 3,570 | 1,460 | 237 | 467 | 1,178 | 228 |
| Total annual payroll, 2016 ($1000) | $1,743,057 | $1,159,296 | $70,676 | $81,647 | $372,283 | $59,155 |
| Paid employees | 36,493 | 20,636 | 1,503 | 2,341 | 10,392 | 1621 |
| | | | | | | |
| EMPLOYMENT BY SECTOR/INDUSTRY | | | | | | |
| Total Private | 76.1% | 79.9% | 69.3% | 68.3% | 73.9% | 65.5% |
| Non-Services | 26.1% | 33.6% | 29.2% | 15.3% | 15.2% | 19.9% |
| Natural Resources and Mining | 15.4% | 23.6% | 12.8% | 6.4% | 3.8% | 7.2% |
| Ag., Forestry, Fishing, Hunting | 1.0% | 0.3% | 2.4% | 1.8% | 2.0% | 1.7% |
| Mining | 14.3% | 23.4% | 10.4% | 4.6% | 1.9% | 5.5% |
| Construction | 8.0% | 8.2% | 9.0% | 7.3% | 8.1% | 6.3% |
| Manufacturing (Incl. Forest Prod.) | 2.7% | 1.8% | 7.4% | 1.6% | 3.2% | 6.4% |
| Services | 50.0% | 46.3% | 40.1% | 53.0% | 58.7% | 45.6% |
| Trade, Transportation, Utilities | 19.1% | 20.4% | 18.5% | 15.3% | 17.6% | 19.0% |
| Information | 1.0% | 0.9% | na | 0.9% | 1.3% | 1.2% |
| Financial Activities | 3.4% | 2.8% | 2.7% | 4.3% | 4.4% | 2.6% |
| Professional and Business | 6.0% | 6.3% | 2.7% | 4.8% | 6.9% | 8.8% |
| Education and Health | 6.6% | 4.2% | 3.6% | 6.0% | 11.1% | 2.9% |
| Leisure and Hospitality | 11.1% | 9.1% | 11.1% | 17.7% | 13.8% | 9.8% |
| Other Services | 2.8% | 2.5% | na | 4.0% | 3.6% | 1.4% |
| Unclassified | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Government | 23.9% | 20.1% | 30.7% | 31.7% | 26.2% | 34.4% |
| Federal Government | 2.4% | 0.3% | 3.9% | 4.1% | 5.6% | 2.4% |
| State Government | 1.8% | 0.7% | 3.0% | 3.6% | 2.5% | 6.6% |
| Local Government | 19.6% | 19.1% | 23.8% | 24.0% | 18.0% | 25.5% |
| Travel & Tourism related jobs as a percentage of total private employment | 17.0% | 11.8% | 17.6% | 25.4% | 25.4% | 16.4% |
| | | | | | | |
| HOUSEHOLD INCOME | | | | | | |
| Total Households | 40,009 | 17,534 | 2,976 | 3,668 | 12,697 | 3,134 |
| Less than $10,000 | 4.3% | 3.3% | 5.6% | 9.1% | 3.7% | 6.2% |

| Characteristic | Region 1 | Campbell County | Crook County | Johnson County | Sheridan County | Weston County |
|---|---|---|---|---|---|---|
| $10,000 to $14,999 | 4.9% | 3.6% | 2.8% | 4.8% | 6.2% | 9.4% |
| $15,000 to $24,999 | 8.3% | 6.5% | 5.7% | 5.5% | 11.3% | 11.3% |
| $25,000 to $34,999 | 8.2% | 6.9% | 8.9% | 10.5% | 9.1% | 8.0% |
| $35,000 to $49,999 | 12.6% | 8.7% | 16.5% | 16.1% | 16.3% | 11.8% |
| $50,000 to $74,999 | 18.0% | 17.1% | 21.6% | 18.0% | 19.1% | 15.3% |
| $75,000 to $99,999 | 15.8% | 17.5% | 15.4% | 16.9% | 13.2% | 16.5% |
| $100,000 to $149,999 | 18.4% | 24.5% | 15.4% | 10.2% | 14.3% | 13.8% |
| $150,000 to $199,999 | 6.2% | 7.9% | 3.5% | 6.1% | 5.0% | 4.3% |
| $200,000 or more | 3.2% | 4.1% | 5.6% | 9.1% | 3.7% | 3.3% |
| Median household income | $66,380 | $80,822 | $60,307 | $54,594 | $53,914 | $55,640 |
| Median monthly mortgage cost (US ave: $1,491) | $1,444 | $1,520 | $1,355 | $1,406 | $1,403 | $1,213 |
| Median monthly rent (US ave: $949) | $853 | $947 | $736 | $871 | $758 | $762 |
| Mean Annual Household Earnings by Source, 2016 | | | | | | |
| Labor earnings | 82.1% | 89.1% | 79.2% | 75.8% | 76.8% | 74.0% |
| Social Security | 27.6% | 16.9% | 32.6% | 37.2% | 36.5% | 35.9% |
| Retirement income | 16.5% | 10.5% | 18.0% | 16.8% | 23.4% | 20.6% |
| Supplemental Security Income | 3.0% | 3.1% | 2.2% | 2.2% | 3.3% | 3.0% |
| Cash public assistance income | 1.6% | 1.5% | 1.0% | 3.9% | 1.4% | 1.3% |
| Food Stamp/SNAP | 3.7% | 3.2% | 1.6% | 4.0% | 4.0% | 7.1% |

Source: U.S. Census Bureau, American Factfinder, https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml

# CHAPTER 3 PLANNING PROCESS

**Requirements §201.6(b) and §201.6(c)(1): An open public involvement process is essential to the development of an effective plan. In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process shall include:**

1) **An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval;**
2) **An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia, and other private and nonprofit interests to be involved in the planning process; and**
3) **Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.**

**[The plan shall document] the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how the public was involved.**

## 3.1 Background on Mitigation Planning in Region 1

While Region 1 has never had a regional hazard mitigation plan prior to 2018, four counties in the region have adopted county-specific hazard mitigation plans over the years. Campbell, Crook, Johnson and Sheridan Counties each had approved county-specific plans; this Regional Plan builds upon and updates those efforts. This plan represents the first official hazard mitigation plan for Weston County, including the incorporated municipalities within the County. The following is a short description of those prior planning efforts.

**Campbell County.** Campbell County began the local hazard mitigation planning process in the Spring of 2015. The Local Emergency Planning Team (LPT) met three times to review, analyze, and evaluate the information in the existing mitigation plan. Both incorporated communities in the County, the City of Gillette and the Town of Wright, participated in the planning process. The Campbell County Multi-Hazard Mitigation Plan was approved in 2016.

**Crook County.** The planning process for the Crook County Multi-Hazard Mitigation began in October 2012. The process was initiated with the contractor and emergency management coordinator meeting with the three county commissioners to explain the planning process. This meeting was followed by meetings with the Local Emergency Planning Commission (LEPC) to review and evaluate existing information and clarifying the purpose and process of the County Hazard Mitigation Plan, and meeting with the County Planner to understand existing plans and future development trends. Public meetings with the incorporated communities were also held at the county seat. The Crook County Multi-Hazard Mitigation Plan was approved in 2013.

**Johnson County.** As part of the process to update the Johnson County hazard mitigation plan the LEPC reviewed the existing plan and identified new information that should be included in the Plan Update. The commission was also tasked with collecting accurate data from plan participants and providing opportunities for outreach to the public and business stakeholders. Throughout the planning process the Johnson County LEPC met six times, four of which were open to the public. The Johnson County Multi-Jurisdictional Hazard Mitigation Plan Update was approved in 2013.

**Sheridan County.** The planning team for the 2013 Sheridan County Multi-Hazard Mitigation Plan update began with the review of the planning process that took place in 2009; the team agreed to follow the same process for the 2013 update. There was a Core Planning Group consisting of the local, state, and federal stakeholders, led by the Sheridan County Emergency Management Office. Flood and wildfire teams were identified at the kick-off meeting. All participating jurisdictions were represented in each of the planning teams. The Sheridan County Multi-Hazard Mitigation Plan was approved in 2014.

**Regional Planning.** In Wyoming, the Wyoming Office of Homeland Security (WOHS) utilizes a regional support structure to assist the counties with all aspects of emergency management, including planning. Region 1 comprises of Campbell, Crook, Johnson, Sheridan and Weston Counties. In 2016, the WOHS began the process of initiating the development of regional hazard mitigation plans statewide. This initiative recognized that the process of facilitating and developing or updating multi-jurisdictional hazard mitigation plans compliant with the Disaster Mitigation Act of 2000 is often beyond local capabilities and expertise. Instead of each county hiring consultants, the WOHS took the lead in procuring and funding a professional hazard mitigation planning consultant through a competitive bid process. Wood Environment and Infrastructure, Inc. (Wood – formally known as Amec Foster Wheeler) of Boulder, Colorado was selected in 2017 to provide assistance to the Region.

Prior to initiating the development of this regional multi-jurisdictional hazard mitigation plan in 2017, a substantial coordination effort took place to ensure the participation of all counties within Region 1. The WOHS received letters of commitment from each county (copies included in Appendix A) indicating their interest in and willingness to participate in the regional planning process. Each county has an Emergency Management Coordinator, who was designated as the primary point of contact. Each Coordinator assumed a coordination role within their respective counties to help fulfill Disaster Mitigation Act of 2000 (DMA) planning requirements. The county Emergency Management Coordinators then contacted each of the incorporated communities, offering them the opportunity to participate in the development of the Region 1 Hazard Mitigation Plan. All of the incorporated communities within the counties chose to participate in the development of this Regional Plan. One special district, the Campbell County Conservation District, also participated as a jurisdiction during the 2017-18 regional planning process.

Each Emergency Management Coordinator led Hazard Mitigation Planning Committees (HMPCs) working in concert with the hazard mitigation planning consultant. As the planning consultant, Wood's role was to:

- Provide guidance on a planning organization for the entire planning area representative of the participants;
- Ensure the plan meets all the DMA requirements as established by federal regulations, following FEMA's most recent planning guidance;
- Facilitate the entire planning process;
- Identify the data requirements that the participating counties and municipalities could provide, and conduct the research and documentation necessary to augment that data;
- Develop and help facilitate the public input process;
- Produce the draft and final plan documents; and
- Ensure acceptance of the final Plan by WOHS and FEMA Region VIII

## 3.2 Government Participation

The DMA planning regulations and guidance stress that each local government seeking FEMA approval of their mitigation plan must participate in the planning effort in the following ways:

- Participate in the process as part of the Hazard Mitigation Planning Committee (HMPC);
- Detail areas within the planning area where the risk differs from that facing the entire area;
- Identify specific projects to be eligible for funding; and
- Have the governing board formally adopt the plan.

For the Region 1 Multi-Hazard Mitigation Plan's HMPC, "participation" meant:

- Attending and participating in HMPC meetings and workshops;
- Establishing or reconvening a local steering committee;
- Providing available data requested by the HMPC coordinator and Wood;
- Providing and updating the hazard profile and vulnerability details specific to jurisdictions;
- Developing, updating and providing input on the local mitigation strategy (action items and progress);
- Advertising and assisting with the public input process;
- Reviewing and commenting on plan drafts; and
- Coordinating the formal adoption of the plan by the governing boards.

This Regional Plan includes the participation of all counties and every municipality in Region 1 as noted in Chapter 1 and detailed further in Section 3.3.1. Documentation of participation is included in Appendix A in the form of meeting sign in sheets, meeting summaries, and more.

## 3.3 The 10-Step Planning Process

Wood established the planning process for the Region 1 plan using the DMA planning requirements and FEMA's associated guidance. This guidance is structured around a four-phase process:

1) Organize Resources
2) Assess Risks
3) Develop the Mitigation Plan
4) Implement the Plan and Monitor Progress

Into this four-phase process, Wood integrated a more detailed 10-step planning process used for FEMA's Community Rating System (CRS) and Flood Mitigation Assistance (FMA) programs. Thus, the modified 10-step process used for this plan meets the requirements of six major programs: FEMA's Hazard Mitigation Grant Program, Pre-Disaster Mitigation program, Community Rating System, Flood Mitigation Assistance Program, Severe Repetitive Loss program, and new flood control projects authorized by the U.S. Army Corps of Engineers. FEMA's March 2013 *Local Mitigation Planning Handbook* recommends a nine-task process within the four-phase process. Table 3.1 summarizes the four-phase DMA process, the detailed CRS planning steps and work plan used to develop the plan, the nine handbook planning tasks from FEMA's 2013 *Local Mitigation Planning Handbook*, and where the results are captured in the Plan. The sections that follow describe each planning step in more detail.

**Table 3.1 Mitigation Planning Process Used to Develop the Regional Hazard Mitigation Plan**

| FEMA 4 Phase Guidance | Community Rating System (CRS) Planning Steps (Activity 510) and Wood Work Plan Steps | FEMA Local Mitigation Planning Handbook Tasks (44 CFR Part 201) | Location in Plan |
|---|---|---|---|
| Phase I: Organize Resources | Step 1. Organize Resources | 1: Determine the Planning Area and Resources | Chapters 1, 2 and 3 |
| | | 2: Build the Planning Team 44 CFR 201.6(c)(1) | Chapter 3, Section 3.3.1 |
| | Step 2. Involve the Public | 3: Create an Outreach Strategy 44 CFR 201.6(b)(1) | Chapter 3, Section 3.3.1 |
| | Step 3. Coordinate with Other Agencies | 4: Review Community Capabilities 44 CFR 201.6(b)(2) & (3) | Chapter 3, Section 3.3.1 and Annexes |
| Phase II: Assess Risks | Step 4. Assess the Hazard | 5: Conduct a Risk Assessment 44 CFR 201.6(c)(2)(i) 44 CFR 201.6(c)(2)(ii) & (iii) | Chapter 4 and Annexes |
| | Step 5. Assess the Problem | | Chapter 4 and Annexes |

| FEMA 4 Phase | Community Rating System | FEMA Local Mitigation | Location in Plan |
|---|---|---|---|
| Phase III: Develop the Mitigation Strategy | Step 6. Set Goals | 6: Develop a Mitigation Strategy 44 CFR 201.6(c)(3)(i); 44 CFR 201.6(c)(3)(ii); and 44 CFR 201.6(c)(3)(iii) | Chapter 5, Section 5.2 |
| | Step 7. Review Possible Activities | | Chapter 5, Section 5.3 |
| | Step 8. Draft an Action Plan | | Chapter 5, Section 5.4 and Annexes |
| Phase IV: Adopt and Implement the Plan | Step 9. Adopt the Plan | 8: Review and Adopt the Plan | Chapter 6 |
| | Step 10. Implement, Evaluate, Revise | 7: Keep the Plan Current | Chapter 6 |
| | | 9: Create a Safe and Resilient Community 44 CFR 201.6(c)(4) | Chapter 6 |

## 3.3.1 Phase 1: Organize Resources

### Planning Step 1: Organize the Planning Effort

With each jurisdiction's commitment to develop a Regional Plan, Wood worked with WOHS and each county coordinator to establish the framework and organization for the process. Organizational efforts were initiated with each county to inform and educate the plan participants of the purpose of and need for a regional hazard mitigation plan. During the development of this Regional Plan, the planning process was directed through a regional planning committee comprised of Campbell County Emergency Management, Crook County Emergency Management, Johnson County Emergency Management, Sheridan County Emergency Management, and Weston County Emergency Management Coordinators, as well as participating jurisdictions. The planning consultant held an initial Uberconference call/webinar to discuss the organizational aspects of the planning process with the county coordinators. Using FEMA's planning guidance, representative participants for each county's HMPC base membership were established, with additional invitations extended as appropriate to other federal, state, and local stakeholders and the public throughout the planning process. The list of agencies and individuals invited to participate is provided in the following table. More details with documentation of participation included are in Appendix A.

Early in the planning process, a coordination conference call occurred on December 19, 2017 prior to the planning process kick-off to ensure planning requirements (were understood. Participants on this call included the county Emergency Management Coordinators, FEMA Region VIII, Wood, and the Wyoming Office of Homeland Security.

**Table 3.2 HMPC Members and Stakeholders by County**

| **Campbell County** |
|---|

| Jurisdictions and Stakeholders | Representatives |
|---|---|
| **Campbell County** | County Emergency Management Coordinator |
| | Director of Public Works |
| | Director of County Parks and Recreation |
| | Project Development, Campbell County Public Health |
| | Lieutenant, Campbell County Sheriff's Office |
| | GIS Analyst, Campbell County Surveying/GIS Dept. |
| | Director, Campbell County Road & Bridge Dept. |
| | Campbell County School District |
| **City of Gillette** | Lieutenant, City of Gillette Police Department |
| | City Planner/GIS Manager |
| | Gillette Chambers of Commerce |
| | City Council Elect |
| | Civil Engineer, City of Gillette |
| | Streets Manager, City Streets Department |
| | Solid Waste Manager, City of Gillette |
| **Town of Wright** | Town Mayor |
| | Town Clerk |
| **Campbell County Conservation District** | Program Assistant |
| **State and Other Local Agencies** | Wyoming Office of Homeland Security |
| | Wyoming Department of Transportation |
| | Wyoming State Forestry |
| **Federal Agencies** | Hydrologist, National Weather Service |
| | Warning Coord. Meteorologist, National Weather Service |
| | District Conservationist, Natural Resources Conservation |
| **Crook County** | |
| **Jurisdictions and Stakeholders** | **Representatives** |
| **Crook County** | County Emergency Management Coordinator |
| | Undersheriff, Crook County Sheriff Office |
| **Town of Hulett** | Town Emergency Manager/Volunteer Fire District |
| | Chief, Hulett Police Department |
| | Emergency Manager |
| **Town of Moorcroft** | Chief, Moorcroft Fire Department |
| | Emergency Manager/Police Chief |
| **Town of Pine Haven** | Chief, Pine Haven Volunteer Fire District |
| **Town of Sundance** | Paramedic, Sundance EMS, Chief of Police |
| **State or Local Agency Stakeholders** | Wyoming Office of Homeland Security |
| | Superintendent, Keyhole State Park |

| | |
|---|---|
| | Public Health Response Coordinator, Crook County Public Health, Wyoming Department of Health |
| **Private Industry/Stakeholders** | Sales/Safety, Blakeman Propane |
| **Johnson County** | |
| **Jurisdictions and Stakeholders** | **Representatives** |
| **Johnson County** | County Commissioner |
| | County Emergency Management Coordinator |
| | County GIS Analyst/Planner |
| | County Planner |
| | County Assessor |
| | Sheriff |
| | Supervisor, Road and Bridge Department |
| **Town of Kaycee** | Mayor of Kaycee |
| | Town Councilman |
| | Director of Public Works Department |
| **Town of Buffalo** | Mayor of Buffalo |
| | Public Works Department |
| **Sheridan County** | |
| **Jurisdictions and Stakeholders** | **Representatives** |
| **Sheridan County** | County Emergency Management Coordinator |
| | County Sheriff |
| | County Planner |
| | County Engineer |
| | County GIS |
| | County Commissioner |
| | County Public Health |
| | Chief, Fire Rescue |
| | Chief, Police Department |
| | Fire Warden, Fire Rescue |
| | Chairman, LEPC |
| | Facilities, Sheridan County School District #2 |
| **City of Sheridan** | Mayor |
| **Town of Clearmont** | Mayor |
| **Town of Ranchester** | Mayor |
| **Town of Dayton** | Mayor |
| **State or Local Agencies Stakeholders** | Public Health Response Coordinator, Sheridan County Public Health, Wyoming Department of Health |
| | CERT |
| | District Forester/Mitigation Coordinator, Firewise |

| | |
|---|---|
| | Wyoming |
| **Private Industry/Stakeholders** | Director, Sheridan Hospital |
| | Safety, AmeriGas Propane |
| | CFO, Farmers CO-OP Oil Company |
| | Field Operations Supervisor, Montana – Dakota Utilities |
| **Weston County** | |
| **Jurisdictions and Stakeholders** | **Representatives** |
| **Weston County** | Emergency Management Coordinator, Department of Homeland Security |
| | County Assessor |
| | Secretary/Treasurer, County Sheriff, and Search & Rescue |
| | County Sheriff Office |
| | County Commissioner |
| **City of Newcastle** | City Clerk/Treasurer |
| **Town of Upton** | Town Clerk/Treasurer |
| **Private Industry/Stakeholders** | Owner, Alpha Communications |

Each Emergency Management Coordinator, with assistance from Wood, identified key county, municipal and other local government and stakeholder representatives. Letters of invitation were mailed to invite them to participate as members of the HMPC, and to attend a series of planning workshops. During the plan development process, communication amongst the county planning teams occurred through a combination of face-to-face meetings, monthly conference calls, a web-based meeting, phone interviews, and mail and email correspondence. Following the initial kickoff Uberconference call/webinar on January 17, 2018, two planning workshops with each county HMPC were held during the plan's development, in February and May 2018. The meeting schedule and topics are listed below. In addition, monthly conference calls were held with the Emergency Management Coordinators, Wyoming OHS, and Wood to discuss the process including upcoming milestones and information needs. The sign-in sheets and agendas for each of the meetings are included in Appendix A. Due to scheduling conflicts in limited cases some municipalities were not able to attend the planning workshops. Emergency Management Coordinators worked with the jurisdictions individually in these cases to obtain necessary information and input into the planning process.

## Kickoff Meeting

A mix of individuals representing counties, municipalities, and the state were present at the kickoff Uberconference/webinar. During the meeting, Wood presented information on the scope and purpose of the plan update, participation requirements of HMPC members, and the proposed project work plan and schedule. Plans for public involvement (Step 2) and coordination with other agencies and departments (Step 3) were discussed. The HMPC reviewed the hazard identification information for each county and the Region and refined the list of identified hazards to mirror that of the Wyoming Hazard Mitigation Plan. In follow-up to the meeting, participants were provided a Geographic Information Systems (GIS) data needs worksheet to facilitate the collection of information needed to support the plan update, and a summary of the conference call/webinar.

HMPC planning workshops were scheduled as follows. Each workshop was 3-4 hours:

**Workshop #1: Hazard Identification and Risk Assessment and Goals update**

| | |
|---|---|
| February 26, 2018 | Weston County |
| February 27, 2018 | Crook County |
| February 27, 2018 | Campbell County |
| February 28, 2018 | Johnson County |
| March 1, 2018 | Sheridan County |

The purpose of this workshop was to review the results of the risk assessment and review and update or develop goals.

**Workshop #2: Mitigation Strategy update**

| | |
|---|---|
| May 7, 2018 | Johnson County |
| May 8, 2018 | Sheridan County |
| May 10, 2018 | Crook County |
| May 16, 2018 | Weston County |
| May 18, 2018 | Campbell County |

This workshop focused on the update of the mitigation strategy and brainstorming of new mitigation actions to include in the HMP. These meetings were all followed by a public meeting in the evening.

In some cases, HMPC meetings were supplemented with additional meetings, emails, and telephone discussions to further engage the municipalities in the process. During the planning process each County Emergency Management Coordinator engaged their incorporated municipalities' elected officials and stakeholders for additional discussions on the planning effort. As a result of this outreach, each county in the region was able to develop multiple new mitigation actions. See **Chapter 5** for more information on new actions for all counties and participating jurisdictions in the Region.

## Planning Step 2: Involve the Public

The 2018 planning process informed and involved the public early in the process. In some cases, the HMPC meetings included members of the public and/or local media. Public outreach included press releases, radio announcements, social media notices, a survey, and newspaper articles. Social media was commonly used to share information related to hazards, and to inform the public on ways to share input on the plan update process. The Weston County Emergency Management Coordinator emailed the link to the public survey to local businesses, asking them to share it with the public, post it to their social media page, or direct people to the Weston County Emergency Management Facebook page where the link was also posted. Sheridan County sent a press release to local news organizations, including Big Horn Mountain Radio, Sheridan Press, and Sheridan Media, to help spread information on how the public could participate in the planning process. The Johnson County Emergency Management Coordinator was interviewed by local radio station KBBS as part of their "Community Speaks" program; during the interview she shared how the public can become informed on hazards they are at risk of, and how they can participate in the HMP planning process. Campbell County also conducted public outreach through social media and public information channels.

Public meetings were held in each county as part of the 2018 planning process. The first public meeting was held on May 7th at the Johnson County Homeland Security and Emergency Management building. Emergency Management Coordinator Marilyn Connolly, Wood Project Manager Jeff Brislawn, and Consultant John Hininger were present to facilitate the meeting. Two members of Johnson County Search and Rescue were also present at the meeting and participated as citizens.

A public meeting for Sheridan County was held at the Sheridan County Courthouse on May 8, 2018. Emergency Management Coordinator Bruce Edwards, and the Wood Project Manager and consultant were present to facilitate the meeting. In addition to the facilitators, a County Commissioner was also present.

The Crook County public meeting took place on May 10, 2018 at the Crook County Courthouse. Emergency Management Coordinator William Cunningham and the Wood Project Manager were present, but no members of the public attended.

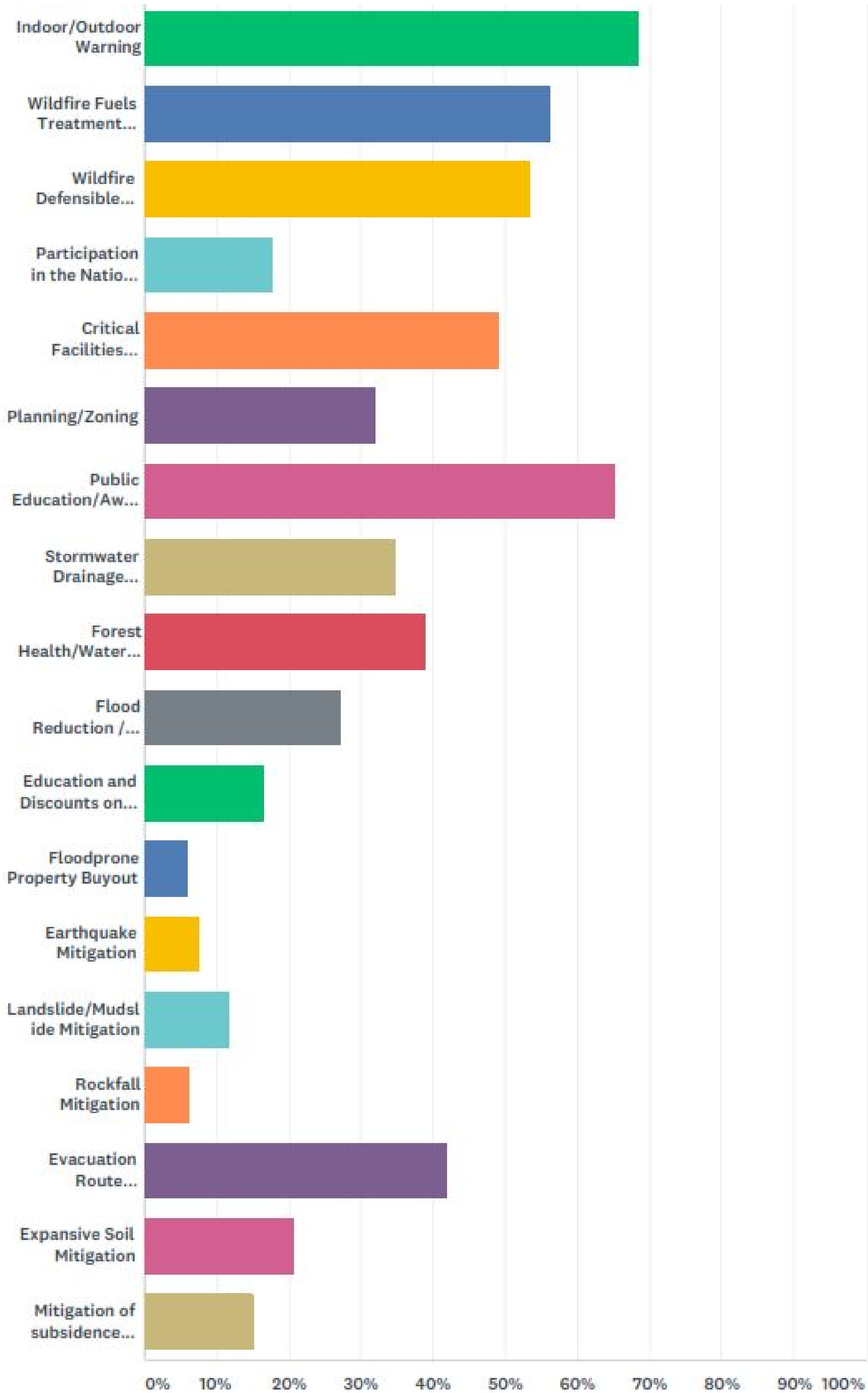
Campbell County opted to utilize public input from a survey in lieu of a meeting.

**2018 Public Survey**

During the regional planning process and drafting stage, a public survey was developed as a tool to gather public input. The survey was for the public to provide feedback to the county planning teams on topics related to hazard concerns and reducing hazard impacts. The survey provided an opportunity for public input during the planning process prior to finalization of the plan update. The survey gathered public feedback on concerns about wildfires, floods, winter storms and other hazards, and solicited input on strategies to reduce their impacts. The highest rated hazards in Region 1 were winter storms, wildfire, and wind. The survey was released as both an online tool and a hardcopy form on or around March 2018 and closed in May 2018. The counties provided links to the public survey by distributing it using social media, email, and posting the link on websites. 329 public responses were received and shared with the county planning committees to inform the process.

Figure 3.1 displays the results from Question 4, which reads: *The following types of mitigation actions may be considered in this plan. Please indicate all the types of mitigation actions that you think should have the highest priority in the Regional Multi-Hazard Mitigation Plan. These results will be considered during the planning process.* The results indicated public education and awareness is the most important mitigation action the public thinks should be included in this plan. Other high rated actions included indoor/outdoor warning, wildfire fuels treatment projects, and wildfire defensible space projects. Additional results of the survey are included in Appendix A, Planning Process Documentation.

**Figure 3.1 Public Survey Results, Question 4.**



Prior to finalizing, a draft of the regional plan was made available to the public for review and comment. The plan was placed on the Wyoming OHS's web page, and the counties used social media, a press release and email blasts to announce the public comment period. An online feedback form was provided to collect specific comments.  Eight persons viewed the comment form but only one comment was left. The comment noted appreciation of the historic hazard information in the plan.

This accomplished task three (3) in the FEMA Local Mitigation Planning Handbook (Create an outreach strategy).

## Planning Step 3: Coordinate with Other Departments and Agencies

Early in the planning process, the HMPC determined that data collection, mitigation strategy development, and plan approval would be greatly enhanced by inviting state and federal agencies and organizations to participate in the process. Neighboring communities and regional agencies involved in hazard mitigation activities, agencies that have the authority to regulate development, as well as other interests, businesses, academia and other private and non-profit interests, were also invited to provide feedback. Based on their involvement in hazard mitigation activities or their role in land stewardship in the Region, representatives from several state and federal agencies and local businesses were included in the HMPC in 2018 and are noted in Table 3.2. Many of these stakeholders participated in planning meetings or were provided an opportunity to review the draft plan before it was finalized.

### *Other Community Planning Efforts and Hazard Mitigation Activities*

Coordination with other community planning efforts is an important aspect of mitigation planning. Hazard mitigation planning involves identifying existing policies, tools, and actions that will reduce a community's risk and vulnerability from natural hazards. Each county and most municipalities in the Region use a variety of comprehensive planning mechanisms, such as master plans and ordinances, to guide growth and development. Integrating existing planning efforts and mitigation policies and action strategies into these plans establishes a credible and comprehensive HMP that ties into and supports other community programs. The development of this plan incorporated information from the following existing plans, studies, reports, and initiatives as well as other relevant data from neighboring communities and other jurisdictions.

- County comprehensive plans
- Community Wildfire Protection Plans
- Wyoming Hazard Mitigation Plan (2016)

Other documents were reviewed and cited, as appropriate, during the collection of data to support Planning Steps 4 and 5, which include the hazard identification, vulnerability assessment, and capability assessment.

## 3.3.2 Phase 2: Assess Risks

### Planning Steps 4 and 5: Identify the Hazards and Assess the Risks

Wood led the HMPCs in an effort to identify and document all the hazards that have impacted or could impact the planning area. The existing hazard mitigation plans, and Wyoming Hazard Mitigation Plan provided a basis for many of the hazard profiles. Where data permitted, Geographic Information Systems (GIS) were used to display, analyze, and quantify hazards and vulnerabilities. Sophisticated analyses for flood, landslide and wildfire hazards were performed by Wood that included an analysis of flood risk based on the Digital Flood Insurance Rate Maps (DFIRMs), where available. A more detailed description of the risk assessment process and the results are included in Chapter 4 Risk Assessment.

Also included in the 2018 plan is a capability assessment to review and document the planning area's current capabilities to mitigate risk and vulnerability from natural hazards. By collecting information about existing government programs, policies, regulations, ordinances, and emergency plans, the HMPC can assess those activities and measures already in place that contribute to mitigating some of the risks and vulnerabilities identified. The results of this assessment are captured in each annex.

## 3.3.3 Phase 3: Develop the Mitigation Plan

### Planning Steps 6 and 7: Set Goals and Review Possible Activities

Wood facilitated discussion sessions with the HMPC's that described the purpose and the process of developing planning goals, a comprehensive range of mitigation alternatives, and a method of selecting and defending recommended mitigation actions using a series of selection criteria. This process was used to update and enhance the mitigation action plan, which is the essence of the planning process and one of the most important outcomes of this effort. The action plans are detailed in each county annex; the process used to identify and prioritize mitigation actions is described in greater detail in Chapter 5 Mitigation Strategy.

### Planning Step 8: Draft an Action Plan

Based on input from the HMPC's regarding the draft risk assessment and the goals and activities identified in Planning Steps 6 and 7, Wood produced a complete first draft of the Regional Plan. This complete draft was shared for HMPC review and comment; HMPC comments were integrated into the second draft, which was advertised and distributed to collect public input and comments. Other agencies and neighboring county emergency managers were invited to comment on this draft as well. Wood integrated comments and issues from the public, as appropriate, along with additional internal review comments, and produced a final draft for the Wyoming Office of Homeland Security and FEMA Region VIII to review and approve, contingent upon final adoption by the governing boards of each participating jurisdiction.

## 3.3.4 Phase 4: Implement the Plan and Monitor Progress

### Planning Step 9: Adopt the Plan

To secure buy-in and officially implement the plan, the plan was adopted by the governing boards of each participating jurisdiction. As the adoption process takes place after FEMA's review and approval of the plan, copies of the adoption resolution will be included electronically in Appendix B Records of Adoption.

### Planning Step 10: Implement, Evaluate, and Revise the Plan

The true worth of any mitigation plan is in the effectiveness of its implementation. Each recommended action includes key descriptors, such as a lead manager and possible funding sources, to help initiate implementation. Progress on the implementation of specific actions identified in the plan is captured in the mitigation action plan summary table in Chapter 5 Mitigation Strategy. An overall implementation strategy is described in Chapter 6 Plan Adoption, Implementation and Maintenance.

Finally, there are numerous organizations within the Region 1 planning area whose goals and interests interface with hazard mitigation. Coordination with these other planning efforts, as addressed in Planning Step 3, is important to the ongoing success of this plan and mitigation in Region 1 and is addressed further in Chapter 6. A plan update and maintenance schedule and a strategy for continued public involvement are also included in Chapter 6. Annexes for each of the five counties include additional local information.

# CHAPTER 4 HAZARD ANALYSIS AND RISK ASSESSMENT

**44 CFR Requirement 201.6(c)(2): [The plan shall include] a risk assessment that provides the factual basis for activities proposed in the strategy to reduce the 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.**

**44 CFR Requirement 201.7(c)(2): [The plan shall include] a risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Tribal risk assessments must provide sufficient information to enable the Indian tribal government to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.**

As defined by the Federal Emergency Management Agency (FEMA), risk is a combination of hazard, vulnerability, and exposure. "It is the impact that a hazard would have on people, services, facilities, and structures in a community and refers to the likelihood of a hazard event resulting in an adverse condition that causes injury or damage."

The risk assessment process identifies and profiles relevant hazards and assesses the exposure of lives, property, and infrastructure to these hazards. The process allows for a better understanding of a jurisdiction's potential risk to hazards and provides a framework for developing and prioritizing mitigation actions to reduce risk from future hazard events.

This risk assessment builds upon the methodology described in the 2013 FEMA Local Mitigation Planning Handbook, which recommends a four-step process for conducting a risk assessment:

1) Describe Hazards
2) Identify Community Assets
3) Analyze Risks
4) Summarize Vulnerability

Data collected through this process has been incorporated into the following sections of this chapter:

**Section 4.1 Hazard Identification** identifies the hazards that threaten the planning area and describes why some hazards have been omitted from further consideration.

**Section 4.2 Hazard Profiles** discusses the threat to the planning area and describes previous occurrences of hazard events, the likelihood of future occurrences, and the Region's vulnerability to particular hazard events.

**County Annexes** include summaries of community assets including population, building stock, critical facilities, and historic, cultural and natural resources. Additional details on vulnerability to specific hazards where they vary from those of the Region are noted in the annexes, with more details including maps, where appropriate.

# 4.1 Hazard Identification

**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 §201.7(c)(2)(i): [The risk assessment shall include a] description of the type, location, and extent of all natural hazards that can affect the tribal planning area.**

The Hazard Mitigation Planning Committee (HMPC) from each county in the Region conducted a hazard identification study to determine the hazards that threaten the planning area.

## 4.1.1 Results and Methodology

Using existing hazards data, plans from participating jurisdictions, and input gained through planning and public meetings, the HMPCs of Campbell, Crook, Johnson, Sheridan, and Weston Counties agreed upon a list of hazards that could affect the Region. Hazards data from FEMA, the Wyoming Office of Homeland Security (including the 2016 State of Wyoming Multi-Hazard Mitigation Plan), the National Oceanic and Atmospheric Administration, county hazard mitigation plans, and many other sources were examined to assess the significance of these hazards to the planning area. The hazards evaluated in this plan include those that have occurred historically or have the potential to cause significant human and/or monetary losses in the future.

The final list of hazards identified and investigated for the 2018 Region 1 Multi-Hazard Mitigation Plan includes:

- Dam Failure
- Drought
- Earthquake
- Expansive Soils
- Flood
- Hail
- Hazardous Materials
- High Winds and Downbursts
- Landslide/Rockfall/Debris Flow
- Lightning
- Mine and Land Subsidence
- Severe Winter Weather
- Tornado
- Wildland Fire

Members of each HMPC used a hazards worksheet to rate the significance of hazards that could potentially affect the region. Significance was measured in general terms, focusing on key criteria such as the likelihood of the event, past occurrences, spatial extent, and damage and casualty potential. Table 4-1 represents the worksheet used to identify and rate the hazards and is a composite that includes input from all the participating jurisdictions. Note that the significance of the hazard may vary from jurisdiction to jurisdiction. The county annexes include further details on hazard significance by county and municipality. To ensure consistency with the Wyoming Multi-Hazard Mitigation Plan expansive soils and land subsidence hazards were added during the 2018 planning process. Other changes in the hazard identification list are noted with an asterisk in the table below.

**Table 4-1 Region 1 Overall Hazard Significance Summary Table**

| | Campbell | Crook | Johnson | Sheridan | Weston |
|---|---|---|---|---|---|
| Dam Failure | M | M | H | M | L* |
| Drought | M | H | M | H | H* |
| Earthquake | M | L | M | L | L* |
| Expansive Soils | M* | L | L | L* | H* |
| Flood | M | M | H | H | M* |
| Hail | M | M | M | M | M* |
| High Winds | M | M* | M | M* | M* |
| Landslide | L | L | M | M | L* |
| Lightning | M | H | M | M | M* |
| Mine and Land Subsidence | L* | L | L | L | M* |
| Severe Winter Storm | H | H | H | H | H* |
| Tornado | H | M | M | M | M* |
| Wildfire | H | H | H | H | H* |
| *Other Hazards* | | | | | |
| Hazardous Materials | M | H | M | M | M* |

Significance based on a combination of Geographic Extent, Potential Magnitude/Severity and Probability as defined below.
An asterisk indicates that hazard was not identified prior to 2018 in the county.

**Geographic Extent**
Negligible: Less than 10% of planning area or isolated single-point occurrences
Limited: 10 to 25% of the planning area or limited single-point occurrences
Significant: 25 to 75% of planning area or frequent single-point occurrences
Extensive: 75 to 100% of planning area or consistent single-point occurrences

**Potential Magnitude/Severity**
Negligible: Less than 10% of property is severely damaged, facilities and services are unavailable for less than 24 hours, injuries and illnesses are treatable with first aid or within the response capability of the jurisdiction.
Limited: 10 to 25% of property is severely damaged, facilities and services are unavailable between 1 and 7 days, injuries and illnesses require sophisticated medical support that does not strain the response capability of the jurisdiction, or results in very few permanent disabilities.
Critical: 25 to 50% of property is severely damaged, facilities and services are unavailable or severely hindered for 1 to 2 weeks, injuries and illnesses overwhelm medical support for a brief period of time, or result in many permanent disabilities and a few deaths.
Catastrophic: More than 50% of property is severely damaged, facilities and services are unavailable or hindered for more than 2 weeks, the medical response system is overwhelmed for an extended period of time or many deaths occur.

**Probability of Future Occurrences**
Unlikely: Less than 1% probability of occurrence in the next year, or has a recurrence interval of greater than every 100 years.
Occasional: Between a 1 and 10% probability of occurrence in the next year, or has a recurrence interval of 11 to 100 years.
Likely: Between 10 and 90% probability of occurrence in the next year, or has a recurrence interval of 1 to 10 years
Highly Likely: Between 90 and 100% probability of occurrence in the next year, or has a recurrence interval of less than 1 year.

**Overall Significance**
Low: Two or more of the criteria fall in the lower classifications or the event has a minimal impact on the planning area. This rating is also sometimes used for hazards with a minimal or unknown record of occurrences/impacts or for hazards with minimal mitigation potential.
Medium: The criteria fall mostly in the middle ranges of classifications and the event's impacts on the planning area are noticeable but not devastating. This rating is also sometimes utilized for hazards with a high impact rating but an extremely low occurrence rating.
High: The criteria consistently fall along the high ranges of the classification and the event exerts significant and frequent impacts on the planning area. This rating is also sometimes utilized for hazards with a high psychological impact or for hazards that the jurisdiction identifies as particularly relevant.

Hazards considered but not profiled further include avalanche, volcanism and windblown deposits. Avalanches can occur in the Bighorn Mountains of Johnson and Sheridan counties, but are limited to back-country areas in national forest. While they sometimes do cause death and injury and affect first responders, they are not considered further in this plan due to isolated impacts. The region could be vulnerable to an eruption of the Yellowstone Caldera due to its location to the east of Yellowstone National Park. A large-scale eruption would have catastrophic global impacts. Because of the overly long expected occurrence of frequency (greater than 10,000 years) for explosive volcanism at Yellowstone, and the fact that a mitigation plan is not possible for an event of this magnitude, it was not analyzed in this document. Windblown deposits include sands that can be mobilized by wind during extended drought. This was not considered to be a significant hazard in the region and thus not profiled further.

### 4.1.2 Disaster Declaration History

As part of the hazard identification process, the HMPC researched past events that triggered federal and/or state emergency or disaster declarations in the planning area. Federal and/or state disaster declarations may be granted when the severity and magnitude of an event surpasses the ability of the local government to respond and recover. Disaster assistance is supplemental and sequential. When the local government's capacity has been surpassed, a state disaster declaration may be issued, allowing for the provision of state assistance. Should the disaster be so severe that both the local and state governments' capacities are exceeded, a federal emergency or disaster declaration may be issued allowing for the provision of federal assistance.

The federal government may issue a disaster declaration through FEMA, the U.S. Department of Agriculture (USDA), and/or the Small Business Administration (SBA). FEMA also issues emergency declarations, which are more limited in scope and without the long-term federal recovery programs of major disaster declarations. The quantity and types of damage are the determining factors.

A USDA declaration will result in the implementation of the Emergency Loan Program through the Farm Services Agency. This program enables eligible farmers and ranchers in the affected county as well as contiguous counties to apply for low interest loans. A USDA declaration will automatically follow a major disaster declaration for counties designated major disaster areas and those that are contiguous to declared counties, including those that are across state lines. As part of an agreement with the USDA, the SBA offers low interest loans for eligible businesses that suffer economic losses in declared and contiguous counties that have been declared by the USDA. These loans are referred to as Economic Injury Disaster Loans.

Fire Management Assistance Grant funding is available to state, local and tribal governments, for the mitigation, management, and control of fires on publicly or privately-owned forests or grasslands, which threaten such destruction as would constitute a major disaster. The Fire Management Assistance declaration process is initiated when a State submits a request for assistance to the Federal Emergency Management Agency (FEMA) Regional Director at the time a "threat of major disaster" exists. The entire process is accomplished on an expedited basis and a FEMA decision is rendered in a matter of hours. The Fire Management Assistance Grant Program (FMAGP) provides a 75 percent Federal cost share and the State pays the remaining 25 percent for actual costs.

Table 4-2 provides information on federal emergencies and disasters declared in Wyoming between 1963 and 2017.

**Table 4-2 Major Disaster Declarations in Wyoming: 1963 –2017**

| Event/ Hazard | Year | Declaration Type | Remarks/Description |
|---|---|---|---|
| Heavy rains, flooding | 1963 | Presidential – Major Disaster Declaration | |
| Drought | 1977 | Presidential - Emergency Declaration | |
| Severe storms, flooding, mudslides | 1978 | Presidential – Major Disaster Declaration | All Reg. 1 Counties included in Designated Areas |
| Severe storms, tornadoes | 1979 | Presidential – Major Disaster Declaration | |
| Severe storms, hail, flooding | 1985 | Presidential – Major Disaster Declaration | |
| Methane gas seepage | 1987 | Presidential - Emergency Declaration | |
| Severe winter storm | 1999 | Presidential – Major Disaster Declaration | |

| Event/ Hazard | Year | Declaration Type | Remarks/Description |
|---|---|---|---|
| Dead Horse Fire | 2000 | Fire Mgmt Assistance Declaration | |
| Winter storm | 2000 | Presidential – Major Disaster Declaration | Crook & Weston Counties included in Designated Areas |
| McFarland Divide Fire | 2001 | Fire Mgmt Assistance Declaration | Crook County included in Designated Areas |
| Elk Mountain #2 Fire | 2001 | Fire Mgmt Assistance Declaration | Weston County included in Designated Areas |
| Hensel Fire | 2002 | Fire Mgmt Assistance Declaration | |
| Reese Mountain Fire | 2002 | Fire Mgmt Assistance Declaration | |
| Commissary Ridge Fire | 2002 | Fire Mgmt Assistance Declaration | |
| Tongue River Fire | 2003 | Fire Mgmt Assistance Declaration | Sheridan County included in Designated Areas |
| Tornado | 2005 | Presidential – Major Disaster Declaration | Campbell County included in Designated Areas |
| Drought | 2006 | USDA Declaration | Statewide drought affecting Region 1 |
| Thorn Divide Fire Complex | 2006 | Fire Mgmt Assistance Declaration | Crook County included in Designated Areas |
| Jackson Canyon Fire | 2006 | Fire Mgmt Assistance Declaration | |
| Drought | 2007 | USDA Declaration | Statewide drought affecting Region 1 |
| Little Goose Fire | 2007 | Fire Mgmt Assistance Declaration | Sheridan County included in Designated Areas |
| Drought | 2009 | USDA Declaration | |
| Severe freeze | 2009 | USDA Declaration | Severe freezes affecting Big Horn, Park, Fremont, Hot Springs, Johnson, **Sheridan**, Teton, and Washakie Counties |
| Flooding | 2010 | Presidential – Major Disaster Declaration | |
| Severe Storms, Flooding, and Landslides | 2011 | Presidential-Major Disaster Declaration | Crook, Johnson, Sheridan & Weston Counties included in Designated Areas |
| Arapahoe Fire | 2012 | Fire Mgmt Assistance Declaration | |
| Squirrel Creek Fire | 2012 | Fire Mgmt Assistance Declaration | |
| Oil Creek Fire | 2012 | Fire Mgmt Assistance Declaration | Weston County included in Designated Areas |
| Sheep Herder Hill Fire | 2012 | Fire Mgmt Assistance Declaration | |
| Severe Storms and Flooding | 2015 | Presidential-Major Disaster Declaration | Johnson County included in Designated Areas |
| Station Fire | 2015 | Fire Mgmt Assistance Declaration | |
| Lava Mountain | 2016 | Fire Mgmt Assistance Declaration | |

| Event/ Hazard | Year | Declaration Type | Remarks/Description |
|---|---|---|---|
| Fire | | | |
| Tokawana Fire | 2016 | Fire Mgmt Assistance Declaration | |
| Severe Winter Storm & Winds | 2017 | Presidential – Major Disaster Declaration | |
| Heavy Rains, Flooding | 2017 | Presidential – Major Disaster Declaration | |

Source: FEMA, https://www.fema.gov/disasters

## 4.2 Hazard Profiles

**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 §201.7(c)(2)(i): [The risk assessment shall include a] description of the type, location, and extent of all natural hazards that can affect the tribal planning area. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.**

The hazards identified in Section 4.1, Identifying Hazards are profiled individually in this section. Much of the profile information came from the same sources used to initially identify the hazards.

### 4.2.1 Profile Methodology

Each hazard is profiled in a similar format that is described below:

#### Hazard/Problem Description

This subsection gives a description of the hazard and associated problems, followed by details on the hazard specific to the Region.

#### Geographical Area Affected

This subsection discusses which areas of the Region are most likely to be affected by a hazard event.

**Limited**: Less than 10% of the planning area
**Significant**: 10 to 50% of the planning area
**Extensive**: 50 to 100% of the planning area

#### Past Occurrences

This subsection contains information on historic incidents, including impacts where known. Information provided by the HMPC is included here along with information from other data sources, including the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI – formerly the National Climatic Data Center (NCDC)) and SHELDUS (where information is referenced from the State Hazard Mitigation Plan).

SHELDUS is a county-level data set for the United States that tracks 18 types of natural hazard events along with associated property and crop losses, injuries, and fatalities. In 2014 this formerly free database transitioned into a fee-based service. Due to this and the availability of similar data in NCEI databases it was not used as a resource during the 2017 regional plan development except for when the data was already available.

When available, tables showing county-specific data from the NCEI and SHELDUS databases may be found in each hazard profile.

## Frequency/Likelihood of Occurrence

The frequency of past events is used in this section to gauge the likelihood of future occurrences. Based on historical data, the likelihood of future occurrences is categorized into one of the following classifications:

- **Highly Likely—**Near 100% chance of occurrence in next year, or happens every year.
- **Likely—**Between 10 and 100% chance of occurrence in next year, or has a recurrence interval of 10 years or less.
- **Occasional—**Between 1 and 10% chance of occurrence in the next year, or has a recurrence interval of 11 to 100 years.
- **Unlikely—**Less than 1% chance of occurrence in next 100 years, or has a recurrence interval of greater than every 100 years.

The frequency, or chance of occurrence, was calculated where possible based on existing data. Frequency was determined by dividing the number of events observed by the number of years and multiplying by 100. Stated mathematically, the methodology for calculating the probability of future occurrences is:

$$\frac{\textbf{\# of known events}}{\text{years of historic record}}\ \mathbf{x100}$$

This gives the percent chance of the event happening in any given year. An example would be three droughts occurring over a 30-year period which equates to 10% chance of that hazard occurring any given year.

## Potential Magnitude

This subsection discusses the potential magnitude of impacts, or extent, from a hazard event. Magnitude classifications are as follows:

- **Catastrophic—**More than 50% of property severely damaged, and/or facilities are inoperable or closed for more than 30 days. More than 50% agricultural losses. Multiple fatalities and injuries. Critical indirect impacts.
- **Critical—**25 to 50% of property severely damaged, and/or facilities are inoperable or closed for at least 2 weeks. 10-50% agricultural losses. Injuries and/or illnesses result in permanent disability and some fatalities. Moderate indirect impacts.
- **Limited—**10 to 25% of area affected. Some injuries, complete shutdown of critical facilities for more than one week, more than 10% of property is severely damaged.
- **Negligible—**Less than 10% of area affected. Minor injuries, minimal quality-of-life impact, shutdown of critical facilities and services for 24 hours or less, less than 10% of property is severely damaged.

## Vulnerability Assessment

Vulnerability is the measurement of exposed structures, critical facilities or populations relative to the risk of the hazard. For most hazards, vulnerability is a best-estimate. Some hazards, such as flood, affect specific areas so that exposure can be quantified, and vulnerability assessments result in a more specific approximation. Other hazards, such as tornados, are random and unpredictable in location and duration that only approximate methods can be applied.

### *Assets Summary*

Assets inventoried for the purpose of determining vulnerability include people, structures, critical facilities, and natural, historic, or cultural resources. For the regional planning process locally-available GIS databases were utilized. Parcel and assessor data for all counties were obtained from the Wyoming Department of Revenue; this information provided the basis for building exposure and property types. A critical facility is defined as one that is essential in providing utility or direction either during the response to an emergency or during the recovery operation. Much of this data is based on GIS databases associated with the 2015 and 2017 Homeland Security Infrastructure Program (HSIP) Freedom datasets; HSIP is an infrastructure geospatial data inventory maintained by the National Geospatial-Intelligence Agency that compiles geospatial data from federal agencies, states, local partners, and commercial vendors, for common use by the homeland security, and emergency management communities. Where applicable, this information was used in an overlay analysis for hazards such as flood, wildfire, and landslide. More detail on total assets potentially exposed to hazards can be found in the county annexes, including totals by jurisdiction.

## Future Development

This section describes how the hazard could impact future development.

## Summary

This section summarizes risk by county/reservation according to the area affected, likelihood, and magnitude of impacts. If the hazard has impacts on specific towns or cities in the region they are noted here, where applicable.

# 4.2.2 Dam Failure

## Hazard/Problem Description

Dams are man-made structures built for a variety of uses, including flood protection, power, agriculture, water supply, and recreation. Dams typically are constructed of earth, rock, concrete, or mine tailings. Dams and reservoirs serve a very important role for Wyoming residents and industry. Rarely, however, the dams can fail, either completely or partially, and become a significant hazard for those downstream.

Dam failure is the uncontrolled release of impounded water resulting in downstream flooding, which can affect life and property. Factors that influence the potential severity of a full or partial dam failure are the amount of water impounded, the dam type, and amount of development and infrastructure located downstream.

Dam failure occurs when the retention function of the dam is compromised, in part or in its entirety. Damage to a dam structure that may result in a failure may be caused by many factors or sources:

- Prolonged periods of rainfall and flooding, which result in overtopping
- Earthquake
- Inadequate spillway capacity resulting in excess overtopping flows
- Internal erosion caused by embankment or foundation leakage or piping or rodent activity
- Improper design
- Age
- Improper maintenance
- Negligent operation
- Failure of upstream dams on the same waterway
- Vandalism or terrorism

A dam failure is not the only type of emergency associated with dams. Spillway discharges that are large enough to cause flooding in downstream areas or flooding upstream of dams due to backwater effects or high pool levels are both considered dam emergencies and may cause significant property damage and loss of life. (Source: U.S. Army Corps of Engineers *Flood Emergency Plans: Guidelines for Corps Dams*. Hydrologic Engineering Center, (June 1980) p 4.)

Dam failures can be grouped into four classifications: overtopping, foundation failure, structural failure, and other unforeseen failures. Overtopping failures result from the uncontrolled flow of water over, around, and adjacent to the dam. Earthen dams are most susceptible to this type of failure. Hydraulic failures account for approximately 28% of all dam failures. Foundation and structural failures are usually tied to seepage through the foundation of the main structure of the dam. Deformation of the foundation or settling of the embankment can also result in dam failure. Structural failures account for approximately 28% of all dam failures, and foundation problems account for another 25%. Earthquakes or sabotage account for 12% of all dam failures, while inadequate design and construction account for the remaining 7% of failures.

Dam failures result in a unique source of flash flooding, when a large amount of previously detained water is suddenly released into a previously dry area. Based on their hazard potential, are classified into three classes. The State of Wyoming has adopted FEMA's risk classifications as set forth in FEMA's *Federal Guidelines for Dam Safety: Hazard Potential Classification System for Dams*. These guidelines define High Hazard (Class I) dams as those rated most hazardous based on an expected loss of human life, should the dam fail. Significant Hazard (Class II) dams as those rated based on expected significant damage, but not loss of human life. Significant damage refers to structural damage where humans live, work, or recreate; or public or private facilities exclusive of unpaved roads and picnic areas. Damage refers to making the structures uninhabitable or inoperable. Finally, Low hazard dams would have minimal downstream impacts from a failure.

## Geographical Area Affected

In 1981, the U.S. Army Corps of Engineers completed an inspection program for nonfederal dams under the National Dam Inspection Act (P.L. 92-367). This was a four-year work effort and included compiling an inventory of about 50,000 dams and conducting a review of each state's capabilities, practices, and regulations regarding design, construction, operation, and maintenance of dams. Part of the inspection included evaluating the selected dams and assigning a hazard potential based on the effects downstream, should one of the dams fail. The dams were rated (1) High, (2) Significant, and (3) Low hazard, just like the classification adopted by FEMA. The Corps of Engineers based the hazard potential designation on such items as acre-feet capacity of the dam, distance from nearest community downstream, population density of the community, and age of the dam**.**

The Wyoming State Engineers Office (WSEO) inspects dams over 20 feet high or with a storage capacity of 50 acre-feet or more, although smaller dams are also inspected in highly populated areas. According to the WSEO website, the WSEO currently (as of 2016) regulates 1,544 dams. As a part of the regulatory process, the WSEO inspects these dams once every five years. Of these dams, 87 are rated high hazard, 107 are rated significant hazard, and 1,350 are rated low hazard. (Source: https://damsafety.org/wyoming)

Figure 4-1 shows the dams affecting Region 1. Of the total 43 hazard dams, 24 are classified as High Hazard (Class I) and 19 are classified as Significant Hazard (Class II). Table 4-3 provides details of the High and Significant Hazard Dams sorted by the county where they are located.

**Figure 4-1 Locations of High and Significant Hazard Dams Affecting Region 1**

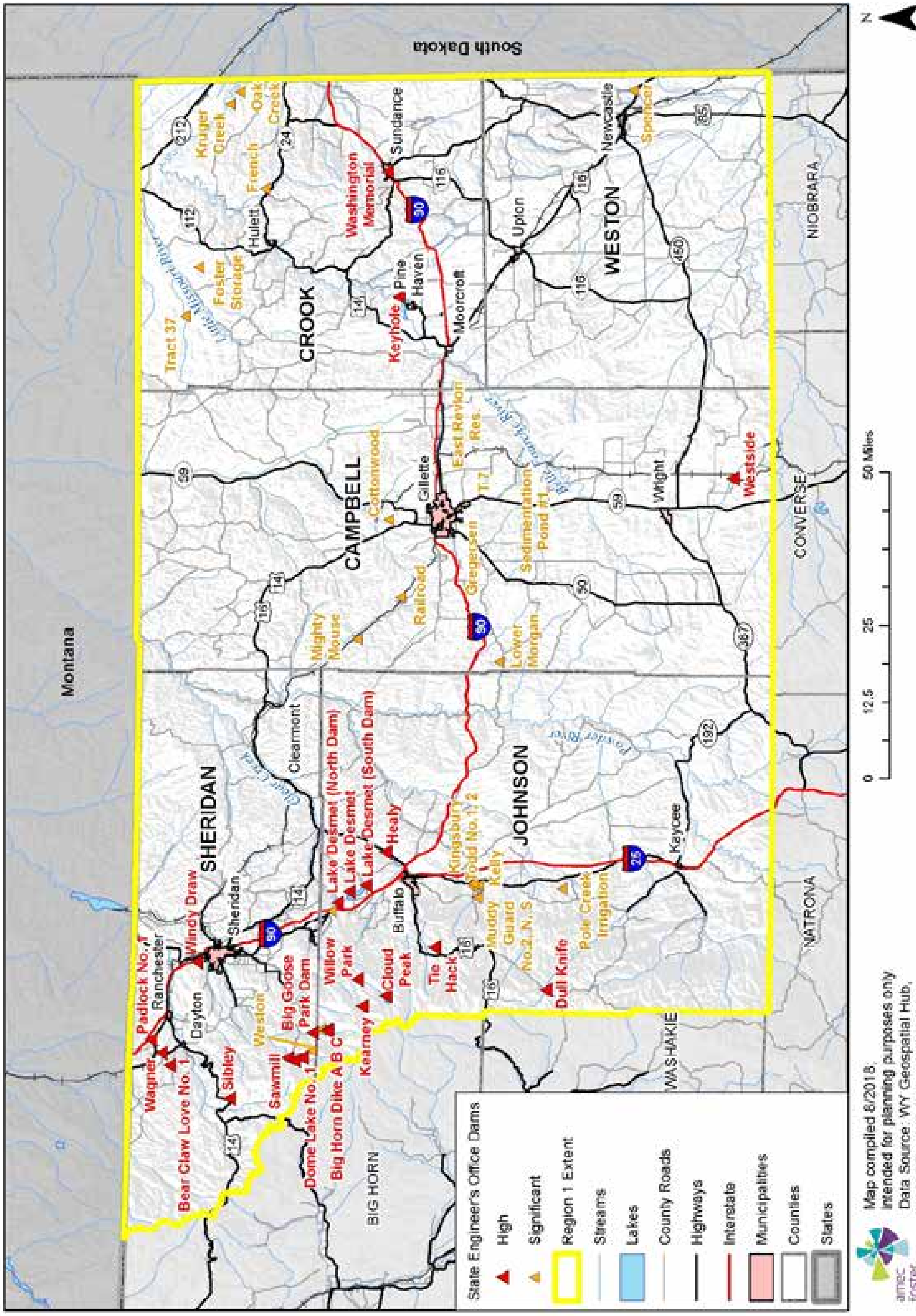


**Table 4-3 High and Significant Hazard Dams in Region 1**

| Hazard | Dam Name | River | Normal Capacity (AF) | Nearby Jurisdiction/ Populated Community |
|---|---|---|---|---|
| **Campbell County** | | | | |
| H | WESTSIDE | PORCUPINE CREEK | 260 | BNSF RAILROAD |
| S | COTTONWOOD | LITTLE RAWHIDE CREEK | 2,043 | BROADUS, MT |
| S | LOWER MORGAN | MORGAN DRAW | 227 | 1-90 |
| S | MIGHTY MOUSE | TRAP DRAW | 43 | BN RR & CO. RD |
| S | RAILROAD | WHISKEY DRAW | 28 | ECHETA ROAD |
| **Crook County** | | | | |
| H | KEYHOLE | BELLE FOURCHE RIVER | 191,500 | SPEERFISH |
| H | WASHINGTON MEMORIAL | SUNDANCE CREEK | 31 | SUNDANCE |
| S | FOSTER STORAGE | FOSTER CREEK | 103 | CAMP CREEK, SD |
| S | FRENCH | MORRIS DRAW | 37 | ALVA |
| S | KRUGER CREEK | KRUGER CREEK | 673 | BELLE FOURCHE SD |
| S | OAK CREEK | ALUM CREEK OR OAK CKEEK | 915 | BELLE FOURCHE, SD |
| S | TRACT 37 | NO FK LITTLE MISSOURI RIVER | 2,454 | ALZADA, MT |
| **Johnson County** | | | | |
| H | BIG HORN DIKE A | CROSS CREEK | 4,624 | BECKTON |
| H | BIG HORN DIKE B | CROSS CREEK | -- | BECKTON |
| H | BIG HORN DIKE C | CROSS CREEK | -- | BECKTON |
| H | CLOUD PEAK | SOUTH FORK SOUTH PINEY CREEK | 3,570 | STORY |
| H | DULL KNIFE | NORTH FORK POWDER RIVER | 4,345 | SUSSEX |
| H | HEALY | CLEAR CREEK | 5,140 | UCROSS |
| H | KEARNEY LAKE | NORTH FORK SOUTH PINEY CREEK | 6,324 | STORY |
| H | LAKE DESMET (A, B, C & SPILLWAY DIKES) | PINEY AND ROCK CREEK | 111,827 | UCROSS |
| H | LAKE DESMET (NORTH DAM) | PINEY AND ROCK CREEK | 111,827 | UCROSS |
| H | LAKE DESMET (SOUTH DAM) | PINEY AND ROCK CREEK | 111,827 | UCROSS |
| H | TIE HACK | SOUTH FORK CLEAR CREEK | 2,435 | BUFFALO |

| | | | | |
|---|---|---|---|---|
| H | WILLOW PARK | SOUTH FORK SOUTH PINEY CREEK | 4,457 | STORY |
| S | KELLY | KELLY CREEK | 102 | ARVADA |
| S | KINGSBURY TODD NO. 1 | LITTLE NORTH FORK CRAZY WOMAN | 213 | HWY 87 |
| S | KINGSBURY TODD NO. 2 | LITTLE NORTH FORK CRAZY WOMAN | 453 | HWY 87 |
| S | MARTIN | CROSS CREEK | 561 | BIG HORN |
| S | MUDDY GUARD NO. 2 NORTH DAM | EROSION DRAW & GUARD DRAW | 1,934 | ARVADA |
| S | MUDDY GUARD NO. 2 SOUTH DAM | EROSION DRAW & GUARD DRAW | 1,934 | ARVADA |
| S | POLE CREEK IRRIGATION | POLE CREEK | 606 | HWY 87 |
| S | REYNOLDS PINEY CREEK DIVERSION DAM | PINEY CREEK | 51 | KEARNY |
| **Sheridan County** | | | | |
| H | BEAR CLAW LOVE NO. 1 | NORTH FORK SMITH CREEK | 248 | DAYTON |
| H | BIG GOOSE PARK (3RD ENL.) | EAST FORK BIG GOOSE CREEK | 10,362 | BECKTON |
| H | DOME LAKE NO. 1 | WEST FORK BIG GOOSE CREEK | 1,506 | BECKTON |
| H | PADLOCK NO. 1 A FIVE MILE | FIVE MILE CREEK | 536 | RANCHESTER |
| H | SAWMILL | SAWMILL CREEK | 1,275 | BECKTON |
| H | SIBLEY | PRUNE CREEK | 379 | DAYTON, WYO |
| H | TWIN LAKES NO. 1 | CONEY CREEK | 3,411 | SHERIDAN |
| H | WAGNER | WAGNER DRAW | 884 | RANCHESTER |
| H | WINDY DRAW | WINDY DRAW | 533 | ACME |
| S | WESTON | BABIONE CREEK | 370 | BECKTON |
| **Weston County** | | | | |
| S | Spencer | Stockade Beaver Creek | 2,162 | Edgemont, SD |

Source: Wyoming State Engineer's Office

## Past Occurrences

The Region 1 has not suffered from a dam failure incident in recent years. However, there have been five recorded events of dam breach events in past years in Campbell County, Johnson County, and Sheridan County. These failures and breaches are summarized in Table 4-4 below.

Campbell County has suffered three dam breaches since 1978, but none caused loss of life or property. Smaller dam incidents have taken place as well but did not get recorded, so there are no details available.

Johnson has record of one dam failure event in 1982, due to dam overtopping that in turn caused erosion and failure of the structure.

Sheridan also has record of one event, that took place early 1978. Overtopping and subsequent erosion occurred, but no human lives or property damages were suffered.

**Table 4-4 Documented Dam Breaches and Failures in Region 1**

| County | Date | Incident Narrative |
|---|---|---|
| Campbell | 1/1/1978 | Durham Dam 1 was an earthen dam with its base keyed into the foundation constructed in 1973. During the spring of 1978, this dam was overtopped and erosion resulted in a complete failure of the structure with a peak discharge of 5630 CFS. No damage was reported. |
| | 5/19/1978 | The Caballo Dam was voluntarily breached. The structure, constructed in 1948, was built of earthen material, but its base was not keyed into the foundation. The dam had saturated and started to overtop, so it was voluntarily breached to save as much of the structure as possible. The peak discharge was 2170 CFS. |
| | 7/1/1998 | Heavy rains caused a stock dam to break on the Iberlin Ranch, flooding Wyoming Highway 387 |
| Johnson | 4/9/1982 | The Case Reservoir on Seventy-Six Draw was overtopped and the erosion action of the water resulted in a complete failure of the structure. It was an earthen dam, built in 1951, and its base was keyed into the foundation. |
| Sheridan | 1/1/1978 | Reynolds #1 Dam partially failed, as the earthen dam had its base keyed into the foundation. The breach resulted from overtopping and subsequent erosion. There was no property damage or loss of life incurred. |

## Frequency/Likelihood of Occurrence

It is estimated that Region 1 will be affected by dam failure occasionally in the future, based on the past history of events and number of dams in the Region. A number of the dam failures in Wyoming and other Rocky Mountain states occurred because of snow melt flooding that exceeded the capacity and strength of levees and dams. Wyoming's dams will continue to be tested by snow melt, heavy rains, and other types of floods every year. Thus, dam failures could possibly threaten Wyoming and Region 1 counties in the future.

## Potential Magnitude

Potential impacts could include injury and loss of life, property damage, damage to infrastructure, drinking water contamination, loss of crops and livestock, evacuations and sheltering and associated costs, interruption of commerce and transportation, search and rescue, and clean-up costs. In addition, dam failure and associated flooding can cause damage to and loss of irrigation structures such as headgates and ditches. Loss or damage to water structures negatively impacts agricultural producers of crops and livestock—and can be costly to repair.

The severity and magnitude of a given dam failure will vary on a county as well as case-by-case basis. Information on potential impacts of specific failures to particular dams is considered sensitive and is not detailed in this plan due to Homeland Security concerns. However, emergency management coordinators have access to inundation maps contained in the emergency action plans for the High and Significant Hazard dams in the state.

### Vulnerability Assessment

As noted in the high and significant hazard dams table in the Geographical Area Affected section (Table 4-3), all counties except Weston contain high hazard dams that could affect downstream areas and communities, and all counties contain at least one significant hazard dam as well. Counties such as Sheridan and Johnson are at higher risk of a dam failure event due to the presence of significant and high hazard dams in relatively close proximity to towns and cities. The one High Hazard Dam in Campbell County is owned by and located on a coal mine, and the population at risk is completely within that same mine.

### Future Development

As communities and unincorporated areas grow, previously lower-classified dams may pose greater risks, which could elevate their hazard classification. Inundation maps and emergency action plans should be consulted in the planning of new development, where applicable. However, growth rates in the region do not indicate that risk is increasing substantially.

### Summary

Overall, dam failure significance in the Region is **medium**, with the greatest risk assessed in Johnson County, followed by Sheridan, Crook, and Campbell Counties. The probability a damaging dam failure event is **occasional**, but impacts could become significant depending upon the dam involved and where it occurred in the region. Jurisdictions at risk include, among others, Sundance, Dayton, Newcastle, and Buffalo, though **Table 4-3** contains more details on the location of dams in comparison with streams and cities/towns (including unincorporated areas within Region 1). While not noted on this table as the nearest downstream community, there is also risk to Ranchester and Sheridan in Sheridan County.

**Table 4-5 Dam Failure Hazard Risk Summary**

| County | Geographic Extent | Probability of Future Occurrence | Potential Magnitude/ Severity | Overall Significance |
|---|---|---|---|---|
| Campbell | Limited | Rare | Limited | Medium |
| Crook | Significant | Occasional | Limited | Medium |
| Johnson | Significant | Occasional | Critical | High |
| Sheridan | Significant | Occasional | Limited | Medium |
| Weston | Limited | Rare | Limited | Low |

## 4.2.3 Drought

### Hazard/Problem Description

Drought is described as a protracted period of deficient precipitation resulting in extensive damage to vegetation. Of all the natural weather-related disasters, drought is by far the costliest to our society. It indirectly kills more people, animals, and plants than the combined effects of hurricanes, floods, tornadoes, blizzards, and wildfires. And, unlike other disasters that quickly come and go, drought's long-term unrelenting destruction has been responsible in the past for mass migrations and lost civilizations. The 1980 and 1988 droughts in the U.S. resulted in approximately 17,500 heat-related deaths and an economic cost of over $100 billion. Drought occurs in four stages and is defined as a function of its magnitude (dryness), duration, and regional coverage. Severity, the most commonly used term for measuring drought, is a combination of magnitude and duration.

The first stage of drought is known as a meteorological drought. The conditions at this stage include any precipitation shortfall of 75% of normal for three months or longer. The second stage is known as agricultural drought. Soil moisture is deficient to the point where plants are stressed and biomass (yield) is reduced. The third stage is the hydrological drought. Reduced stream flow (inflow) to reservoirs and lakes is the most obvious sign that a serious drought is in progress. The fourth stage is the socioeconomic drought. This final stage refers to the situation that occurs when physical water shortage begins to affect people.

As these stages evolve over time, the impacts to the economy, society, and environment can converge into an emergency situation. Without reservoir water to irrigate farms, food supplies are in jeopardy. Without spring rains for the prairie grasslands, open range grazing is compromised. Without groundwater for municipalities, the hardships to communities can result in increases in mental and physical stress as well as conflicts over the use of whatever limited water is available. Without water, wetlands disappear. Other animal and plant species also suffer from lack of (or degraded) proper food, nutrients, water, and habitat. The quality of any remaining water decreases due to its higher salinity concentration. There is also an increased risk of fires, and air quality degrades as a result of increased soil erosion particles in strong winds (blowing dust).

## Geographical Area Affected

According to estimates by the Region 1 Hazard Mitigation Plan Committee, the Region is at high risk to drought events over an extensive spatial area which covers two of the five counties in the region. Since droughts are often regional events that impact multiple counties and states simultaneously, given the climate of the planning area being contiguous, it is reasonable to assume that a drought will impact the entire planning region to some extent. According to the Wyoming State Climate Office, Wyoming is the 5$^{th}$ driest state in the United States, and since 1999 moderate to severe droughts have been normal occurrences in much of the state due to its natural climate. Although the Region falls within two river drainage basins in the state (Powder/Tongue and the Northeast Basins), and while the Bighorn Mountains get some snow, the Bear Lodge Mountains do not collect significant snowpack during the winter months to discharge large amounts of flow through major local streams (e.g., Belle Fourche River, Cheyenne River, Little Missouri River). Furthermore, as of 2018, parts of both the Powder River and the Belle Fourche River were declared as impaired waters by the Wyoming Water Resources Data System & Wyoming State Climate Office services (WRDS-UWY, 2018); streams falling under this impairment criteria are considered threatened, significantly degraded, or too contaminated to meet the water quality standards set by the Environmental Protection Agency's Clean Water Act (EPA, 2017). Given the Region's lack of widespread access to large amounts of fresh water locally, effects from droughts may be exacerbated and the areas affected may be quite large.

## Past Occurrences

The Region 1 area has experienced several multi-year droughts over the past century. A significant statewide drought began in the spring of 2000 and endured through 2004. The region had a wetter year in 2005, technically signifying the end of the drought period. Dry conditions returned in the following years and became severe between 2006 and 2007. According to the Wyoming State Climate Office, "conditions [had] eased somewhat in mid-2008, but a near decade with warm temperatures and relatively little precipitation has left [Wyoming] very vulnerable" (http://www.wrds.uwyo.edu/sco/drought/drought.html). The driest year to date occurred in 2012, with only 10.9 inches of precipitation, or 69.06% of the normal precipitation observed in the state.

The 2000-2004 drought is considered by many to be the most severe in collective memory. However, some older residents have indicated that they remember streams drying up in the 1930s and 1950s. According to instrument records, since 1895 there have been only six multi-year (three years or longer) statewide droughts. Based on deficit precipitation totals (negative departures from the long-term average), they are ranked statewide. Refer to Table 4-6 for a summary of the years that suffered drought, their average precipitation records, and the percent of those years' precipitation compared to the average annual records (i.e., average precipitation in the range of years / the average annual precipitation of 15.87).

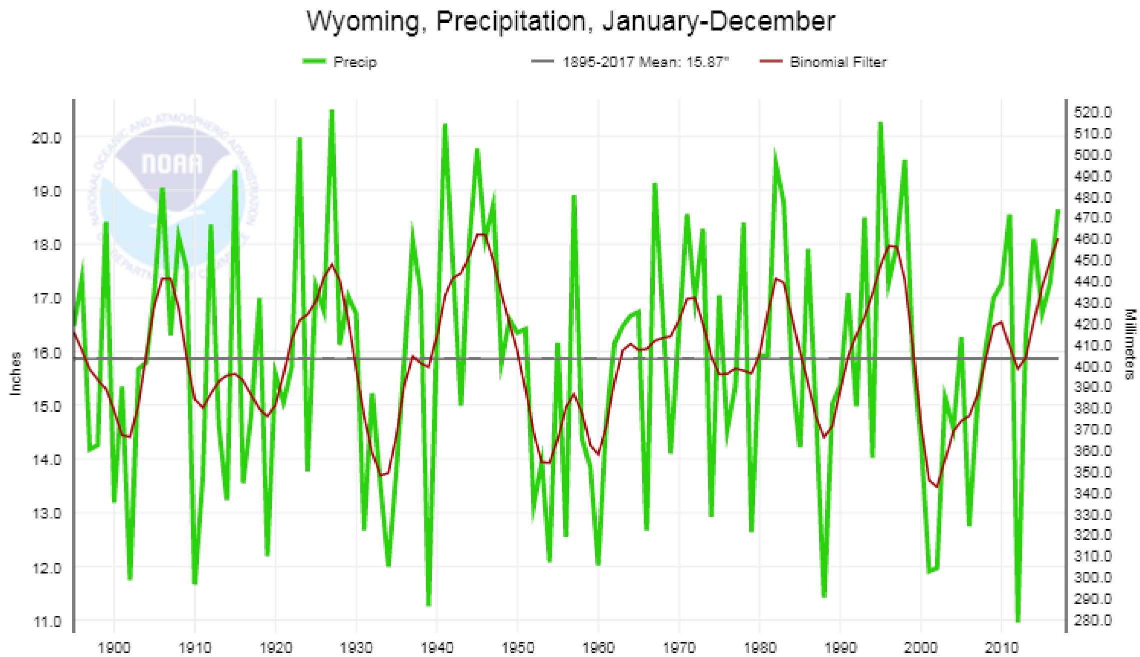
**Table 4-6 Significant Multi-Year Wyoming Droughts since 1895 (Modern Instrumented Era)**

| Years | Average Annual Precipitation (inches) | Percent of 1895-2017 Average Annual Precipitation (15.87") |
|---|---|---|
| 1900-1903 | 13.53 | 85.28% |
| 1931-1935 | 13.43 | 84.65% |
| 1952-1956 | 12.93 | 81.47% |
| 1958-1960 | 13.23 | 83.36% |
| 1987-1990 | 14.17 | 89.29% |
| 2000-2004 | 13.44 | 84.67% |

Source: NOAA – National Centers for Environmental Information

Overall, Wyoming's precipitation record from 1895-2017 reveals that, for the first half of the 20th century (except for the Dust Bowl years of the 1930s and the localized event in the mid-1950s), there was generally a surplus of moisture. During the second half of the 20th century and into the 21st century there was a trend of increased periods of drought (Figure 4-2) The dry years are denoted by the binomial filter troughs (i.e., red line dips). Note the dips in 2002-2006 and in 2012 which were the most recent severe droughts in Wyoming.

**Figure 4-2 Wyoming Annual Precipitation: 1895-2017**




Source: NOAA – NCEI (http://www.ncdc.noaa.gov/cag/time-series/)

The U.S. Drought Monitor provides a general summary of current drought conditions. The U.S. Department of Agriculture (USDA), the National Oceanic and Atmospheric Administration (NOAA), and the National Drought Mitigation Center (University of Nebraska-Lincoln) collaborate on this weekly product, which is released each Thursday. Multiple drought indicators, including various indices, outlooks, field reports, and news accounts are reviewed and synthesized. In addition, numerous experts from other agencies and offices across the country are consulted. The result is the consensus assessment presented on the U.S. Drought Monitor map (with Wyoming's current drought conditions portrayed in Figure 4-3). The image is color-coded for six levels of drought intensity. The first drought category, "Abnormally Dry," is used to show areas that might be moving into a drought, as well as those that have recently come out of one. The last category is called "Exceptional Drought", and is reserved to classify the most severe drought events. The remaining four categories define droughts ranging from less to more severe (Source: https://www.drought.gov/drought/)

As of February 8, 2018, two drought conditions were identified in parts of the Region: "Abnormally Dry" and "Moderate Drought". Note that the majority of the Region is not currently impacted by drought, and hence displayed in white by Figure 4-3.

## Figure 4-3 U.S. Drought Monitor

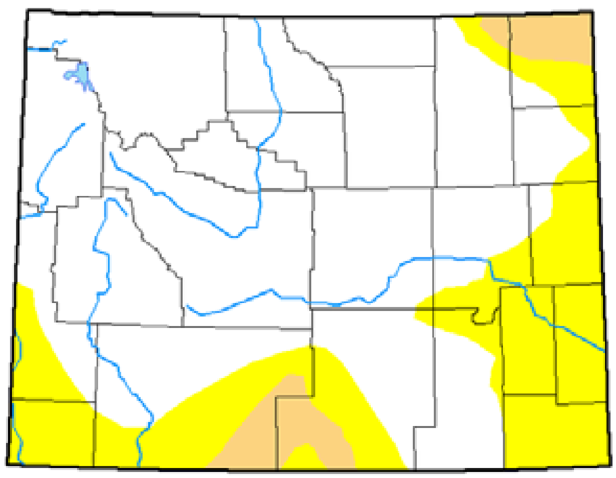
*U.S. Drought Monitor*

**Wyoming**

**February 6, 2018**

*(Released Thursday, Feb. 8, 2018)*

Valid 7 a.m. EST



*Drought Conditions (Percent Area)*

| | None | D0-D4 | D1-D4 | D2-D4 | D3-D4 | D4 |
|---|---|---|---|---|---|---|
| Current | 70.75 | 29.25 | 4.62 | 0.00 | 0.00 | 0.00 |
| Last Week 01-30-2018 | 70.64 | 29.36 | 3.88 | 0.00 | 0.00 | 0.00 |
| 3 Months Ago 11-07-2017 | 86.56 | 13.44 | 1.93 | 0.00 | 0.00 | 0.00 |
| Start of Calendar Year 01-02-2018 | 75.18 | 24.82 | 1.73 | 0.00 | 0.00 | 0.00 |
| Start of Water Year 09-26-2017 | 81.27 | 18.73 | 2.11 | 0.00 | 0.00 | 0.00 |
| One Year Ago 02-07-2017 | 85.14 | 14.86 | 9.34 | 0.00 | 0.00 | 0.00 |

Intensity:
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

*The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.*

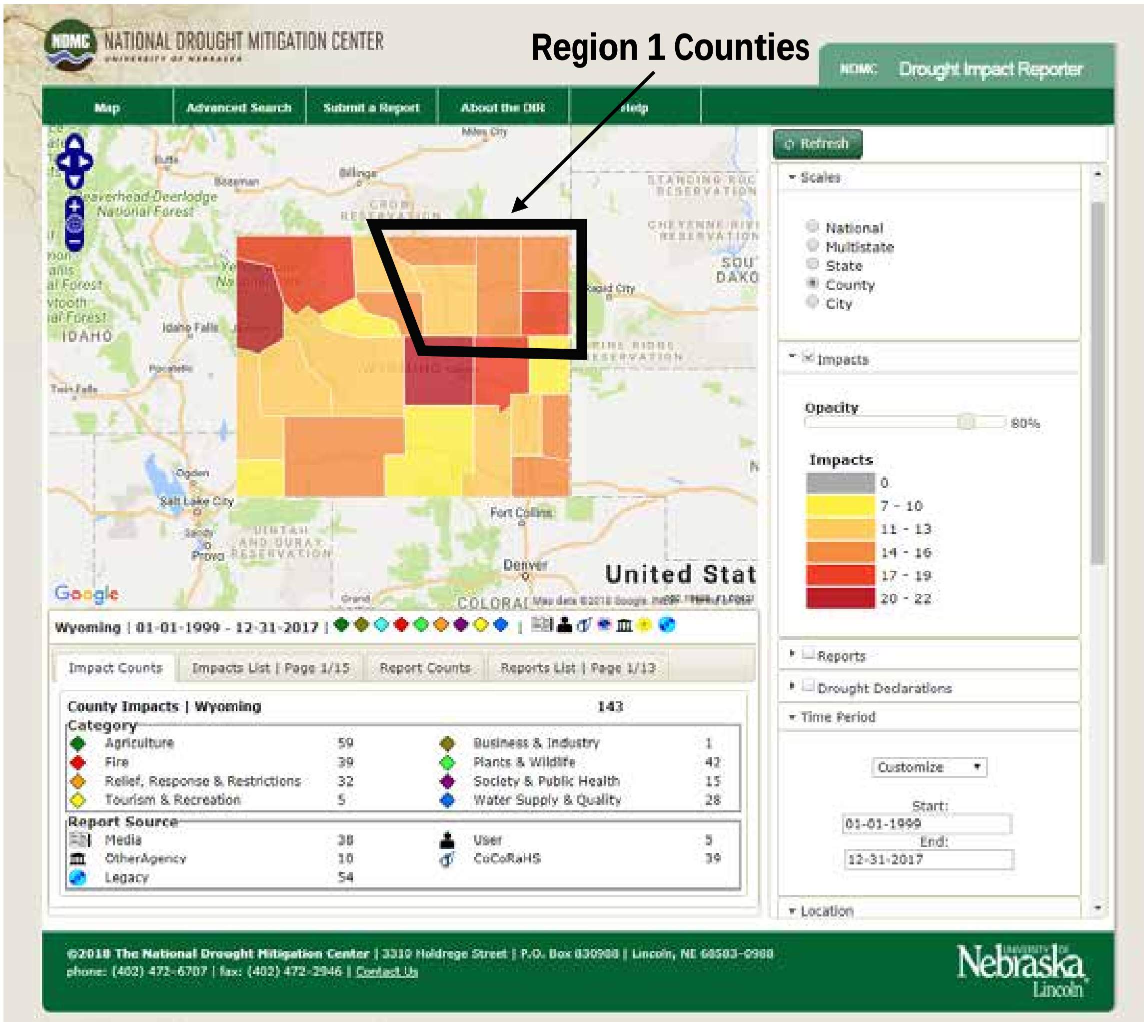
Author:
Eric Luebehusen
U.S. Department of Agriculture

http://droughtmonitor.unl.edu/

A particularly useful resource to determine the impacts of drought is the Drought Impact Reporter (DIR), launched by the National Drought Mitigation Center in July 2005 as the nation's first comprehensive database accounting for a range of drought impacts. The Drought Impact Reporter is an interactive web-based mapping tool designed to compile and display impact information across the United States in near real-time. Information within the DIR is collected from a variety of sources including the media, government agencies and reports, and citizen observers. Each of these sources provides different types of information at different spatial and temporal scales. (Source: http://drought.unl.edu/monitoringtools/droughtimpactreporter.aspx)

A search of the database for Region 1 from 1999 to 2017 (which includes the most recent severe droughts) shows a total of 143 reported impacts. Figure 4-4 below contains the breakdown of reported impacts by county, with color-coding ranging from fewest (yellow) to most reported impacts (reds). The majority of reported impacts fall within the Agriculture Category. Drought effects associated with agriculture include damage to crop quality; income loss for farmers due to reduced crop yields; reduced productivity of cropland; reduced productivity of rangeland; forced reduction of foundation stock; and closure/limitation of public lands to grazing, among others.

**Figure 4-4 Number of Reported Drought Impacts from 1999 to 2017 in Region 1**

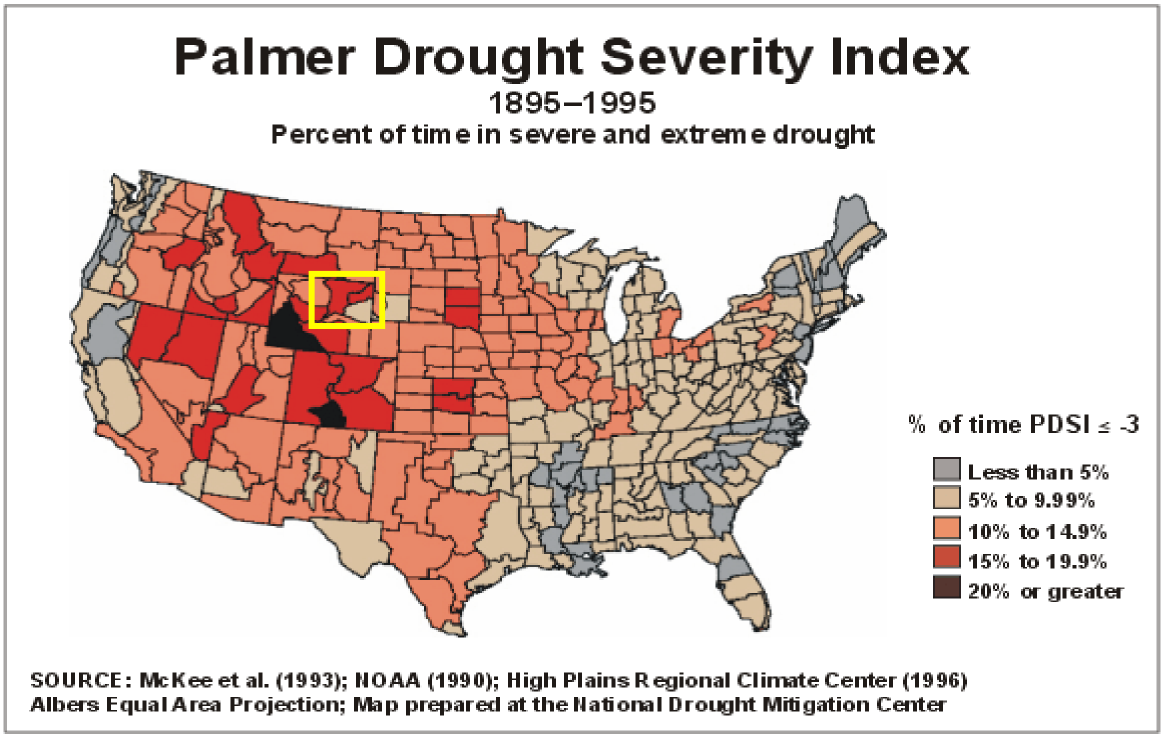



All areas in Region 1 have, at various times, been included in regional USDA disaster declarations for droughts. In 2017 specifically, both Campbell and Crook counties were included in the Secretarial Drought Designation statement as a primary disaster designated county. That same year, the USDA received reports from 8 Wyoming counties suffering from drought-induced natural disasters: Big Horn, Campbell, Converse, Crook, Johnson, Laramie, Sheridan, and Weston. Note that all five counties in Region 1 suffered from drought disasters, accounting for 11 out of the total 14 state claims in the year.

## Frequency/Likelihood of Occurrence

Figure 4-5 indicates the Region 1 area spent approximately 15-20% of the 100-year span from 1895 to 1995 in severe or extreme drought. This is consistent with the data in the Past Occurrences subsection which suggests that severe multi-year droughts have occurred roughly every twenty years, since the beginning of precipitation data collection in 1895. An occurrence interval of roughly once every twenty years for the Region until 1995 may not quite correspond to a likely frequency of occurrence, but given more recent data records since then, the trend has changed. From 1995 onward, Region 1 has experienced eight additional years of drought, averaging to a drought (of at least one year) every 1.71 years, or a multi-year drought every 5 years.

**Figure 4-5 Palmer Drought Severity Index Time Series for the Continental U.S.: 1895-1995**




## Potential Magnitude

In order to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area, information from the event of record is used. Impacts can help understand the effects of a hazard, and potentially assist in preparing for and preventing against said hazard (e.g., drought). In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of a common occurrence. Based upon Table 4-6, the drought of 2000-2004 was more significant, in terms of losses and changes in productivity, than some of the other droughts in the last 100 years for the entire state. The droughts noted previously in, derived from NOAA's National Center for Environmental Information database, indicate that the most significant droughts in the last century, in terms of precipitation deficit, were in 1952-1956, 1958-1960, 1931-1935, and 1999-2004. To determine how the drought periods had significant negative impacts on Wyoming, crop production and livestock inventory data for the driest period (1952-1956) and the latest multi-year drought period (2000-2004) were compared. 1957 and 2005 were wetter years, with annual statewide precipitation totals above the 1895-2017 average. Those two years were used as endpoints for the droughts that started in 1952 and 2000 respectively. In both cases, the years following saw a return to drier conditions. Because of this, the most recent drought impacts were also calculated for 2005 and 2006, and are included in summary tables. Table 4-7 and Table 4-8 show percentage of peak decline in one or more production categories during drought compared to the 5-year pre-drought production averages for various commodities.

A comparison of Table 4-7 and Table 4-8 indicate that drought impacts to the Wyoming agricultural community were greater in the 2000-2004 drought than in the 1952-1956 drought. With the exception of dry beans, all commodities in the worst years of the 2000-2004 drought showed a greater percentage decline in production than in the 1952-1956 drought. As a result, the 2000-2004 drought will be used as the drought of historic record to calculate dollar impacts. (Note that the abbreviation 'Bu.' means *bushel*, and 'cwt' stands for *hundredweight*.)

**Table 4-7 Peak Commodity Production Changes from Pre-Drought (1947-1951) to Drought (1952-1956)**

| Commodity | 5-Year Pre-Drought Production Average (1947-1951) | Units | Lowest Production During Drought (1952-1956) | Year of Lowest Production (1952-1956) | Production Losses* | Percent Change |
|---|---|---|---|---|---|---|
| Winter Wheat | 5,072 | 1,000 bu. | 2,346 | 1954 | 2,726 | -54% |
| Spring Wheat | 1,579 | 1,000 bu. | 600 | 1954 | 979 | -62% |
| Barley | 4,414 | 1,000 bu. | 2,700 | 1956 | 1,714 | -39% |
| Oats | 4,577 | 1,000 bu. | 2,470 | 1954 | 2,107 | -46% |
| Dry Beans | 1,009 | 1,000 cwt. | 589 | 1955 | 420 | -42% |
| Sugar beets | 413 | 1,000 tons | 421 | 1955 | No Losses | +2% |
| Corn | 227 | 1,000 bu. | 161 | 1953 | 66 | -29% |
| Alfalfa Hay | 490 | 1,000 tons | 675 | 1954 | No Losses | +38% |
| Other Hay | 674 | 1,000 tons | 442 | 1954 | 232 | -34% |
| Cattle/ Calves Inventory | 1,050 | 1,000 head | 1,096 | 1954 | No Losses | +4% |

Source: USDA * Difference between 5-year production averages and lowest production rates, during drought

**Table 4-8 Peak Commodity Production Changes from Pre-Drought (1994-1998) to Drought (2000-2004)**

| Commodity | 5-Year Pre-Drought Production Average (1994-1998) | Units | Lowest Production During Drought (1999-2006) | Year of Lowest Production (1999-2006) | Production Losses* | Percent Change |
|---|---|---|---|---|---|---|
| Winter Wheat | 6,029 | 1,000 bu. | 2,375 | 2002 | 3,654 | -61% |

| Commodity | 5-Year Pre-Drought Production Average (1994-1998) | Units | Lowest Production During Drought (1999-2006) | Year of Lowest Production (1999-2006) | Production Losses* | Percent Change |
|---|---|---|---|---|---|---|
| Spring Wheat | 648 | 1,000 bu. | 96 | 2002 | 552 | -84% |
| Barley | 8,383 | 1,000 bu. | 4,680 | 2002 | 3,703 | -44% |
| Oats | 1,648 | 1,000 bu. | 600 | 2005 | 1,048 | -64% |
| Dry Beans | 691 | 1,000 cwt. | 514 | 2001 | 177 | -26% |
| Sugar beets | 1,151 | 1,000 tons | 659 | 2002 | 492 | -43% |
| Corn | 6,328 | 1,000 bu. | 4,165 | 2002 | 2,163 | -34% |
| Alfalfa Hay | 1,581 | 1,000 tons | 1,150 | 2002 | 431 | -27% |
| Other Hay | 817 | 1,000 tons | 450 | 2002 | 367 | -45% |
| Cattle/ Calves Inventory | 1,536 | 1,000 head | 1,300 | 2004 | 236 | -16% |

Source: USDA * Difference between 5-year production averages and lowest production rates, during drought

### *Economic Impacts*

Agricultural dollar impacts can also be used to show the effects of drought. For Wyoming, historic data from the 2000-2004 drought and the two subsequent years was obtained from the U.S. Department of Agriculture (USDA) Quick Stats database (https://quickstats.nass.usda.gov).

The data below represent changes in production value for crops, and changes in inventory value for cattle and calves. As such, the data should be considered to summarize impact value versus economic loss value. For example, with cattle and calves inventory (Table 4-9 through Table 4-15), the inventory decreased during the drought. Therefore, the value of inventory on hand decreased. The inventory decreased, however, because of the reduced sales in cattle and calves, due to hardships in raising the cattle, feeding, etc. The net result, therefore, is an overall decrease in inventory value, which is a negative impact stemming from drought. Although these summaries have been obtained state-wide, they serve as a good indicator of how drought can affect a specific industry or business over time.

**Table 4-9 2000 Production and Inventory Value Impact**

| Commodity | 5-Year Pre-Drought Production Average (1994-1998) | Units | 2000 Production | Value (USD) | Production and Inventory Value Impact (USD) |
|---|---|---|---|---|---|
| Winter Wheat | 6,029 | 1,000 bu. | 4,080 | $2.70/bu | - $ 5,262,300 |
| Spring Wheat | 648 | 1,000 bu. | 232 | $2.70/bu | - $ 1,124,280 |
| Barley | 8,383 | 1,000 bu. | 7,885 | $3.08/bu | - $ 1,533,840 |

| Commodity | 5-Year Pre-Drought Production Average (1994-1998) | Units | 2000 Production | Value (USD) | Production and Inventory Value Impact (USD) |
|---|---|---|---|---|---|
| Oats | 1,648 | 1,000 bu. | 1,156 | $1.55/bu | - $ 252,650 |
| Dry Bean | 691 | 1,000 cwt. | 762 | $16.80/cwt | + $ 1,196,160 |
| Sugar Beet | 1,150 | 1,000 tons | 1,556 | $32.50/ton | + $ 195,000 |
| Corn | 6,328 | 1,000 bu. | 7,656 | $2.02/bu | + $ 2,682,560 |
| Alfalfa Hay | 1,581 | 1,000 tons | 1,449 | $85.00/ton | - $ 11,220,000 |
| Other Hay | 817 | 1,000 tons | 650 | $80.00/ton | - $ 13,392,000 |
| Cattle/Calves Inventory | 1,536 | 1,000 head | 1,550 | $780.00/head | +$10,920,000 |
| **TOTAL** | | | | | **-$17,791,350** |

Source: USDA

### Table 4-10 2001 Production and Inventory Value Impact

| Commodity | 5-Year Pre-Drought Production Average (1994-1998) | Units | 2001 Production | Value (USD) | Production and Inventory Value Impact (USD) |
|---|---|---|---|---|---|
| Winter Wheat | 6,029 | 1,000 bu. | 2,880 | $2.70/bu | - $ 8,502,300 |
| Spring Wheat | 648 | 1,000 bu. | 168 | $2.90/bu | - $ 1,393,160 |
| Barley | 8,383 | 1,000 bu. | 6,970 | $3.32/bu | - $ 4,691,160 |
| Oats | 1,648 | 1,000 bu. | 1,344 | $1.65/bu | - $ 501,600 |
| Dry Bean | 691 | 1,000 cwt. | 514 | $23.00/cwt | - $ 4,066,400 |
| Sugar Beet | 1,150 | 1,000 tons | 794 | $39.70/ton | - $ 14,133,200 |
| Corn | 6,328 | 1,000 bu. | 6,375 | $2.30/bu | + $ 108,100 |
| Alfalfa Hay | 1,581 | 1,000 tons | 1,276 | $110.00/ton | - $ 33,550,000 |
| Other Hay | 817 | 1,000 tons | 605 | $105.00/ton | - $ 22,302,000 |
| Cattle/Calves Inventory | 1,536 | 1,000 head | 1,470 | $780.00/head | - $ 51,480,000 |
| **TOTAL** | | | | | **-$140,511,720** |

Source: USDA

### Table 4-11 2002 Production and Inventory Value Impact

| Commodity | 5-Year Pre-Drought Production Average (1994-1998) | Units | 2002 Production | Value (USD) | Production and Inventory Value Impact (USD) |
|---|---|---|---|---|---|
| Winter Wheat | 6,029 | 1,000 bu. | 2,375 | $3.70/bu | - $ 13,519,800 |

| Commodity | 5-Year Pre-Drought Production Average (1994-1998) | Units | 2002 Production | Value (USD) | Production and Inventory Value Impact (USD) |
|---|---|---|---|---|---|
| Spring Wheat | 648 | 1,000 bu. | 96 | $3.90/bu | - $ 2,154,360 |
| Barley | 8,383 | 1,000 bu. | 4,680 | $3.23/bu | - $ 11,960,690 |
| Oats | 1,648 | 1,000 bu. | 750 | $2.20/bu | - $ 1,975,600 |
| Dry Bean | 691 | 1,000 cwt. | 624 | $18.30/cwt | - $ 1,222,440 |
| Sugar Beet | 1,150 | 1,000 tons | 659 | $42.30/ton | - $ 20,769,300 |
| Corn | 6,328 | 1,000 bu. | 4,165 | $2.60/bu | - $ 5,623,800 |
| Alfalfa Hay | 1,581 | 1,000 tons | 1,150 | $111.00/ton | - $ 47,841,000 |
| Other Hay | 817 | 1,000 tons | 450 | $106.00/ton | - $ 38,944,400 |
| Cattle/Calves Inventory | 1,536 | 1,000 head | 1,320 | $760.00/head | - $164,160,000 |
| **TOTAL** | | | | | **-$308,171,390** |

Source: USDA

## Table 4-12 2003 Production and Inventory Value Impact

| Commodity | 5-Year Pre-Drought Production Average (1994-1998) | Units | 2003 Production | Value (USD) | Production and Inventory Value Impact (USD) |
|---|---|---|---|---|---|
| Winter Wheat | 6,029 | 1,000 bu. | 3,915 | $3.40/bu | -$ 7,187,600 |
| Spring Wheat | 648 | 1,000 bu. | 180 | $3.15/bu | -$ 1,474,200 |
| Barley | 8,383 | 1,000 bu. | 6,975 | $3.46/bu | -$ 4,871,680 |
| Oats | 1,648 | 1,000 bu. | 1,104 | $1.80/bu | -$ 979,200 |
| Dry Bean | 691 | 1,000 cwt. | 645 | $17.40/cwt | -$ 800,400 |
| Sugar Beet | 1,150 | 1,000 tons | 752 | $41.20/ton | -$16,397,600 |
| Corn | 6,328 | 1,000 bu. | 6,450 | $2.50/bu | $ 305,000 |
| Alfalfa Hay | 1,581 | 1,000 tons | 1,625 | $80.00/ton | $ 3,520,000 |
| Other Hay | 817 | 1,000 tons | 770 | $73.00/ton | -$ 3,431,000 |
| Cattle/Calves Inventory | 1,536 | 1,000 head | 1,350 | $890.00/head | -$ 165,540,000 |
| **TOTAL** | | | | | **-$ 196,856,680** |

Source: USDA

## Table 4-13 2004 Production and Inventory Value Impact

| Commodity | 5-Year Pre-Drought Production Average (1994-1998) | Units | 2004 Production | Value (USD) | Production and Inventory Value Impact (USD) |
|---|---|---|---|---|---|
| Winter Wheat | 6,029 | 1,000 bu. | 3,510 | $3.20/bu | -$ 8,060,800 |
| Spring Wheat | 648 | 1,000 bu. | 240 | $3.25/bu | -$ 1,326,000 |
| Barley | 8,383 | 1,000 bu. | 7,050 | $3.41/bu | -$ 4,545,530 |
| Oats | 1,648 | 1,000 bu. | 795 | $1.55/bu | -$ 1,322,150 |
| Dry Bean | 691 | 1,000 cwt. | 541 | $25.90/cwt | -$ 3,885,000 |
| Sugar Beet | 1,150 | 1,000 tons | 812 | $41.70/ton | -$ 14,094,600 |
| Corn | 6,328 | 1,000 bu. | 6,550 | $2.48/bu | $ 550,560 |
| Alfalfa Hay | 1,581 | 1,000 tons | 1,305 | $74.50/ton | -$ 20,562,000 |
| Other Hay | 817 | 1,000 tons | 756 | $69.50/ton | -$ 4,239,500 |
| Cattle/Calves Inventory | 1,536 | 1,000 head | 1,300 | $1020.00/head | -$ 240,720,000 |
| **TOTAL** | | | | | **-$ 298,205,020** |

Source: USDA

## Table 4-14 2005 Production and Inventory Value Impact

| Commodity | 5-Year Pre-Drought Production Average (1994-1998) | Units | 2005 Production | Value (USD) | Production and Inventory Value Impact (USD) |
|---|---|---|---|---|---|
| Winter Wheat | 6,029 | 1,000 bu. | 4,350 | $3.50/bu | -$ 5,876,500 |
| Spring Wheat | 648 | 1,000 bu. | 315 | $3.19/bu | -$ 1,062,270 |
| Barley | 8,383 | 1,000 bu. | 5,580 | $3.28/bu | -$ 9,193,840 |
| Oats | 1,648 | 1,000 bu. | 600 | $1.60/bu | -$ 1,676,800 |
| Dry Bean | 691 | 1,000 cwt. | 776 | $18.70/cwt | $ 1,589,500 |
| Sugar Beet | 1,150 | 1,000 tons | 801 | $42.80/ton | -$ 14,937,200 |
| Corn | 6,328 | 1,000 bu. | 6,860 | $2.45/bu | $ 1,303,400 |
| Alfalfa Hay | 1,581 | 1,000 tons | 1,560 | $75.00/ton | -$ 1,575,000 |
| Other Hay | 817 | 1,000 tons | 756 | $72.00/ton | -$ 4,392,000 |
| Cattle/Calves Inventory | 1,536 | 1,000 head | 1,400 | $1140.00/head | -$ 155,040,000 |
| **TOTAL** | | | | | **-$ 190,860,710** |

Source: USDA

**Table 4-15 2006 Production and Inventory Value Impact**

| Commodity | 5-Year Pre-Drought Production Average (1994-1998) | Units | 2006 Production | Value (USD) | Production and Inventory Value Impact (USD) |
|---|---|---|---|---|---|
| Winter Wheat | 6,029 | 1,000 bu. | 3,645 | $4.58/bu | -$ 10,918,720 |
| Spring Wheat | 648 | 1,000 bu. | 234 | $3.80/bu | -$ 1,573,200 |
| Barley | 8,383 | 1,000 bu. | 4,845 | $3.32/bu | -$ 11,746,160 |
| Oats | 1,648 | 1,000 bu. | 684 | $2.15/bu | -$ 2,072,600 |
| Dry Bean | 691 | 1,000 cwt. | 590 | $22.00/cwt | -$ 2,222,000 |
| Sugar Beet | 1,150 | 1,000 tons | 798 | $46.80/ton | -$ 16,473,600 |
| Corn | 6,328 | 1,000 bu. | 5,805 | $2.64/bu | -$ 1,380,720 |
| Alfalfa Hay | 1,581 | 1,000 tons | 1,400 | $101.00/ton | -$ 18,281,000 |
| Other Hay | 817 | 1,000 tons | 715 | $103.00/ton | -$ 10,506,000 |
| Cattle/Calves Inventory | 1,536 | 1,000 head | 1,400 | $1010.00/head | -$ 137,360,000 |
| **TOTAL** | | | | | **-$ 212,534,000** |

Source: USDA

**Table 4-16 Production and Inventory Value Impact for Worst Year of Drought**

| Commodity | 5-Year Pre-Drought Production Average (1994-1998) | Units | Worst Yearly Production of Drought | Year | Value (USD) | Production and Inventory Value Impact (USD) |
|---|---|---|---|---|---|---|
| Winter Wheat | 6,029 | 1,000 bu. | 2,375 | 2002 | $3.70/bu | -$13,519,800 |
| Spring Wheat | 648 | 1,000 bu. | 96 | 2002 | $3.90/bu | -$2,152,800 |
| Barley | 8,383 | 1,000 bu. | 4,505 | 2007 | $3.62/bu | -$14,038,360 |
| Oats | 1,648 | 1,000 bu. | 376 | 2007 | $2.82/bu | -$3,587,040 |
| Dry Bean | 691 | 1,000 cwt. | 514 | 2001 | $23.00/cwt | -$4,071,000 |
| Sugar Beet | 1,150 | 1,000 tons | 658 | 2007 | $40.20/ton | -$19,778,400 |
| Corn | 6,328 | 1,000 bu. | 4,165 | 2002 | $2.60/bu | -$5,623,800 |
| Alfalfa Hay | 1,581 | 1,000 tons | 1,150 | 2002 | $111.00/ton | -$47,841,000 |
| Other Hay | 817 | 1,000 tons | 450 | 2002 | $106.00/ton | -$38,902,000 |
| Cattle/Calves Inventory | 1,536 | 1,000 head | 1,300 | 2004 | $1,020/head | -$240,720,000 |
| **TOTAL** | | | | | | **-$390,234,200** |

Source: USDA – National Agricultural Statistics Service

The 2000-2004 drought made historical record impacts, with significant negative ramifications particularly on the agricultural industry. The worst-case year was 2002, with a negative dollar impact of $308,171,390 statewide. Region 1 comprises 17.47% of the State of Wyoming in land area. While drought impacts are not always equally distributed across the state, the potential drought impact in Region 1 could nevertheless be estimated to be almost $168 million for the period, based on the region's size alone. The total impact statewide for the 2000-2004 drought was about $961,536,160. The 2002 year alone caused Region 1 about $53,837,542 in production losses.

Another tool provided by the USDA and used to assess commodity and crop losses is the Risk Management Agency's indemnity summaries, which highlight insurance payments to counties based on damages caused to different crops, by specific hazards (such as drought). From 2008 to 2017, the Region 1 counties experienced drought-caused damages to 168,574 acres of land, totaling $6,894,142 in indemnity payments. Table 4-17 below breaks down the drought impacts by county, acreage, and commodity type. The largest losses were associated with forage production. The HMPC also noted that there are livestock sell-offs that also result from drought.

**Table 4-17 Indemnities Paid for Commodities that Suffered from Drought in Region 1, 2008-2017**

| Commodity | Counties Affected | Acres Damaged | Indemnity Amount |
|---|---|---|---|
| Barley | Crook, Campbell, Sheridan | 473 | $13,656 |
| Forage Production | Crook, Campbell, Johnson, Sheridan, Weston | 151,049 | $5,876,584 |
| Forage Seeding | Crook, Campbell | 882 | $61,616 |
| Oats | Crook, Campbell, Weston | 2,089 | $53,023 |
| Wheat | Crook, Campbell, Weston | 10,449 | $688,478 |
| All Other Crops | Johnson, Sheridan, Weston | 3,632 | $200,785 |
| **TOTAL** | | **168,574 acres** | **$6,894,142** |

Source: USDA – Risk Management Agency

In addition to affecting the agricultural industry as well as ranching businesses, drought can exacerbate the risk of wildfires, increase the cost of municipal water usage, and deplete water resources used for recreation and tourism, hence negatively affecting the economy in various ways.

## Vulnerability Assessment

The specific vulnerability of the region to drought is difficult to quantify. Typically, people and structures are not directly vulnerable to drought, although secondary, indirect, and compound impacts may increase vulnerability. Some areas are more vulnerable than others and may therefore benefit from adequate mitigation planning and implementation.

Economically, the agricultural sector is the most vulnerable to drought and will benefit the most from mitigation efforts. Outdoor recreation and tourism, which are important to the region's economy, are also vulnerable to drought. Drought can have a cascading impact on other hazards, notably wildfire, and can lead to increased soil expansion/contraction in expansive soils.

The geographic extent of the hazard is considered **extensive**. The probability of future drought occurrences is considered **likely**, and the potential magnitude/severity is **high**. The HMPC considers the hazard to have an overall impact rating of **high** for the Region.

Vulnerability is tempered somewhat for Johnson and Sheridan counties, due to the Bighorn mountains being a headwaters area. The snowpack in the Bighorn Range helps feed rivers and streams during normal years, but can be affected by dry, low snow pack years.

### Future Development

Future development in the Region is not anticipated to change its vulnerability to drought in a significant way.

### Summary

Drought is considered a high significance hazard for most of the Region due to the extensive economic and environmental impacts. Drought can be widespread and pervasive for several years, affecting more than people's way of life.

**Table 4-18 Drought Hazard Risk Summary**

| County | Geographic Extent | Probability of Future Occurrence | Potential Magnitude/ Severity | Overall Significance |
|---|---|---|---|---|
| Campbell | Significant | Likely | Critical | Medium |
| Crook | Significant | Likely | Critical | High |
| Johnson | Significant | Likely | Limited | Medium |
| Sheridan | Significant | Likely | Critical | High |
| Weston | Significant | Likely | Critical | High |

## 4.2.4 Earthquake

### Hazard/Problem Description

An earthquake is generally defined as a sudden motion or trembling in the earth caused by the abrupt release of strain accumulated within or along the edge of the earth's tectonic plates. The most common types of earthquakes are caused by movements along faults or by volcanic forces, although they can also result from explosions, cavern collapse, and other minor causes not related to slowly accumulated strains.

The amount of energy released during an earthquake is usually expressed as a Richter magnitude and is measured directly from the earthquake as recorded on seismographs. The moment magnitude scale (abbreviated as MMS; denoted as MW or M) is used by seismologists to measure the size of earthquakes in terms of the energy released. The scale was developed in the 1970s to succeed the Richter magnitude scale. Even though the formulas are different, the new scale retains a similar continuum of magnitude values to that defined by the older one. Another measure of earthquake severity is intensity. Intensity is an expression of the amount of shaking at any given location on the ground surface as felt by humans or resulting damage to structures and defined in the Modified Mercalli scale (see Table 4-19). Seismic shaking is typically the greatest cause of losses to structures during earthquakes.

**Table 4-19 Modified Mercalli Intensity (MMI) Scale**

| MMI | Felt Intensity | Acceleration (%g) (PGA) |
|---|---|---|
| I | Not felt except by a very few people under special conditions. Detected mostly by instruments. | <0.17 |
| II | Felt by a few people, especially those on upper floors of buildings. Suspended objects may swing. | 0.17 – 1.4 |
| III | Felt noticeably indoors. Standing automobiles may rock slightly. | 0.17 – 1.4 |
| IV | Felt by many people indoors, by a few outdoors. At night, some people are awakened. Dishes, windows, and doors rattle. | 1.4 – 3.9 |
| V | Felt by nearly everyone. Many people are awakened. Some dishes and windows are broken. Unstable objects are overturned. | 3.9 – 9.2 |
| VI | Felt by everyone. Many people become frightened and run outdoors. Some heavy furniture is moved. Some plaster falls. | 9.2 – 18 |
| VII | Most people are alarmed and run outside. Damage is negligible in buildings of good construction, considerable in buildings of poor construction. | 18 – 34 |
| VIII | Damage is slight in specially designed structures, considerable in ordinary buildings, great in poorly built structures. Heavy furniture is overturned. | 34 – 65 |
| IX | Damage is considerable in specially designed buildings. Buildings shift from their foundations and partly collapse. Underground pipes are broken. | 65 – 124 |
| X | Some well-built wooden structures are destroyed. Most masonry structures are destroyed. The ground is badly cracked. Considerable landslides occur on steep slopes. | >124 |
| XI | Few, if any, masonry structures remain standing. Rails are bent. Broad fissures appear in the ground. | >124 |
| XII | Virtually total destruction. Waves are seen on the ground surface. Objects are thrown in the air. | >124 |

Source: USGS. http://earthquake.usgs.gov/learn/topics/mercalli.php, Modified Mercalli Intensity and peak ground acceleration (PGA) (Wald, et al 1999).

Earthquakes can cause structural damage, injury, and loss of life, as well as damage to infrastructure networks, such as water, power, communication, and transportation lines. Other damaging effects of earthquakes include surface rupture, fissuring, ground settlement, and permanent horizontal and vertical shifting of the ground. Secondary impacts can include landslides, seiches, liquefaction, fires, and dam failure. The combination of widespread primary and secondary effects from large earthquakes make this hazard potentially devastating.

Part of what makes earthquakes so destructive is that they generally occur without warning. The main shock of an earthquake can usually be measured in seconds, and rarely lasts for more than a minute. Aftershocks can occur within the days, weeks, and even months following a major earthquake.

By studying the geologic characteristics of faults, geoscientists can often determine when the fault last moved and estimate the magnitude of the earthquake that produced the last movement. Because the occurrence of earthquakes is relatively infrequent in Region 5 and the historical earthquake record is short, accurate estimations of magnitude, timing, or location of future dangerous earthquakes in the Region are difficult to estimate.

### *Liquefaction*

During an earthquake, near surface (within 30 feet), relatively young (less than 10,000 years old), water-saturated sands and silts may act as a viscous fluid. This event is known as liquefaction (quicksand is a result of liquefaction). Liquefaction occurs when water-saturated materials are exposed to seismic waves. These seismic waves may compact the material (i.e. silts and sands), increasing the interior pore water pressure within the material mass.

When the pore pressure rises to about the pressure of the weight of the overlying materials, liquefaction occurs. If the liquefaction occurs near the surface, the soil bearing strength for buildings, roads, and other structures may be lost. Buildings can tip on their side, or in some cases sink. Roads can shift and become unstable to drive on. If the liquefied zone is buried beneath more competent material, cracks may form in the overlying material, and the water and sand from the liquefied zone can eject through the cracks as slurry.

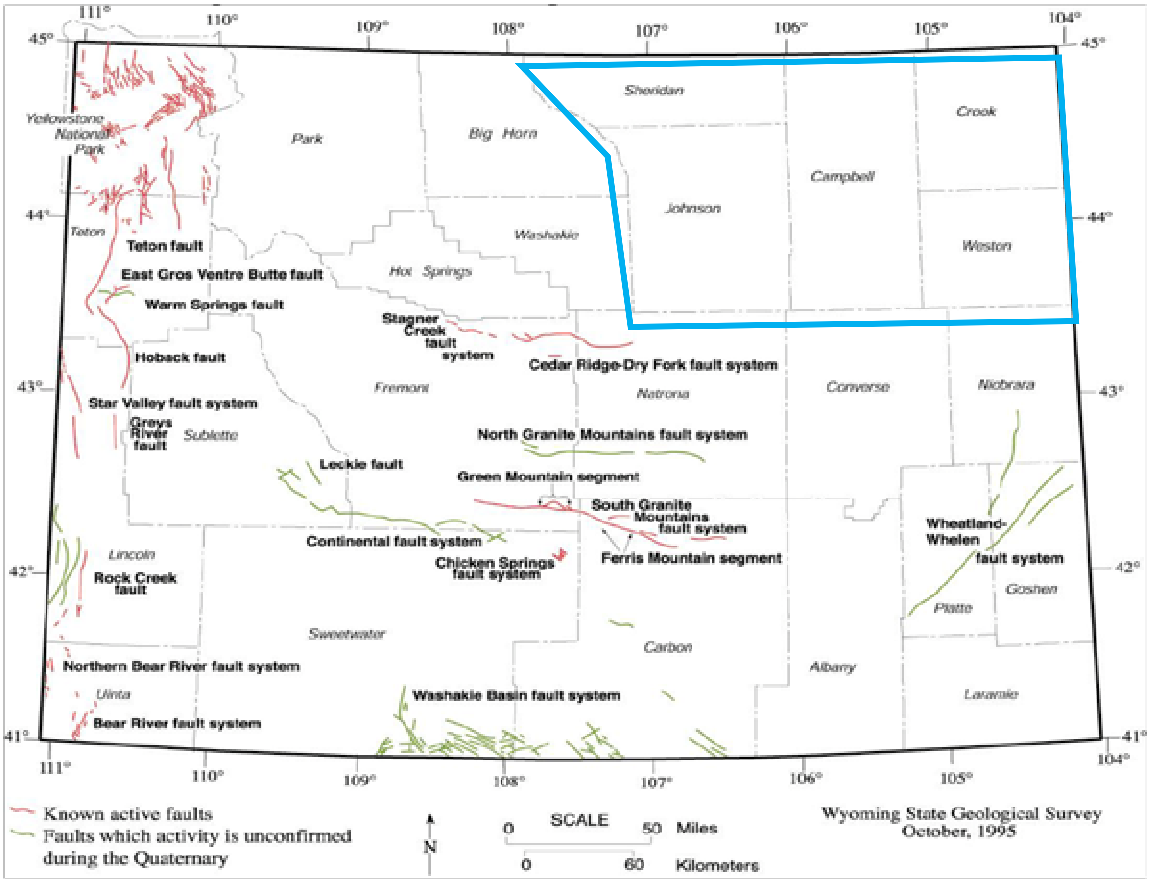
## Geographical Area Affected

Most Wyoming earthquakes outside of Yellowstone National Park occur as a result of movement on faults. If the fault has moved within the Quaternary geological period, or last 1.6 million years, the fault is considered to be active. Active faults can be exposed at the surface or deeply buried with no significant surface expression. Historically, no earthquakes in Wyoming have been associated with exposed active faults. The exposed active faults, however, have the potential to generate the largest earthquakes. As a result, it is necessary to understand both exposed and buried active faults in order to generate a realistic seismological characterization of the state.

There are approximately 80 Quaternary faults mapped in Wyoming, with 26 considered active (Source: www.wsgs.wyo.gov). All of the exposed active faults are outside of Region 1. The Cedar Ridge-Dry Fork in northern Fremont and Natrona counties is the closest fault system capable of generating a magnitude 6.5+ earthquake. Additionally, the Stagner Creek fault system near Boysen Reservoir and the South Granite Mountain fault system near Jeffrey City, are both considered potentially active and capable of generating magnitude 6.5 to 6.75 earthquakes.

A dynamic magma chamber beneath Yellowstone National Park, combined with regional tectonic forces, results in significant seismic activity. Many of the earthquakes are associated with movement of hydrothermal fluids in the subsurface. Some deeper earthquakes may be related to fluids within or around the magma chamber. Earthquakes which may be related to active faults also occur in the park. Yellowstone is a super-volcano, and it has explosively erupted 0.64 million, 1.3 million, and 2.1 million years ago. The explosive eruptions led to the formation of three giant calderas, the collapse of which led to the formation of faults. In addition, after major eruptions, resurgent domes formed within the calderas. The doming process led to the formation of other faults; as a result, many of the faults in Yellowstone are not considered major threats. There are other faults, however, that are easily capable of generating magnitude 6.5+ earthquakes (State Hazard Mitigation Plan 2016). Refer to the following figure; the box indicates Region 1.

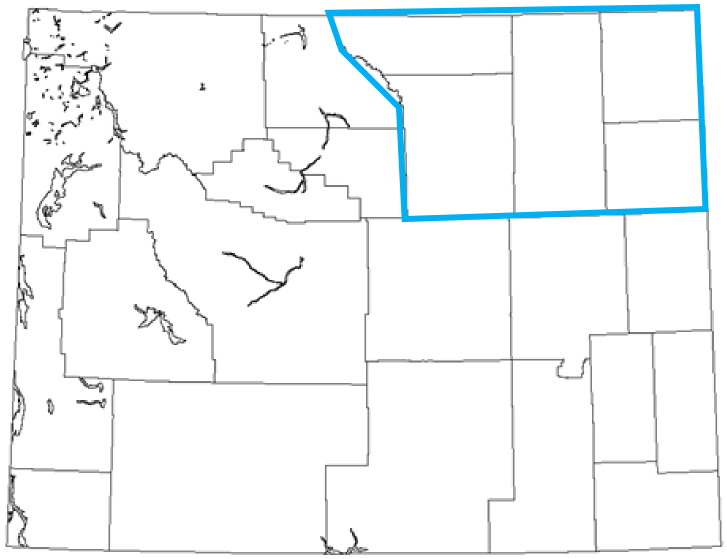
**Figure 4-6  Exposed Known or Suspected Active Faults in Wyoming**




Source: Wyoming Geological Survey
Blue square denotes Region 1 planning area

Figure 4-7 shows areas in Wyoming that could experience liquefaction during an intense earthquake. Areas shown have sands and coarse silts that are less than 10,000 years in age and are within 30 feet of the surface. As indicated by the box on the map, Region 1 does not contain any areas susceptible to liquefaction

**Figure 4-7 Wyoming Liquefaction Coverage**



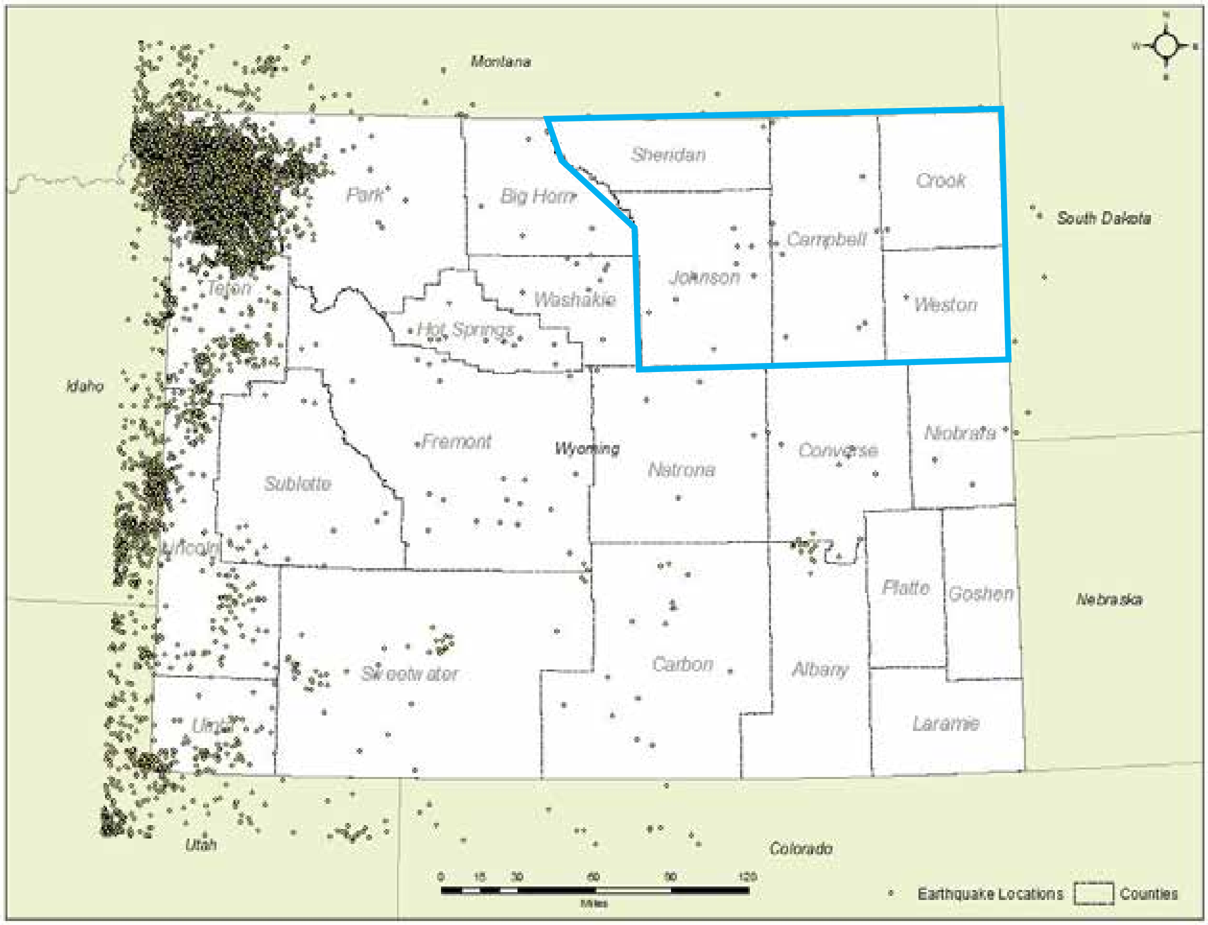
Source: Wyoming Geological Survey
Blue box denotes Region 1 planning area

## Past Occurrences

Prior to the 1950s, most earthquakes were detected and located by personal reports. After the Hebgen Lake earthquake in 1959 near Yellowstone Park, monitoring in Wyoming started to improve and earthquakes were more commonly located by seismometers.

Since 1871, the state has logged some 47,000 earthquakes, with the majority of the events taking place in the western third of the state (see Figure 4-8) where the majority of the potentially active, or Quaternary Period, faults are identified.

**Figure 4-8 Wyoming Historic Earthquake Occurrences Statewide 1963- 2010**




Source: Wyoming Geological Survey - Wyoming Earthquake Hazard and Risk Analysis: HAZUS-MH Loss Estimations for 16 Earthquake Scenarios Report
Blue square denotes Region 1 planning area

Historically, earthquakes have occurred in every county in Wyoming. The first was reported in Yellowstone National Park in 1871. Data on instrumentally recorded earthquakes is available from the USGS Earthquake Hazards Program dating back to 1973. Five magnitude 4.5 and greater earthquakes have been recorded in the Region since 1973, with two of these events taking place in Johnson County, and three in Campbell County. These earthquakes are noted in the tables below and discussed in further detail below by county.

### *Johnson County*

There have been 8 earthquake events that have occurred in Johnson County since 1922. Most of these events fall in the 4.0-4.9/IV-V intensity range, though an earthquake was recorded in 1984 at a magnitude 5.1. These events are presented in the table below and described further in the following text.

**Table 4-20 Johnson County Seismic Events, 1922 – 2018**

| Location | Date | Magnitude/Intensity | Damage or Injuries |
|---|---|---|---|
| 8 Miles east of Sheridan | 10/24/1922 | IV-V | No |
| 3-4 Miles Southwest of Buffalo | 10/6/1943 | IV-V | No |
| 12 Miles South of Kaycee | 6/3/1965 | 4.7 | No |
| Kaycee | 10/2/1976 | 4.8 | No |
| 33 Miles East-Southeast of Buffalo | 10/7/1984 | 5.1 | No |
| 18 Miles East of Buffalo | 2/22/1992 | 2.9 | No |

Source: http://earthquake.usgs.gov and Wyoming Geological Survey

The following excerpts are from a report published for the Wyoming State Geological Survey in 2002 entitled "Basic Seismological Characterization for Johnson County, Wyoming".

The first earthquake recorded in the county occurred on October 24, 1922. Reagor, Stover, and Algermissen (1985) located the earthquake near Buffalo. The Sheridan Post reported that at Cat Creek, 8 miles east of Sheridan, houses were shaken and dishes were rattled. In addition, the October 26, 1922 edition of the Sheridan Post reports that only a slight earthquake shock was felt in Sheridan. Based upon this information, it seems reasonable to locate the earthquake 8 miles east of Sheridan, and to assign an intensity of IV-V to the event.

On September 6, 1943, an intensity IV earthquake was felt in the Sheridan area, although Reagor, Stover, and Algermissen (1985) located the epicenter approximately 3-4 miles south-southwest of Buffalo. Beds and chairs were reported "to sway" in the Sheridan area (The Casper Tribune Herald, September 7, 1943).

Two earthquakes were recorded in Johnson County in the 1960s. A magnitude 4.7 earthquake occurred on June 3, 1965. This event was centered approximately 12 miles south of Kaycee.

On September 2, 1976, a magnitude 4.8, intensity IV-V earthquake was felt in Kaycee. The event was located approximately 33 miles northeast of Kaycee. No damage was reported.

A magnitude 5.1, intensity V earthquake occurred on September 7, 1984, approximately 33 miles east-southeast of Buffalo. The earthquake was felt throughout northeastern Wyoming, including Buffalo, Casper, Kaycee, Linch, and Midwest, and in parts of southeastern Montana. No significant damage was reported (Laramie Daily Boomerang, September 8, 1984).

Two earthquakes were detected in Johnson County in 1992. The first occurred on February 22, 1992. This magnitude 2.9 event was recorded approximately 18 miles east of Buffalo. As expected with such a small earthquake, no damage was reported. Most recently, a magnitude 3.6, intensity IV earthquake occurred on August 30, 1992. The earthquake was centered near Mayoworth, approximately 22 miles west-northwest of Kaycee. It was felt in Barnum and Kaycee, but no damage was reported.

Several earthquakes have also occurred near Johnson County. Two earthquakes occurred near the Johnson County-Campbell County border in 1984. On May 29, 1984, a magnitude 5.0, intensity V earthquake occurred approximately 38 miles east-southeast of Buffalo. The earthquake was felt in Gillette, Sheridan, Buffalo, Casper, Douglas, Thermopolis, and Sundance. A rancher, living 35 miles west of Gillette, reported that he could see the ground shaking, and he heard a loud noise similar to a sonic boom. Pictures were shaken from the walls of the ranch house, but no other damage occurred at the ranch (Casper Star-Tribune, May 30, 1984). All other reports only indicated that dishes rattled. On October 29, 1984, a magnitude 2.5 earthquake occurred approximately 35 miles east of Buffalo. No damage was reported.

### *Campbell County*

Campbell County has the highest number of reported earthquake events within Region 1. There have been eleven recorded earthquakes in Campbell County since 1967. These earthquakes are detailed in the table below and discussed in more detail in the following text. It should be noted that Campbell County has experienced over 300 events of greater than 3.0 magnitude recorded by the USGS and attributable to mining explosions and quarry blasts.

**Table 4-21 Campbell County Seismic Events, 1976 – 2018**

| Location | Date | Magnitude/Intensity | Damage or Injuries |
|---|---|---|---|
| SW Campbell County | 5/11/1976 | 4.8 | No |
| 18 Miles East of Gillette | 2/18/1972 | 4.3 | No |
| 33 Miles NE of Kaycee | 9/2/1976 | 4.8 | No |
| 24 Miles SW of Gillette | 5/29/1984 | 5.0 | No |
| 25 Miles SW of Gillette | 10/29/1984 | 2.5 | No |
| 27 Miles West of Gillette | 9/7/1984 | 5.1 | No |
| SE Campbell County | 2/24/1993 | 3.6 | No |
| 10 Miles East of Weston | 9/4/2004 | 2.8 | No |
| 40 Miles West of Gillette | 12/6/2008 | 2.5 | No |
| North Campbell County | 3/31/2009 | 2.6 | No |
| 7 Miles NE of Wright | 1/20/2011 | 3.2 | No |

Source: http://earthquake.usgs.gov and Wyoming Geological Survey

The following excerpts are from a report published for the Wyoming State Geological Survey in 2002 entitled “Basic Seismological Characterization for Campbell County, Wyoming.”

The first earthquake recorded in the county occurred on May 11, 1967. This magnitude 4.8 earthquake was centered in southwestern Campbell County approximately 7 miles west-northwest of Pine Tree Junction. The second event took place on February 18,1972, when a magnitude 4.3 earthquake occurred approximately 18 miles east of Gillette. No damage was reported for either event (Case, Toner, Kirkwood WGS 2002).

Two earthquakes were recorded in Campbell County during the 1980s. On May 29, 1984, a magnitude 5.0, intensity V earthquake occurred approximately 24 miles west-southwest of Gillette. The earthquake was felt in Gillette, Sheridan, Buffalo, Casper, Douglas, Thermopolis, 2 and Sundance. A rancher, living 35 miles west of Gillette, reported that he could see the ground shaking, and he heard a loud noise similar to a sonic boom. Pictures were shaken from the walls of the ranch house, but no other damage occurred at the ranch (Casper Star-Tribune, May 30, 1984). Surprisingly, all other reports only indicated that dishes rattled. On October 29, 1984, a magnitude 2.5 earthquake occurred approximately 25 miles west-northwest of Gillette. No damage was reported.

On February 24, 1993, a magnitude 3.6 earthquake occurred in southeastern Campbell County approximately 10 miles east-southeast of Reno Junction. No damage was reported.

Earthquakes have also occurred near the Campbell County-Johnson County border. On September 2, 1976, a magnitude 4.8, intensity IV-V earthquake occurred approximately 33 miles northeast of Kaycee and 38 miles west-southwest of Gillette. Although the event was felt in Kaycee, no damage was reported. A magnitude 5.1, intensity V earthquake was reported on September 7, 1984, approximately 27 miles west of Gillette. The earthquake was felt throughout northeastern Wyoming, including Buffalo, Casper, Kaycee, Linch, and Midwest, and parts of southeastern Montana. No significant damage was reported (Laramie Daily Boomerang, September 8, 1984).

***Sheridan County***

Sheridan County has experience four seismic events in the past 95 years. These earthquakes ranged from intensity III-IV and did not result in any damages or injuries. They are identified in the table below and described further in the following text.

**Table 4-22 Sheridan County Seismic Events, 1923 – 2018**

| Location | Date | Magnitude/Intensity | Damage or Injuries |
|---|---|---|---|
| 6.5 Miles Southwest of Sheridan | 1/17/1923 | III | No |
| 3 Miles East-Northeast of Sheridan | 4/26/1953 | IV | No |
| 6 miles Southwest of Big Horn | 3/24/1977 | 3.6 | No |
| Northeastern Sheridan County | 2/25/1993 | 3.9 | No |

Source: http://earthquake.usgs.gov and Wyoming Geological Survey

The following excerpts are from a report published for the Wyoming State Geological Survey in 2002 entitled "Basic Seismological Characterization for Johnson County, Wyoming."

Only one earthquake occurred in Sheridan County during the 1920s. On January 17, 1923, an intensity III earthquake occurred 6.5 miles southwest of Sheridan. No damage was reported from this event. Sheridan County did not experience another earthquake until the mid-1900s. On April 26, 1953, an intensity IV earthquake was reported approximately 3 miles east-northeast of Sheridan. Area residents reported that some beds were rocked, dishes were rattled, and some electrical wires swayed (Murphy and Cloud, 1955).

A magnitude 3.6, intensity IV earthquake was reported on March 24, 1977, approximately 6 miles south-southwest of Big Horn. No damage was associated with this event.

More recently, a 3.9 magnitude earthquake occurred in northeastern Sheridan County on February 25, 1993. This earthquake was centered approximately 19 miles north-northeast of Arvada. No damage was reported.

Several earthquakes have also occurred near Sheridan County. An intensity IV earthquake was felt in the Sheridan area on September 6, 1943, causing beds and chairs "to sway" (Casper Tribune-Herald, September 7, 1943). The epicenter of this earthquake was later found to be near Buffalo, approximately 21 miles south-southeast of Story (Reagor, Stover, and Algermissen, 1985). On September 2, 1962, an earthquake was recorded in Big Horn County, approximately 12.5 miles south-southwest of Burgess Junction. No one reported damage or feeling this event. (U.S.G.S. National Earthquake Information Center). Two earthquakes were recorded near Sheridan County in 1976.

On August 8, 1976, a magnitude 3.4 earthquake occurred in southern Montana, approximately 25 miles northeast of Sheridan. A few months later, on October 8, 1976, a magnitude 3.5 earthquake was detected in the same area. According to the U.S.G.S. National Earthquake Information Center, no one reported feeling either event. A magnitude 5.1, intensity V earthquake occurred in Johnson County on September 7, 1984, approximately 32 miles southeast of Clearmont. The earthquake was felt throughout northeastern Wyoming, including Buffalo, Casper, Kaycee, Linch, and Midwest, and in parts of southeastern Montana. No significant damage was reported (Laramie Daily Boomerang, September 8, 1984).

### *Crook County*

Since 1972, there has only been one recorded seismic events in Crook County. The intensity was reported to be in the IV-V intensity scale, with no associated damages or injuries.

**Table 4-23 Crook County Seismic Events, 1972 – 2018**

| Location | Date | Magnitude/Intensity | Damage or Injuries |
|---|---|---|---|
| 18 Miles East of Gillette | 2/18/1972 | IV | No |

Source: http://earthquake.usgs.gov and Wyoming Geological Survey

The following excerpts are from a report published for the Wyoming State Geological Survey in 2002 entitled "Basic Seismological Characterization for Crook County, Wyoming."

On February 18, 1972, a magnitude 4.3 earthquake occurred approximately 18 miles east of Gillette near the Crook County-Campbell County border. No damage was reported.

### *Weston County*

There has only been one recorded earthquake event with an epicenter in Weston County. This intensity IV event occurred in 1926 and is identified in the table below and described further in the following text.

**Table 4-24 Weston County Seismic Events, 1926 – 2018**

| Location | Date | Magnitude/Intensity | Damage or Injuries |
|---|---|---|---|
| 15 miles Northwest of Newcastle | 5/1/1926 | IV | No |

Source: http://earthquake.usgs.gov and Wyoming Geological Survey

The following excerpts are from a report published for the Wyoming State Geological Survey in 2002 entitled "Basic Seismological Characterization for Weston County, Wyoming".

The only reported earthquake in Weston County occurred near Osage on May 1, 1926, about 15 miles north-northwest of Newcastle. Several individuals felt this earthquake as an intensity IV event, and there were reports of dishes shifting and objects moving (Neumann, 1928).

### *Regional Summary*

**Table 4-25 Earthquakes Greater than M 2.5 in Region 1: 1968 – 2018**

| County | Magnitude 2.5-2.9 Intensity I | Magnitude 3.0-3.9 Intensity II-III | Magnitude 4.0-4.9 Intensity IV-V | Magnitude 5.0-5.9 Intensity VI-VII | Total |
|---|---|---|---|---|---|
| Johnson | 1 | - | 2 | 1 | 4 |
| Campbell | 4 | 2 | 2 | 2 | 10 |
| Sheridan | - | - | 2 | | 2 |
| Crook | - | - | 1 | | 1 |
| Weston | - | - | - | - | - |
| **Total** | **5** | **2** | **7** | **3** | **17** |

Source: Analysis of data from USGS Earthquake Hazards Program and Wyoming Geological Survey

**Table 4-26 Ten Highest Magnitude* Earthquakes in Region 1: 1968 – 2018**

| County | Magnitude/Intensity | Date |
|---|---|---|
| Johnson | 5.1 | 10/7/1984 |
| Campbell | 5.1 | 9/7/1984 |
| Campbell | 5.0 | 5/29/1984 |
| Johnson | 4.8 | 10/2/1976 |
| Campbell | 4.8 | 5/11/1976 |
| Campbell | 4.8 | 9/2/1976 |
| Campbell/Crook | 4.3 | 2/18/1972 |
| Sheridan | 3.9 | 2/25/1993 |
| Campbell | 3.6 | 2/24/1993 |
| Sheridan | 3.6 | 3/24/1977 |

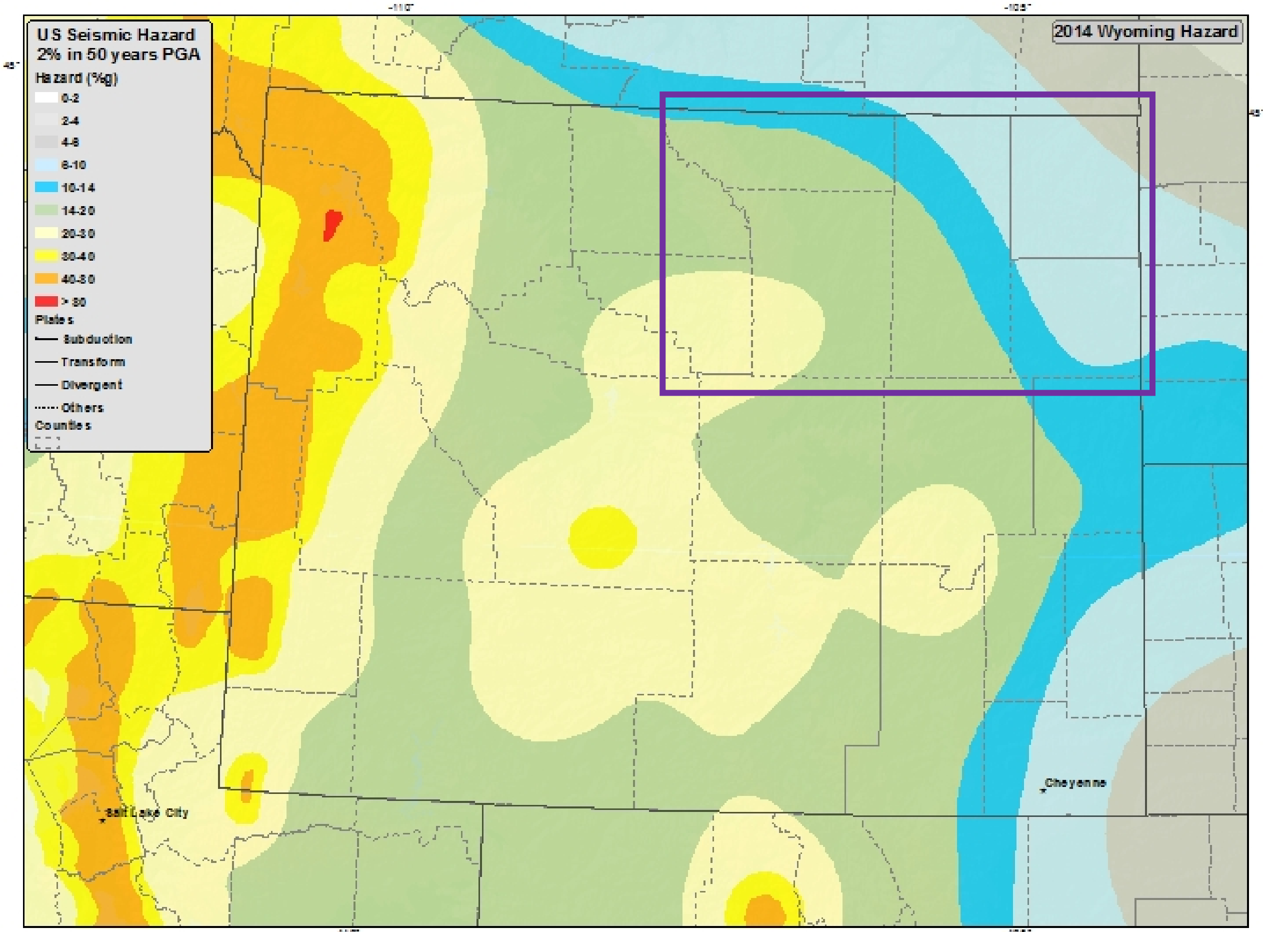
*Based on instrumentally recorded earthquakes.
Source: USGS Earthquake Hazards Program and Wyoming Geological Survey

## Frequency/Likelihood of Occurrence

With a total of 17 recorded earthquakes with a magnitude greater than 2.5 in the last 50 years, the region is likely to experience an earthquake almost every three years; or a somewhat **likely** occurrence rating. However also based on past occurrences, the earthquakes are likely to cause little to no damage. To determine the likelihood of damaging earthquakes the U.S. Geological Survey (USGS) publishes probabilistic acceleration maps for 500-, 1000-, and 2,500-year time frames. The maps show what accelerations may be met or exceeded in those time frames by expressing the probability that the accelerations will be met or exceeded in a shorter time frame. For example, a 10% probability that acceleration may be met or exceeded in 50 years is roughly equivalent to a 100% probability of exceedance in 500 years. The 2,500-year (2% probability of exceedance in 50 years) map is shown in the figure below. The International Building Code uses a 2,500-year map as the basis for building design. The maps reflect current perceptions on seismicity in Wyoming based on available science. In many areas of Wyoming, ground accelerations shown on the USGS maps can be increased further due to local soil conditions. For example, if fairly soft, saturated sediments are present at the surface, and seismic waves are passed through them, surface ground accelerations will usually be greater than would be experienced if only bedrock was present. In this case, the ground accelerations shown on the USGS maps would underestimate the local hazard, as they are based upon accelerations that would be expected if firm soil or rock were present at the surface.

As the historic record is limited, it is nearly impossible to determine when a 2,500-year event last occurred in the Region. Because of the uncertainty involved, and based upon the fact that the International Building Code utilizes 2,500-year events for building design, it is suggested that the 2,500-year probabilistic maps be used for regional and county analyses. This conservative approach is in the interest of public safety.

**Figure 4-9 2500-year Probabilistic Acceleration Map (2% Probability of Exceedance in 50 years)**




Source: Wyoming Geological Survey
Purple square denotes Region 1 planning area

## Potential Magnitude

Limited damages have been documented in the Region from historic earthquakes. Because of the limited historic record, however, it is possible to underestimate the seismic hazard in the Region if historic earthquakes are used as the sole basis for analysis. Earthquake and ground motion probability maps give a more reasonable estimate of damage potential in areas with or without exposed active faults at the surface. Current earthquake probability maps that are used in the newest building codes suggest a scenario that would result in moderate damage to buildings and their contents.

Some HMPCs noted concerns about damage to hospitals from an earthquake. The presence of historic buildings that include unreinforced masonry buildings in many of the region’s towns and cities was also noted as a potential vulnerability.

## Vulnerability Assessment

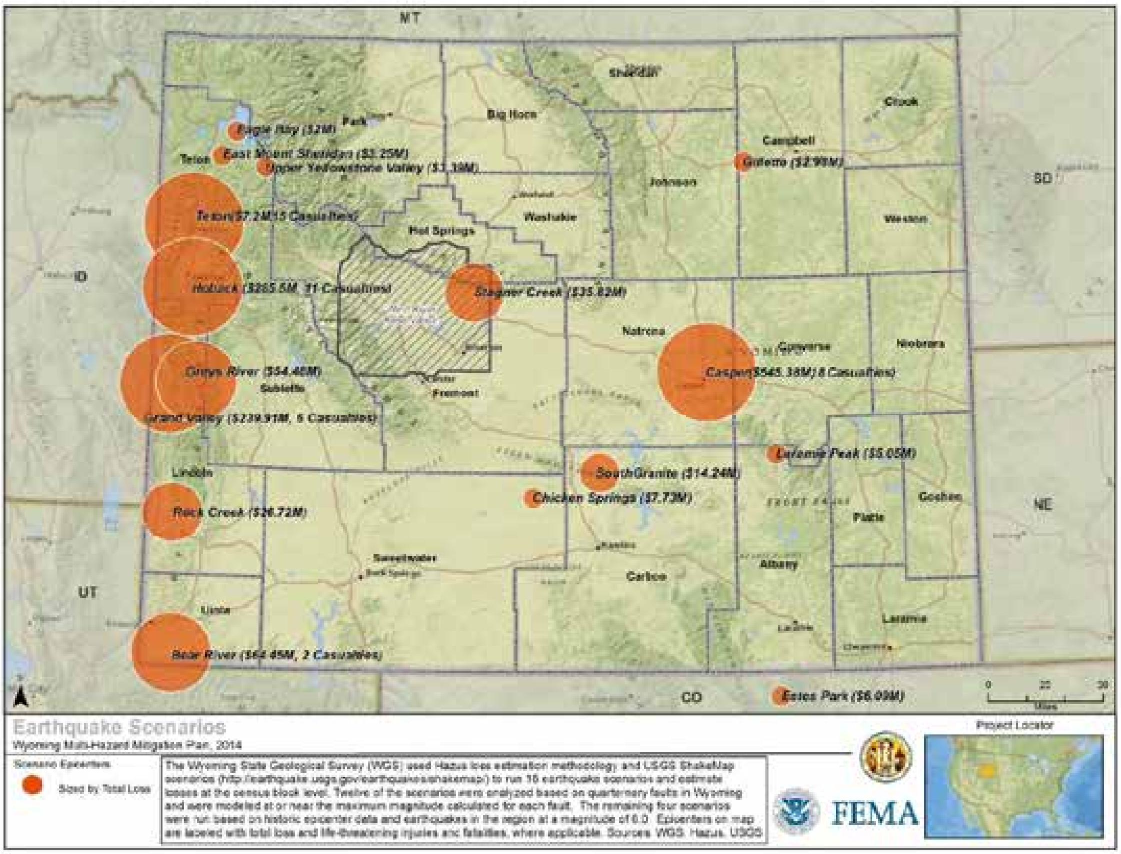
The Wyoming State Geological Survey conducted a study in 2011 to model loss estimations for 16 earthquake scenarios in order to quantify the magnitude of earthquake impacts around the state. The scenarios included four random event scenarios run on the basis of data from historic earthquakes that occurred near Casper, Gillette, Laramie Peak, and Estes Park (Colorado). Each of the historic, random event earthquake scenarios registered a 6.0 magnitude. The Estes Park Scenario was based on an event occurring in 1882, the Casper area event in 1897, and the Gillette and Laramie Peak events in 1984 (Source: Wyoming Geological Survey, "Wyoming Earthquake Hazard and Risk Analysis: HAZUS-MH Loss Estimations for 16 Earthquake Scenarios, 2011*)*

HAZUS (Hazards U.S.) is a nationally standardized, GIS-based, risk assessment and loss estimation computer program that was originally designed in 1997 to provide the user with an estimate of the type, extent, and cost of damages and losses that may occur during and following an earthquake. It was developed for the FEMA by the National Institute of Building Sciences (NIBS). There have been a number of versions of HAZUS generated by FEMA, with HAZUS-MH (HAZUS - Multi-Hazard) being the most recent release.

The study included information regarding the likelihood of damage to local and regional infrastructure, including fire stations, police stations, sheriffs' departments, schools, and hospitals. The scenarios reflect anticipated functionality of each infrastructure system immediately following the scenario earthquake, on day seven following the earthquake and one month after the earthquake. Additional information provided includes anticipated households displaced or seeking temporary shelter, electrical outages anticipated, number of households without potable water, debris generated by the scenario and economic losses resulting from three categories: buildings, transportation and utilities.

The map in Figure 4-10 shows epicenter locations of the scenarios, sized by total loss. Epicenters on map are labeled with total loss and if applicable, life-threatening injuries and fatalities.

**Figure 4-10    Hazus-MH Earthquake Scenarios for Wyoming, 2011**




(Source: Wyoming Multi-Hazard Mitigation Plan, 2014)

### *Random Event Scenario – Gillette Area Historic Earthquake*

The Gillette Area historic earthquake scenario had the most impact on all counties in Region 1, with the most significant effects felt in Campbell and Johnson County. The earthquake scenario was modeled at magnitude 6.0. Scenario results estimate that light damage would be expected up to 14 miles from the epicenter, with very light damage expected out to 42 miles. The scenario results estimate that no households would be displaced, and no one would seek temporary shelter. There are 25,836 buildings in the area and scenario results show that 96 of those would sustain at least moderate damage from the earthquake. The earthquake would generate 1,000 tons of debris.

The modeled earthquake in the Gillette historic earthquake area would cause a total economic loss of $3.86 million dollars for the region. Direct economic losses are estimated in three categories: buildings, transportation, and utilities. Estimated ground shaking levels for essential facilities are described below.

*Buildings*

Direct economic losses for buildings, which include structural and content damage, would total $2.669 million dollars for the region. Campbell County would experience the greatest loss at $2.35 million dollars, while Johnson County is modeled to have $265,000 dollars in direct losses for buildings, followed by Sheridan County at $54,000.

*Transportation*

In total, the Region would experience $266 million dollars in loss to transportation systems. Campbell County would have the highest transportation losses at $266 million dollars, while Johnson County would experience $26,000 in transportation losses. The losses include damage to highways, bridges, and facilities for railways, buses, and airports.

*Utilities*

The regional direct economic loss for utilities would be $580,000 dollars. Losses to potable water, waste water, and natural gas facilities and pipelines, along with communication facilities would be expected.

*Essential Facilities*

Essential facilities include fire stations, hospitals, police stations, and schools. As shown in Table 4-27, essential facilities that would experience damaging ground motion include 3 fire stations, 1 hospital, 1 police station, and 21 schools. Most of these are expected to have minor damage at most.

**Table 4-27 Critical Facility Impacts - Gillette Area Historic Earthquake**

| Name | City | Functionality | | PGA (%g) | Damage | | |
|---|---|---|---|---|---|---|---|
| | | Day 1 | Day 7 | | Slight | Moderate | Extensive |
| Campbell County FD Station 4 | Gillette | 96.3 | 98.7 | 6.01 | 3.62 | 1.21 | 0.1 |
| Campbell County FD Station 3 | Gillette | 97.2 | 99 | 5.28 | 2.78 | 0.88 | 0.07 |
| Clearmont Vol FD | Clearmont | 98.1 | 99.4 | 4.35 | 1.84 | 0.054 | 0.04 |
| Campbell County Memorial Hospital | Gillette | 100 | 100 | 4 | - | - | - |
| Campbell County Sherriff's Department Headquarters | Gillette | 100 | 100 | 4 | - | - | - |
| Sunflower Elementary | Gillette | 97 | 98.9 | 5.43 | 2.95 | 0.94 | 0.08 |
| 4-J Elementary | Gillette | 98.5 | 99.8 | 4.93 | 1.4 | 0.12 | 0.01 |
| Arvada-Clearmont High School | Clearmont | 98.1 | 99.4 | 4.36 | 1.85 | 0.54 | 0.04 |
| Arvada-Clearmont Junior High | Clearmont | 98.1 | 99.4 | 4.36 | 1.85 | 0.54 | 0.04 |
| Clearmont Elementary | Clearmont | 99 | 99.8 | 4.36 | 0.99 | 0.078 | 0 |
| Pronghorn Elementary | Gillette | 98.1 | 99.4 | 4.33 | 1.84 | 0.54 | 0.04 |
| Paintbrush Elementary | Gillette | 98.2 | 99.4 | 4.19 | 1.7 | 0.49 | 0.04 |
| Sage Valley Junior High | Gillette | 98.2 | 99.4 | 4.19 | 1.7 | 0.49 | 0.04 |
| Arvada Elementary | Arvada | 99.3 | 99.9 | 3.76 | 0.65 | 0.05 | 0 |

| Name | City | Functionality | | PGA (%g) | Damage | | |
|---|---|---|---|---|---|---|---|
| | | Day 1 | Day 7 | | Slight | Moderate | Extensive |
| Wagonwheel Elementary | Gillette | 98.8 | 99.6 | 3.57 | 1.19 | 0.32 | 0.02 |
| Rawhide Elementary | Gillette | 98.8 | 99.6 | 3.56 | 1.18 | 0.32 | 0.02 |
| Stocktrail Elementary | Gillette | 98.8 | 99.6 | 3.48 | 1.12 | 0.3 | 0.2 |

Source: Wyoming State Geological Survey

### *Probabilistic Scenario*

In the Wyoming Multi-Hazard Mitigation Plan, HAZUS 2.1 was used to develop losses associated with a 2,500-year probabilistic earthquake scenarios for each county in the State of Wyoming. This scenario uses USGS probabilistic seismic contour maps to model ground shaking with a 2% probability of being exceeded in 50 years (or a 2,500-year event). Total losses include building, contents, inventory, and income-related losses.

The following table lists total loss, loss ratio (total loss/total building inventory value), and ranges of casualties within severity levels. HAZUS provides casualty estimates for 2 am, 2 pm, and 5 pm to represent periods of the day that different sectors of the community are at their peak occupancy loads. The casualty ranges represent the lowest to highest casualties within these times of day. Casualty severity levels are described as follows:

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

The table is sorted and ranked by total loss.

There are two methods for ranking counties to determine where earthquake impacts may be the greatest. Either loss ratios or total damage figures can be used. The loss ratio is determined by dividing the sum of the structural and non-structural damage by the total building value for the county. The loss ratio is a better measure of impact for a county, since it gives an indication of the percent of damage to buildings.

**Table 4-28 2500-Year Probabilistic Scenario Loss Estimates**

| Rank | County | Total Loss ($M) | Loss Ratio | Casualties Level 1 | Casualties Level 2 | Casualties Level 3 | Casualties Level 4 |
|---|---|---|---|---|---|---|---|
| 1 | Teton | $654 | 27% | 150-300 | 40-90 | 0-20 | 10-30 |
| 2 | Lincoln | $528 | 63% | 190-220 | 50-60 | 0-20 | 10-20 |
| 3 | Natrona | $268 | 11% | 50-60 | 10 | 0 | 0 |
| 4 | Uinta | $247 | 18% | 90-120 | 20-30 | 0-10 | 0-10 |
| 5 | Sweetwater | $181 | 19% | 50 | 10 | 0 | 0 |
| 6 | Fremont | $115 | 25% | 20 | 0 | 0 | 0 |
| 7 | Laramie | $105 | 4% | 20 | 0 | 0 | 0 |
| 8 | Sheridan | $84 | 9% | 20 | 0 | 0 | 0 |
| 9 | Albany | $81 | 21% | 20 | 0 | 0 | 0 |
| 10 | Campbell | $79 | 14% | 20 | 0 | 0 | 0 |
| 11 | Park | $79 | 1% | 20 | 0 | 0 | 0 |
| 12 | Sublette | $74 | 6% | 20 | 0-10 | 0 | 0 |
| 13 | Carbon | $64 | 1% | 10 | 0 | 0 | 0 |
| 14 | Converse | $50 | 28% | 10 | 0 | 0 | 0 |
| 15 | Washakie | $28 | 1% | 10 | 0 | 0 | 0 |
| 16 | Big Horn | $26 | 4% | 0-10 | 0 | 0 | 0 |
| 17 | Johnson | $25 | 1% | 0-10 | 0 | 0 | 0 |
| 18 | Platte | $20 | 3% | 0 | 0 | 0 | 0 |
| 19 | Hot Springs | $20 | 1% | 0 | 0 | 0 | 0 |
| 20 | Goshen | $11 | 1% | 0 | 0 | 0 | 0 |
| 21 | Weston | $7 | 0% | 0 | 0 | 0 | 0 |
| 22 | Crook | $5 | 1% | 0 | 0 | 0 | 0 |
| 23 | Niobrara | $4 | 1% | 0 | 0 | 0 | 0 |
| | ***Total*** | **$2,755** | | | | | |

Source: Wyoming State Hazard Mitigation Plan 2016

The total damage figure by itself does not reflect the percentage of building damage, since small damage to a number of valuable buildings may result in a higher total damage figure than may be found in a county with fewer, less expensive buildings, with a higher percentage of damage.

### *Liquefaction Vulnerability*

There have been little, if any, reported damages from liquefaction in Wyoming. Given that ground motions associated with Intensity VIII or larger are usually needed to trigger liquefaction, and that only small areas of the Region would experience that level of shaking during the 2% event (2% probability of exceedance in 50 years), liquefaction would be a rare occurrence in the Region

### Future Development

Future development in the Region is not anticipated to extensively change vulnerability to earthquake significantly.

### Summary

There are not any active faults within the region, but previous occurrence data indicates potential for damaging seismic activity in Campbell and Johnson counties. In summary, within Region 1, the two counties have the highest level of susceptibility and structural exposure. Though the probability is low, WSGS studies indicate the possibility of a 6.5 magnitude could occur anywhere in the state.

**Table 4-29 Earthquake Hazard Risk Summary**

| County | Geographic Extent | Probability of Future Occurrence | Potential Magnitude/ Severity | Overall Significance |
|---|---|---|---|---|
| Campbell | Limited | Occasional | Limited | Medium |
| Crook | Limited | Occasional | Negligible | Low |
| Johnson | Limited | Occasional | Limited | Medium |
| Sheridan | Limited | Occasional | Negligible | Low |
| Weston | Limited | Occasional | Negligible | Low |

## 4.2.5 Expansive Soils

### Hazard/Problem Description

Expansive soils contain clay which causes the material to increase in volume when exposed to moisture and shrink as it dries. They are also commonly known as expansive, shrinking and swelling, bentonitic, heaving, or unstable soils.

The clay materials in swelling soils are capable of absorbing large quantities of water and expanding 10% or more as the clay becomes wet. The force of expansion is capable of exerting pressures of 15,000 pounds per square foot or greater on foundations, slabs, and other confining structures. (Ibid., p 17.) The amount of swelling (or potential volume of expansion) is linked to five main factors: the type of mineral content, the concentration of swelling clay, the density of the materials, moisture changes in the environment, and the restraining pressure exerted by materials on top of the swelling soil. Each of these factors impact how much swelling a particular area will experience, but may be modified, for better or worse, by development actions in the area.

- **Low—**this soils class includes sands and silts with relatively low amounts of clay minerals. Sandy clays may also have low expansion potential, if the clay is kaolinite. Kaolinite is a common clay mineral.
- **Moderate—**this class includes silty clay and clay textured soils, if the clay is kaolinite, and also includes heavy silts, light sandy clays, and silty clays with mixed clay minerals.
- **High—**this class includes clays and clay with mixed montmorillonite, a clay mineral which expands and contracts more than kaolinite.

## Geographical Area Affected

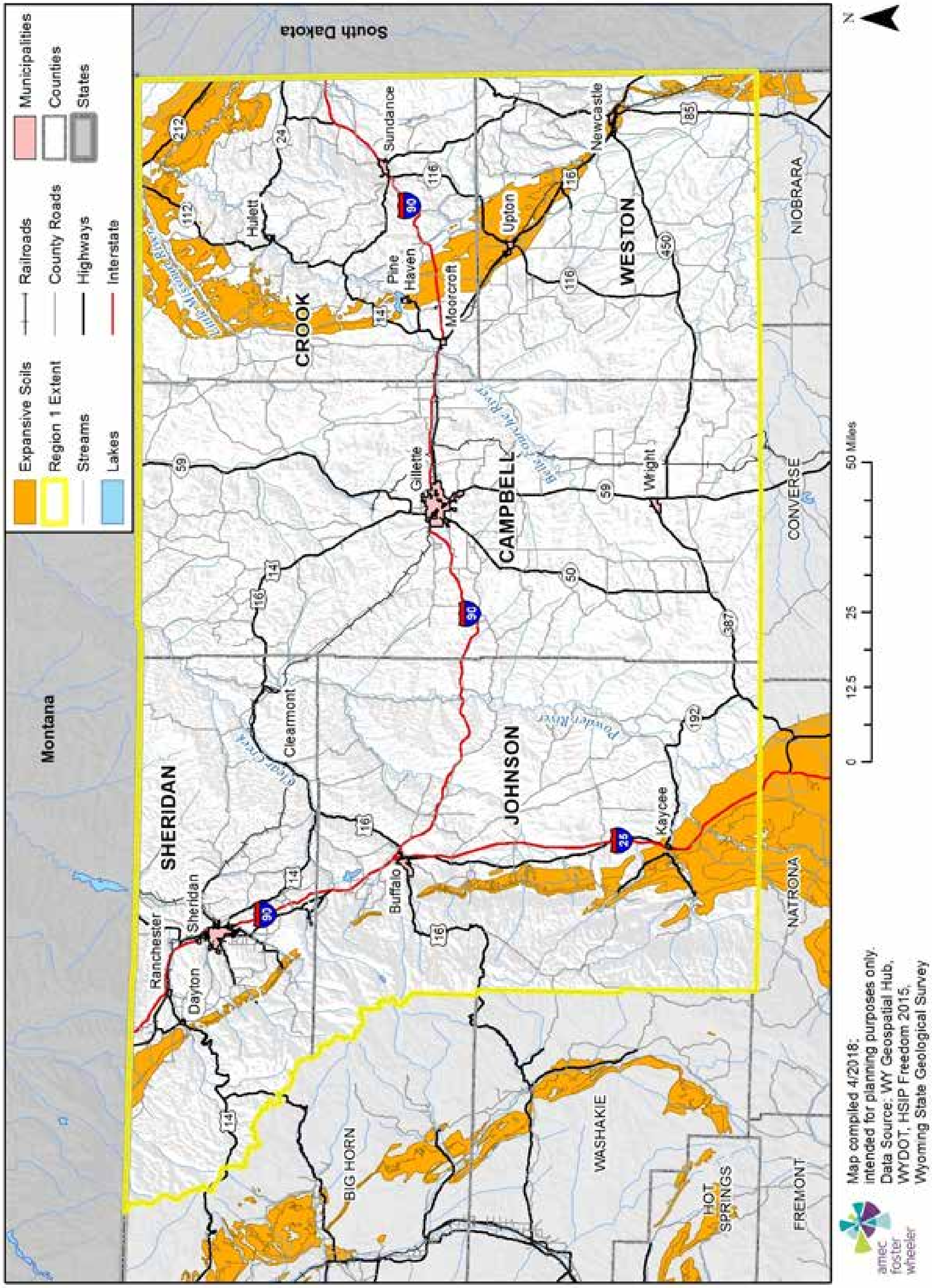
Expansive soils occur throughout the Region. Figure 4-11 and Figure 4-12 illustrate possible expansive soils locations in Wyoming. Figure 4-12 is based on select geologic formations that have characteristics that could lead to expansive soils where they outcrop.

The Campbell County HMPC observed that the statewide hazard mapping does not accurately characterize the extent of expansive soils in Campbell County. It is a continuous issue, especially in Wright. There are also concerns about possibly collapsible soils affecting subdivisions in Gillette. Campbell County, the City of Gillette and Town of Wright have spent over $500,000 on soils remediation for a new fire station in Wright in the last three years; the school district has also dealt with expansive soils issues at great cost for years, and similar concerns have occurred all over the county. The HMPC felt the hazard significance should be upgraded.

Johnson County noted that Kaycee has regular sinkhole problems west of town, including one incident where shifting soils led to broken saddles on a water main. Weston County reported broken foundations in some residences, and has had problems with Highway 85 south of Newcastle. A proposed middle school site was denied due to potential impacts of expansive soils. Sheridan County has not reported any impacts from expansive soils.

The HMPCs reported that the U.S. Bureau of Land Management in coordination with Wyoming DOT is working on updating their expansive soils mapping. Additionally, the Natural Resources Conservation Service (NCRS) is conducting research to identify expansive soils in Campbell County.

## Figure 4-11 Expansive Soil Potential in Region 1



## Figure 4-12 Wyoming Mapped Formations with Potential for Expansive Soils


Source: State of Wyoming Multi-Hazard Mitigation Plan 2016

## Table 4-30 Percentage of Land Area Susceptible to Expansive Soils

| County | % Expansive Soils |
|---|---|
| Campbell | 0% |
| Crook | 20.21% |
| Johnson | 8.95% |
| Sheridan | 2.66% |
| Weston | 8.69% |
| **Regional Average** | **7.33%** |

Source: State of Wyoming Geospatial Hub

Although the mapping data does not show any identified expansive soils area within Campbell County, the County has experienced expansive soil problems.

Based on the figures above, expansive soils have the potential to affect a **negligible** portion of the planning area. The geographic extent of any individual expansive soil incident is likely to be extremely localized as well.

### Past Occurrences

Very little data exists on expansive soil problems and damages in Wyoming. Studies on the issue have not been performed and no database exists to catalog occurrences. The 2016

State of Wyoming Multi-Hazard Mitigation Plan lists no known events in Region 1. Damages due to expansive soils such as foundation cracks, parking lot/sidewalk cracks, etc. do occur but are generally handled by individual property owners. Other damages to supply lines, roads, railways, bridges and power lines typically occur over time and are not attributed to or reported as an event.

### Frequency/Likelihood of Occurrence

Historical data on expansive soils issues was not readily available, making frequency difficult to extrapolate. Based on HMPC discussions, expansive soils are Likely to continue to be an occasional problem for the jurisdictions in Region 1.

### Potential Magnitude

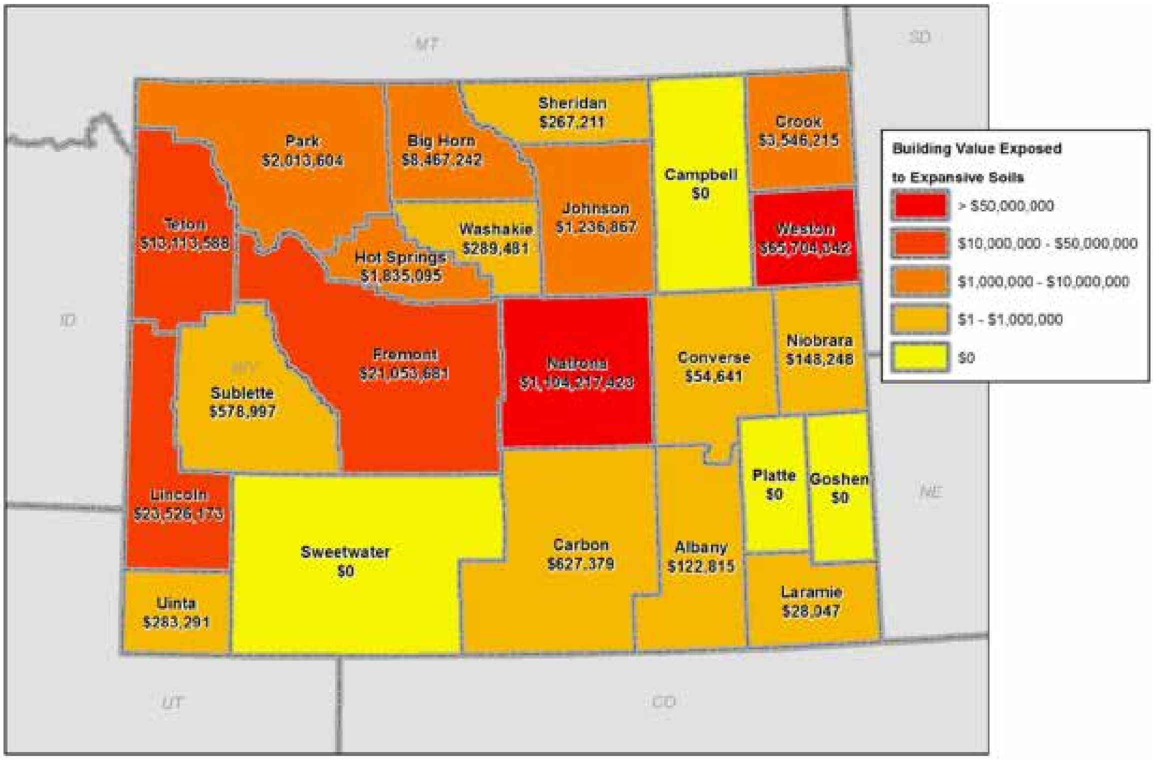
The potential magnitude of expansive soils events and damages is estimated to be Negligible for the counties in the Region, with limited and isolated impacts. Because damages from expansive soils are difficult to track due to limited reporting, it is difficult to estimate the potential severity of a problem. Expansive soils can create localized damage to individual structures and supply lines, such as roads, railways, bridges and power lines, but no significant impacts have been reported.

### Vulnerability Assessment

According to the Wyoming State Multi-Hazard Mitigation Plan there are two measurements used for calculating potential impacts: historic dollar damages and building exposure values. There is not enough current data to accurately estimate historic damages.

The Wyoming State Geological Survey (WSGS) calculated the building exposure values for buildings that may occur within the areas of expansive soils. All expansive soils mapped have been digitized and the expansive soil layer was then digitally crossed with the Census block building values. In the event of an expansive soil boundary dissecting a census block, the proportional value of the buildings in the census block will be assigned to the expansive soil. In a case where a census block is within an expansive soil, the combined values of all the buildings in the census block are assigned. The values derived by county are shown in the map below.

## Figure 4-13 Wyoming Building Exposure to Shrinking-Swelling Clays




Source: Wyoming State Hazard Mitigation Plan 2016

These values represent exposure and the potential for damage, not a true loss estimate. Weston County is 2nd highest in the state ($65M) for value of buildings at risk from expansive soils. On the other hand, Campbell County's risk is shown as being essential nonexistent, although as noted above evidence suggests this is not the case. Critical facilities within expansive soils areas include emergency response facilities (police, fire, EMS, etc.), infrastructure nodes (transmission towers, electric substations, refineries), and community resources (schools, nursing homes, daycare facilities). Damage from these soils will be individual events, damaging a small number of buildings or road segments over time.

## Table 4-31 Critical Facilities Vulnerable to Mapped Expansive Soil Hazards

| County | Jurisdiction | Facility Type | Facility Count |
|---|---|---|---|
| Crook | Pine Haven | EMS Stations | 1 |
| | Pine Haven | Fire Stations | 1 |
| | Pine Haven | Microwave Service Towers | 2 |
| | Unincorporated | Electric Substations | 1 |
| | | County Total: | 5 |
| Johnson | Kaycee | EMS Stations | 1 |
| | Kaycee | Fire Stations | 1 |
| | Unincorporated | Cellular Towers | 4 |

| County | Jurisdiction | Facility Type | Facility Count |
|---|---|---|---|
| | Unincorporated | Microwave Service Towers | 11 |
| | | County Total: | 17 |
| Sheridan | Unincorporated | Public Schools | 1 |
| | | County Total: | 1 |
| Weston | Newcastle | Day Care Facilities | 5 |
| | Newcastle | Electric Substations | 1 |
| | Newcastle | EMS Stations | 1 |
| | Newcastle | Fire Stations | 1 |
| | Newcastle | Hospitals | 1 |
| | Newcastle | Local Law Enforcement | 1 |
| | Newcastle | Nursing Homes | 1 |
| | Newcastle | Public Schools | 2 |
| | Newcastle | Oil Refinery | 1 |
| | Upton | Day Care Facilities | 1 |
| | Upton | Electric Substations | 3 |
| | Upton | EMS Stations | 1 |
| | Upton | Fire Stations | 1 |
| | Upton | Local Law Enforcement | 1 |
| | Upton | Public Schools | 2 |
| | Unincorporated | AM Transmission Towers | 1 |
| | Unincorporated | Cellular Towers | 4 |
| | Unincorporated | Electric Substations | 11 |
| | Unincorporated | EMS Stations | 1 |
| | Unincorporated | Fire Stations | 1 |
| | Unincorporated | FM Transmission Towers | 2 |
| | Unincorporated | Microwave Service Towers | 23 |
| | Unincorporated | Natural Gas Plants | 1 |
| | | County Total: | 69 |
| | | **Grand Total:** | **92** |

Source: Homeland Infrastructure Foundation-Level Data (HIFLD)

## Future Development

Modern building practices incorporate mitigation techniques, provided proper geotechnical testing is employed to identify expansive soils. If areas prone to expansive soils are identified, future areas for development will need to take this hazard into account.

### Summary

Overall, expansive soils are a low significance hazard for the counties in the region. While the impacts of individual expansive soils incidents are fairly limited, the HMPCs indicated that it is a more significant risk for them than the data indicates. Additional research and mapping is needed, particularly in Campbell County, to better understand the extent of the hazard.

**Table 4-32 Expansive Soil Hazard Risk Summary**

| County | Geographic Extent | Probability of Future Occurrence | Potential Magnitude/ Severity | Overall Significance |
|---|---|---|---|---|
| Campbell | Limited | Likely | Negligible | Medium |
| Crook | Limited | Likely | Negligible | Low |
| Johnson | Limited | Likely | Negligible | Low |
| Sheridan | Negligible | Likely | Negligible | Low |
| Weston | Limited | Likely | Negligible | High |

## 4.2.6 Flood

### Hazard/Problem Description

Floods can and have caused significant damage in Region 1, and are one of the more significant natural hazards in the Region. They have caused millions of dollars in damage in just a few hours or days. A flood, as defined by the National Flood Insurance Program, is a general and temporary condition of partial or complete inundation of two or more acres of normally dry land area, or of two or more properties from: overflow of waters; unusual and rapid accumulation or runoff of surface waters from any source; or, a mudflow. Floods can be slow or fast rising, but generally develop over a period of hours or days. Causes of flooding relevant to the Region include:

- Rain in a general storm system
- Rain in a localized intense thunderstorm
- Melting snow
- Rain on melting snow
- Urban stormwater drainage
- Hail drifts clogging stormwater drainage
- Ice Jams
- Dam failure
- Levee Failure
- Rain on fire damaged watersheds

The area adjacent to a river channel is its floodplain. In its common usage, "floodplain" most often refers to that area that is inundated by the 100-year flood, the flood that has a 1% chance in any given year of being equaled or exceeded. The 100-year flood is the national standard to which communities regulate their floodplains through the National Flood Insurance Program. This is also called the Special Flood Hazard Area (SFHA) on flood insurance maps and in floodplain management ordinances.

Riverine flooding occurs when a watercourse exceeds its "bank-full" capacity; this is usually the most common type of flood event. Riverine flooding generally occurs as a result of prolonged rainfall, or rainfall that is combined with soils already saturated from previous rain events. Slow rise floods associated with snowmelt and sustained precipitation usually are preceded with adequate warning, though the event can last several days.

Floods can also occur with little or no warning and can reach full peak in only a few minutes. Such floods are called flash floods. A flash flood usually results from intense storms dropping large amounts of rain within a brief period. Flash floods, by their nature, occur very suddenly but usually dissipate within hours. Even flash floods are usually preceded with warning from the National Weather Service, in terms of flash flood advisories, watches, and warnings. Intense hail can exacerbate flooding problems by clogging stormwater drains and causing water to back up.

Floods can occur for reasons other than precipitation or rapidly melting snow. They can also occur because of ice jams. An ice jam is a stationary accumulation of ice that restricts flow. Ice jams can cause considerable increases in upstream water levels, while at the same time downstream water levels may drop. Types of ice jams include freeze up jams, breakup jams, or combinations of both. Floods arising from these types of ice jams can be slow or fast rising, but generally develop over a period of many hours or days.

Levee failure can also cause a flash flood and poses a risk in the region. A levee is an earthen embankment constructed along the banks of rivers, canals, and coastlines to protect adjacent lands from flooding by reinforcing the banks. However, by confining the flow, levees can also increase the speed of the water. Levees can be natural or man-made. A natural levee is formed when sediment settles on the river bank, raising the level of the land around the river. To construct a man-made levee, workers pile dirt or concrete along the river banks, creating an embankment. This embankment is flat at the top, and slopes at an angle down to the water. For added strength, sandbags are sometimes placed over dirt embankments. Natural disasters such as Hurricane Katrina demonstrate that, although levees can provide strong flood protection, they are not failsafe. Levees can *reduce* the risk to individuals and structures behind them, but they do not eliminate risk entirely. Levees are designed to protect against a specific flood level; severe weather could create a higher flood level that the levee cannot withstand. Levees can fail by either overtopping or breaching. Overtopping occurs when floodwaters exceed the height of a levee and flow over its crown. As the water passes over the top, it may erode the levee, worsening the flooding and potentially causing an opening, or breach, in the levee. A levee breach occurs when part of a levee gives way, creating an opening through which floodwaters may pass. A breach may occur gradually or suddenly. The most dangerous breaches happen quickly during periods of high water. The resulting torrent can quickly swamp a large area behind the failed levee with little or no warning. Unfortunately, in the rare occurrence when a levee system fails or is overtopped, severe flooding can occur due to increased elevation differences associated with levees and the increased water velocity that is created. It is also important to remember that no levee provides protection from events for which it was not designed, and proper operation and maintenance are necessary to reduce the probability of failure.

The potential for flooding can also change and increase through various land use changes and changes to land surface. A change in the built environment can create localized flooding problems inside and outside of natural floodplains, by altering or confining watersheds or natural drainage channels. These changes are commonly created by human activities. Flooding in the communities in Region 1 could be exacerbated by inadequate drainage and channel systems that would not stand up to the 1% annual chance flood. Inadequate culverts and drainage systems can flood and adjacent properties. Refer to the specific county annexes for a description of localized problems.

Increased flooding can also be created by other hazards such as wildfires. Wildfires create hydrophobic soils, a hardening or "glazing" of the earth's surface that prevents rainfall from being absorbed into the ground, thereby increasing runoff, erosion, and downstream sedimentation of channels.

## Geographical Area Affected

All counties within the planning region have the potential for flooding. The extent of the flooding varies based on the location of the county, and on what part of the county is being examined. Detailed geographic flood assessments are provided later in this section for each county and flood-prone community.

The counties of Region 1 are predominantly located in the Northeast Wyoming River Basin and the Powder/Tongue River Basin. In addition, the northwest corner of Sheridan county crosses slightly onto the Big Horn Basin. The Northeast Wyoming River Basin encompasses the basins of the Little Missouri River, Cheyenne River, and Belle Fourche River, among other smaller ones.

The Little Missouri River originates near Devils Tower, close to the Crook and Campbell county boundaries, and flows northeast into North Dakota, draining into the Missouri River. Some tributaries to the Little Missouri River within the Region 1 boundaries include the Prairie Creek River (falling between Campbell and Crook counties), the North Fork Little Missouri River (also between the two counties), and Thompson Creek, touching on the north/northwest edge of Crook County.

The Cheyenne River originates south of the Region, touching on the edges of Campbell and Weston counties. The river flows east to South Dakota, and north onto the Missouri River. The Cheyenne River is approximately 295 miles long, and drains over 24 thousand square miles into the basin named after it. The river has some major tributaries including Dry Fork Creek and Antelope Creek.

The Belle Fourche River originates near south Campbell County, and is a tributary to the Cheyenne River. It flows north towards the northeast corner of Crook County, then southeast into South Dakota to meet the Cheyenne River. The Belle Fourche is about 290 miles long, and many of its contributing tributary streams originate in the Black Hills mountains, crossing the Wyoming/South Dakota boundaries.

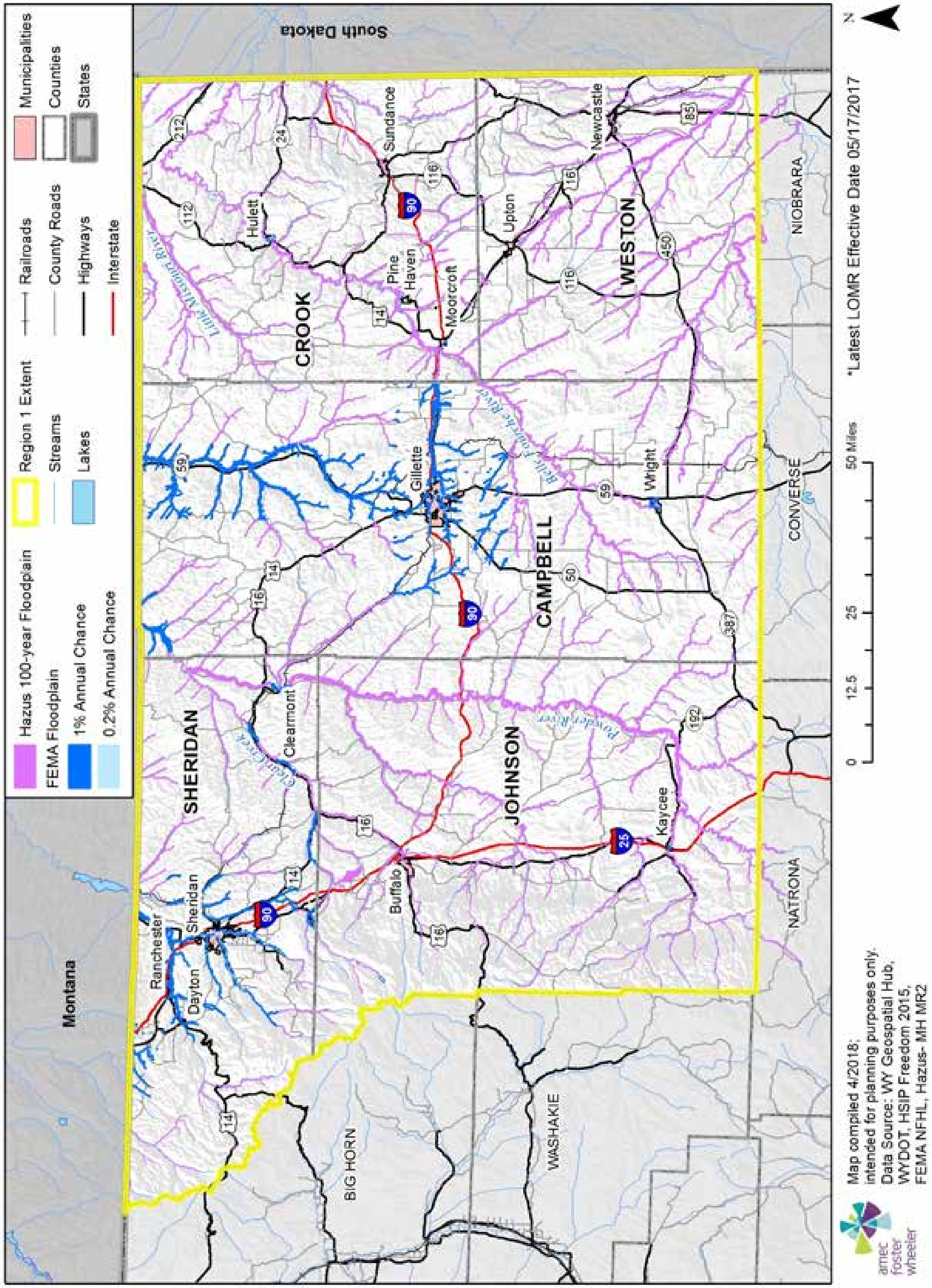
The Tongue River is approximately 265 miles long, and originates in the Big Horn Mountains west of Sheridan County. It flows northeast into Montana, finally merging into the Yellowstone River. Some major rivers within the Region that drain into the Tongue River include Wolf Creek, Big and Little Goose Creeks, and Prairie Dog Creek.

Another major tributary of the Yellowstone River, the Powder River, encompasses three main forks originating on the Big Horn Mountains, all of which meet near Kaycee, Johnson County. The Powder River is around 375 miles long, flowing north and east of Johnson and into Sheridan and then Campbell County (from where it connects to Montana). Major tributaries flowing into the Powder River include Crazy Woman Creek, Ninemile Creek, Salt Creek, Clear Creek, and Buffalo Creek.

The only major river within the Big Horn River Basin and the Region 1 area is the Little Big Horn River, which originates northwest of Sheridan County (in the Big Horn Mountains), then flows north to join the Big Horn River on the Montana side. The Little Big Horn River is approximately 138 miles long.

The geographic extent rating for Region 1 is **significant**, meaning that a flood event could impact 10-50% of the planning area. The following sections detail the extent and history of flood hazards in the Region. The figure below shows the Region 1 Flood Hazards, highlighting both the available Digital Flood Insurance Rate Maps (DFIRM) layers from FEMA, for parts of Sheridan and Campbell, as well as Hazus-derived flooding area estimates (portrayed in purple) to supplement those provided by the federal agency. Both DFIRM and Hazus derived datasets are utilized in the maps to follow, as only limited parts of the region contain updated flooding study information.

## Figure 4-14    Region 1 Flood Hazards



## Past Occurrences

A brief history of significant floods is presented below by county. A damaging flood occurs in the area every year or two on average, based upon the historical data presented below. The data indicates that Johnson County has had the largest number and most damaging floods in the Region.

**Table 4-33 NCEI Flood Events in Campbell County**

| Type | Location | Date | Property Damage | Crop Damage |
|---|---|---|---|---|
| Flood | Gillette | 6/14/1996 | $0 | $0 |
| Flood | Recluse | 7/18/1997 | $0 | $0 |
| Flash Flood | Weston | 6/22/1998 | $0 | $0 |
| Flash Flood | Wright | 7/1/1998 | $0 | $0 |
| Flash Flood | Wright | 7/1/1998 | $0 | $0 |
| Flash Flood | Gillette | 7/2/1998 | $0 | $0 |
| Flash Flood | Gillette | 5/28/2001 | $400,000 | $0 |
| Flash Flood | Wright | 7/13/2004 | $0 | $0 |
| Flash Flood | Wright | 7/13/2004 | $0 | $0 |
| Flood | Northern Campbell (Zone) | 6/24/2005 | $0 | $0 |
| Flood | Weston | 5/5/2007 | $0 | $0 |
| Flood | Gillette | 5/5/2007 | $58,000 | $0 |
| Flood | Gillette | 6/7/2007 | $ | $0 |
| Flood | Weston | 6/7/2007 | $0 | $0 |
| Flood | Rockypoint | 5/23/2008 | $0 | $0 |
| Flash Flood | Recluse | 7/22/2008 | $0 | $0 |
| Flash Flood | Echeta | 5/26/2013 | $25,000 | $0 |
| Flash Flood | Wright | 8/1/2013 | $150,000 | $0 |
| Flash Flood | Wright | 8/9/2013 | $0 | $0 |
| Flash Flood | (Gcc)Gillette Arpt | 5/24/2014 | $10,000 | $0 |
| Flood | Recluse | 5/27/2015 | $0 | $0 |
| Flash Flood | Savageton | 6/3/2015 | $1,000 | $0 |
| Flood | Savageton | 6/3/2015 | $1,000 | $0 |
| Flood | Rockypoint | 6/4/2015 | $0 | $0 |
| **TOTAL** | | | **$645,000** | **$0** |

Source: NCEI

## Table 4-34 NCEI Flood Events in Crook County

| Type | Location | Date | Property Damage | Crop Damage |
|---|---|---|---|---|
| Flood | Aladdin | 6/4/2001 | $0 | $0 |
| Flash Flood | Sundance | 6/30/2001 | $0 | $0 |
| Flood | Moorcroft | 5/5/2007 | $0 | $0 |
| Flood | Moorcroft | 5/23/2008 | $0 | $0 |
| Flood | Colony | 6/5/2008 | $100,000 | $0 |
| Flash Flood | Colony | 5/18/2010 | $0 | $0 |
| Flood | Lightning Flat | 5/21/2011 | $0 | $0 |
| Flash Flood | Oshoto | 7/2/2011 | $0 | $0 |
| Flood | Colony | 3/11/2012 | $0 | $0 |
| Flood | New Haven | 5/31/2013 | $60,000 | $0 |
| Flood | New Haven | 6/1/2013 | $100,000 | $0 |
| Flash Flood | Sundance | 7/22/2014 | $0 | $0 |
| Flash Flood | Moorcroft | 6/17/2015 | $5,000 | $0 |
| Flood | Moorcroft | 7/27/2017 | $1,000 | $0 |
| **TOTAL** | | | **$266,000** | **$0** |

Source: NCEI

## Table 4-35 NCEI Flood Events in Johnson County

| Type | Location | Date | Property Damage | Crop Damage |
|---|---|---|---|---|
| Flood | Bighorn Mountains Southeast (Zone) | 1/29/1996 | $2,000 | $0 |
| Flood | Bighorn Mountains Southeast (Zone) | 3/13/1996 | $0 | $0 |
| Flash Flood | Barnum | 6/8/1997 | $0 | $0 |
| Flash Flood | Buffalo | 6/8/1997 | $0 | $0 |
| Flash Flood | Southwest Portion | 7/30/1998 | $0 | $0 |
| Flash Flood | Southwest Portion | 7/30/1998 | $0 | $0 |
| Flash Flood | Kaycee | 5/17/2000 | $0 | $0 |
| Flash Flood | Kaycee | 5/17/2000 | $0 | $0 |
| Flash Flood | Kaycee | 5/17/2000 | $0 | $0 |
| Flash Flood | Kaycee | 7/10/2001 | $0 | $0 |
| Flash Flood | Kaycee | 7/10/2001 | $18,000 | $0 |
| Flash Flood | Buffalo | 8/21/2002 | $0 | $0 |
| Flash Flood | South Portion | 8/26/2002 | $0 | $0 |
| Flash Flood | Kaycee | 8/26/2002 | $459,000 | $0 |
| Flash Flood | Buffalo | 6/19/2003 | $60,000 | $0 |
| Flash Flood | Buffalo | 8/7/2006 | $1,400 | $0 |
| Flash Flood | Kaycee | 7/19/2007 | $50,000 | $2,000 |
| Flood | Buffalo Arpt | 5/22/2008 | $50,000 | $0 |
| Flood | Mayoworth | 5/22/2008 | $0 | $0 |
| Flash Flood | Mayoworth | 7/12/2009 | $5,000 | $0 |
| Flood | Buffalo | 6/8/2010 | $0 | $0 |

| Type | Location | Date | Property Damage | Crop Damage |
|---|---|---|---|---|
| Flash Flood | Barnum | 7/12/2011 | $0 | $0 |
| Flash Flood | Barnum | 7/4/2013 | $0 | $10,000 |
| Flash Flood | Kaycee | 7/5/2013 | $50,000 | $0 |
| Flash Flood | Buffalo | 5/24/2014 | $0 | $0 |
| Flash Flood | Kaycee | 5/24/2015 | $0 | $0 |
| Flood | Buffalo | 5/24/2015 | $0 | $0 |
| Flood | Kaycee | 5/24/2015 | $50,000 | $250,000 |
| Flood | Sussex | 5/25/2015 | $5,000 | $0 |
| Flash Flood | Buffalo | 6/3/2015 | $10,000 | $0 |
| Flash Flood | Buffalo | 6/3/2015 | $1,500,000 | $0 |
| Flash Flood | Linch | 6/3/2015 | $0 | $0 |
| Flash Flood | Buffalo | 6/12/2017 | $0 | $0 |
| **TOTAL** | | | **$2,260,400** | **$262,000** |

Source: NCEI

## Table 4-36 NCEI Flood Events in Sheridan County

| Type | Location | Date | Property Damage | Crop Damage |
|---|---|---|---|---|
| Flash Flood | Sheridan | 6/15/1996 | $0 | $0 |
| Flood | Sheridan | 8/19/1998 | $20,000 | $0 |
| Flash Flood | Sheridan | 7/14/2001 | $0 | $0 |
| Flash Flood | Sheridan | 8/21/2002 | $0 | $0 |
| Flood | Sheridan Foothills (Zone) | 5/7/2005 | $0 | $0 |
| Flood | Sheridan Foothills (Zone) | 5/8/2005 | $0 | $0 |
| Flood | Sheridan Foothills (Zone) | 5/11/2005 | $0 | $0 |
| Flash Flood | (Shr)Sheridan Co Arp | 6/6/2007 | $0 | $0 |
| Flood | (Shr)Sheridan Co Arp | 6/6/2007 | $0 | $0 |
| Flood | Sheridan | 6/7/2007 | $0 | $0 |
| Flash Flood | Sheridan | 7/7/2007 | $0 | $0 |
| Flash Flood | (Shr)Sheridan Co Arp | 6/22/2010 | $0 | $0 |
| Flood | Parkman | 5/20/2011 | $520,000 | $0 |
| Flash Flood | Ft Mackenzie | 5/24/2011 | $0 | $0 |
| Flash Flood | Ft Mackenzie | 5/24/2011 | $0 | $0 |
| Flood | Dayton | 5/25/2011 | $0 | $0 |
| Flood | Ranchester | 6/8/2011 | $0 | $0 |
| Flood | Clearmont | 2/22/2012 | $0 | $0 |
| Flash Flood | Ft Mackenzie | 6/11/2013 | $0 | $0 |
| Flood | (Shr)Sheridan Co Arp | 5/24/2015 | $0 | $0 |
| Flash Flood | Sheridan Co Arp | 6/5/2015 | $0 | $0 |
| Flash Flood | Big Horn | 6/10/2015 | $0 | $0 |
| **TOTAL** | | | **$540,000** | **$0** |

Source: NCEI

## Table 4-37 NCEI Flood Events in Weston County

| Type | Location | Date | Property Damage | Crop Damage |
|---|---|---|---|---|
| Flash Flood | Four Corners | 7/2/1998 | $0 | $0 |
| Flash Flood | Upton | 7/24/1998 | $0 | $0 |
| Flood | Upton | 6/4/2001 | $0 | $0 |
| Flash Flood | Newcastle | 8/12/2005 | $100,000 | $0 |
| Flood | Newcastle | 5/23/2008 | $0 | $0 |
| Flash Flood | Osage | 5/9/2011 | $163,000 | $0 |
| Flash Flood | Upton | 5/24/2011 | $50,000 | $0 |
| Flash Flood | Osage | 7/17/2012 | $5,000 | $0 |
| Flash Flood | Four Corners | 6/21/2013 | $25,000 | $0 |
| Flash Flood | Rochelle | 7/28/2013 | $100,000 | $0 |
| Flash Flood | Osage | 8/7/2013 | $10,000 | $0 |
| Flash Flood | Osage | 6/10/2015 | $0 | $0 |
| Flash Flood | Osage | 6/17/2015 | $0 | $0 |
| Flash Flood | Rochelle | 6/25/2015 | $30,000 | $0 |
| Flood | Rochelle | 6/25/2015 | $0 | $0 |
| **TOTAL** | | | **$483,000** | **$0** |

Source: NCEI

## Figure 4-15 Flood Events in Wyoming, 1996-2017

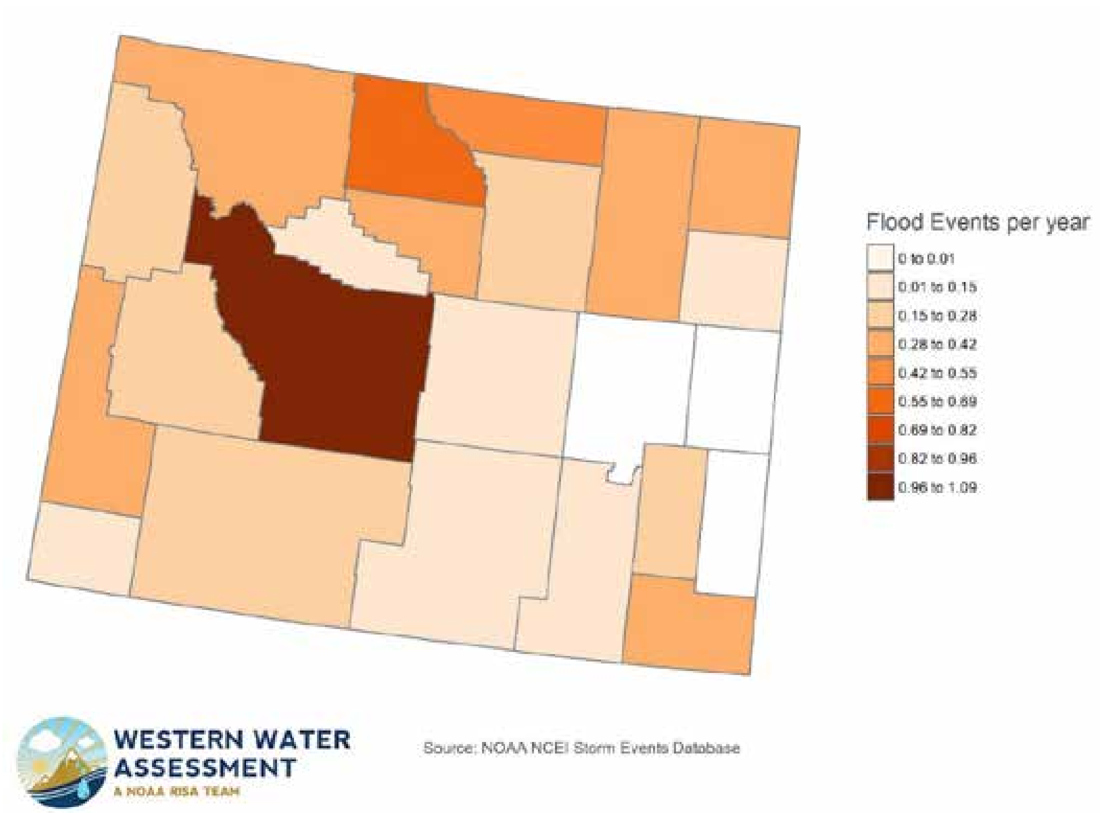
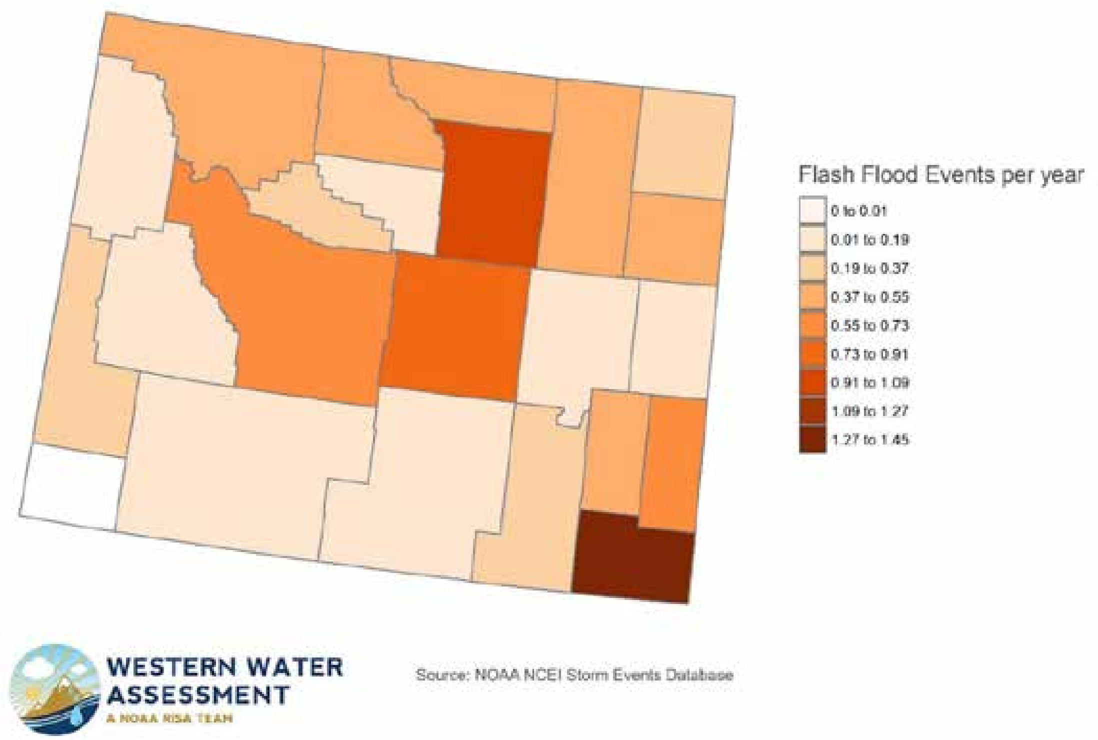


Figure 4-15 and Figure 4-16 were created by Western Water Assessment based on their analysis of NCEI data; they show the number of flood and flash flood events in Wyoming per county from 1996-2017.

**Figure 4-16 Flash Flood Events in Wyoming, 1996-2017**




The HMPCs noted that ice jams are also an issue, and can lead to major flooding problems; there was a major one near Dayton in Sheridan County in 2016. While sometimes the jam resolves itself, they have sometimes had to use backhoes to break it up.

### *Campbell County*

The principal flooding sources in the county are heavy rains and rapid snowmelt, which turn into flash flooding often in a matter of just hours. Some river flooding is also common, particularly overflowing of the Belle Fourche River.

The costliest flood related event in the recent history of Campbell County (in terms of human injuries and deaths) occurred July 22 of 2008, when heavy rains from a severe thunderstorm caused flash flooding east of Highway 59. A pickup truck drove into a washed-out culvert and small section of Trail Creek Road, resulting in one fatality and three human injuries. Three to six inches of water had accrued in a short period of time that day, and golf ball size hail fallen during this event.

The flooding event with the highest property damage accrued began May 28 of 2001, when heavy rain fell over the Donkey Creek drainage, pouring over 2 inches per hour. Donkey

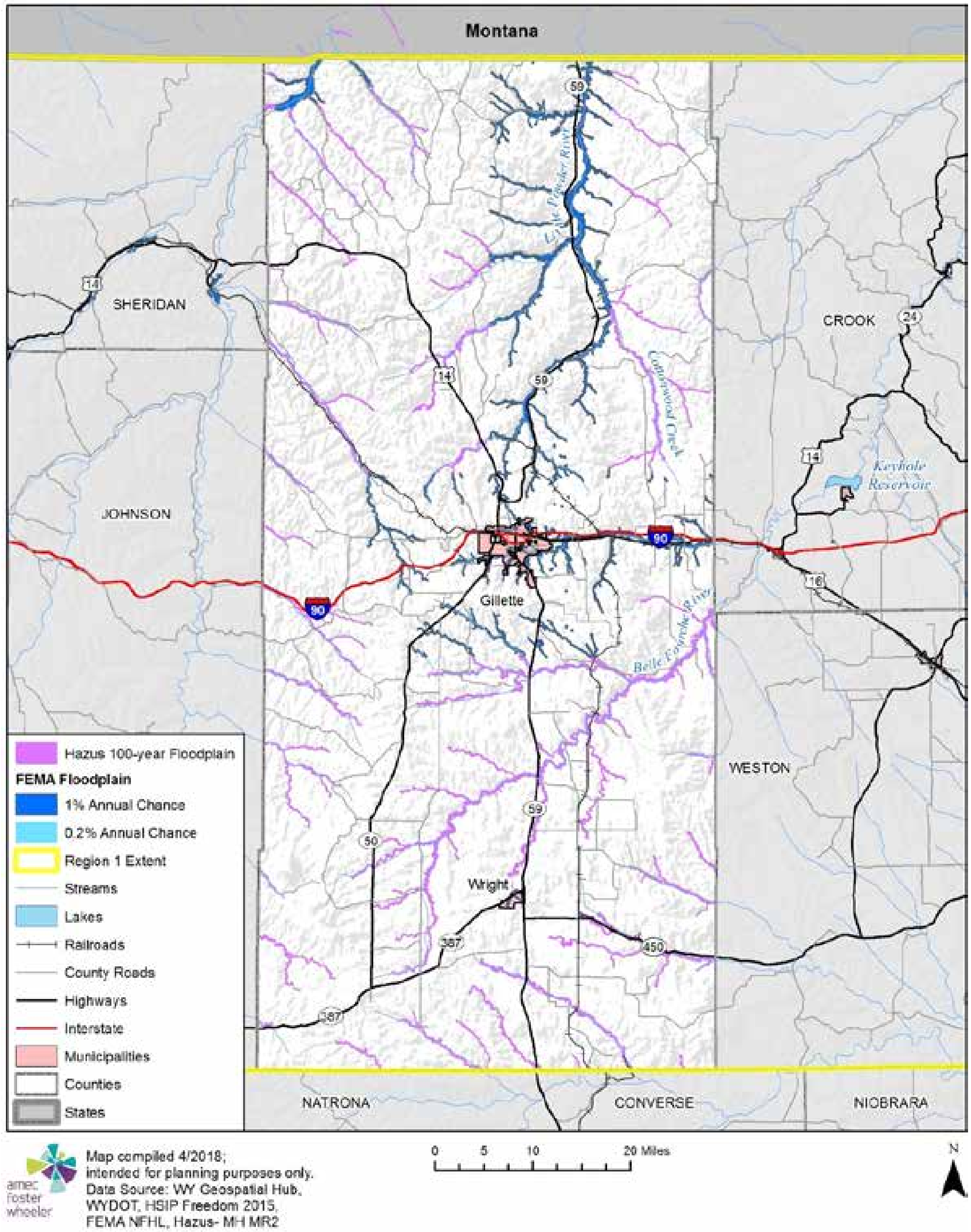
Creek flooded, tearing up paved golf cart paths and a service bridge in the Gillette County Club. Many businesses reported flooding of 1-2 feet, and one man needed rescue from a stalled vehicle in chest-deep water. The event only lasted about three hours total, but caused around $400,000 in property damages.

Wright had its costliest flooding event, in terms of property damages, on the 1st of August 2013. A thunderstorm producing large hail and wind gusts affected many vehicles in Wright, also impacting homes and other low-lying areas and properties. Heavy rain flooded roads, yards, and basements after drainage systems clogged with hail. A dam on Panther Pond was overtopped, and Wright Golf Course inundated. This event caused around $150,000 in damages.

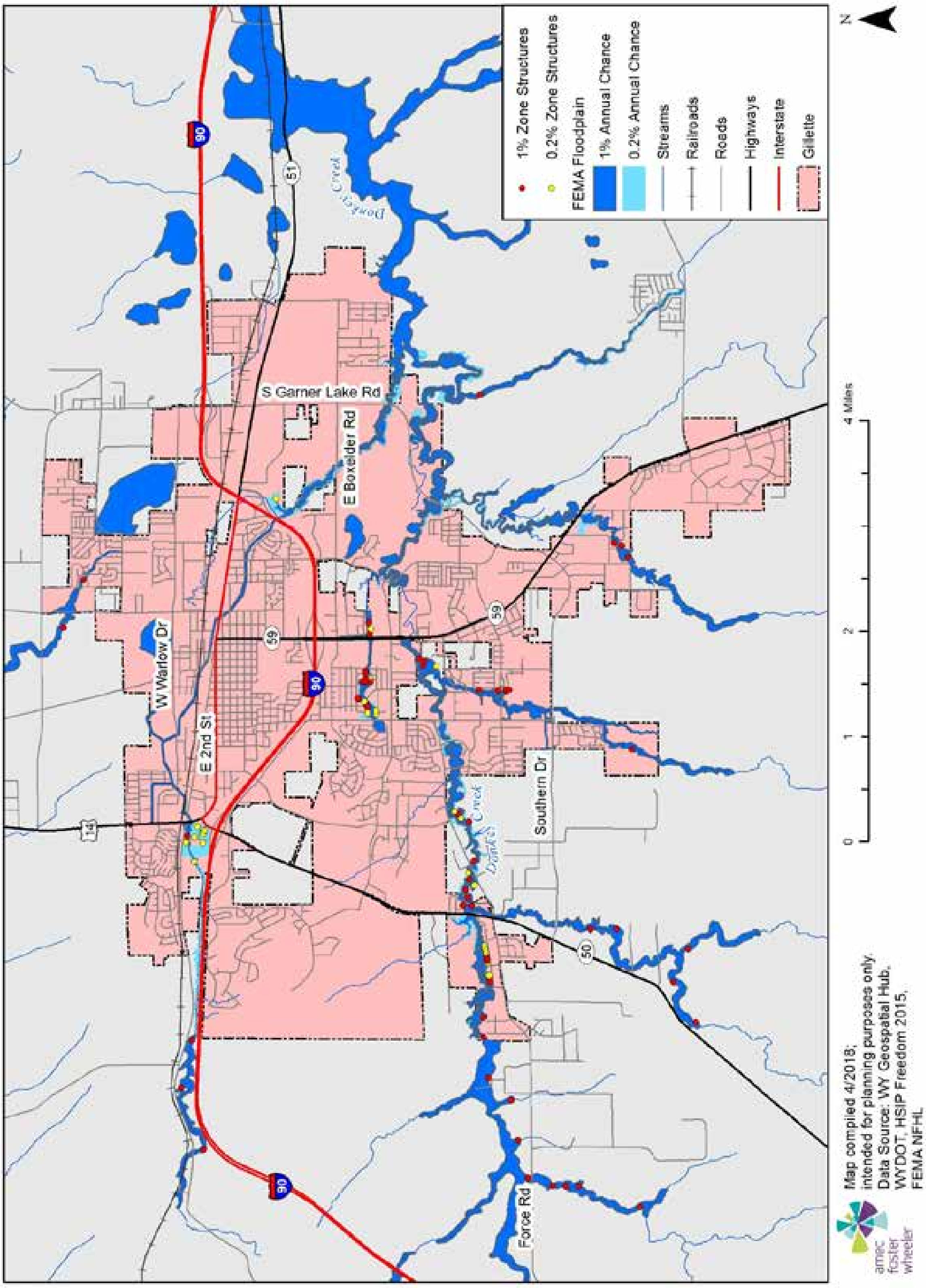
The other five floods causing property damages in the County occurred from 2007 to 2015, accruing a total of $95,000. Inundation took place, primarily, because of water ponding, heavy rain water runoff, and general flash flooding about roads and railroads.

Below are maps of FEMA and HAZUS designated floodplains overlaid by the parcels/infrastructure at risk of flooding (displayed as parcel centroid dots). Campbell County is shown first, then its jurisdictions.

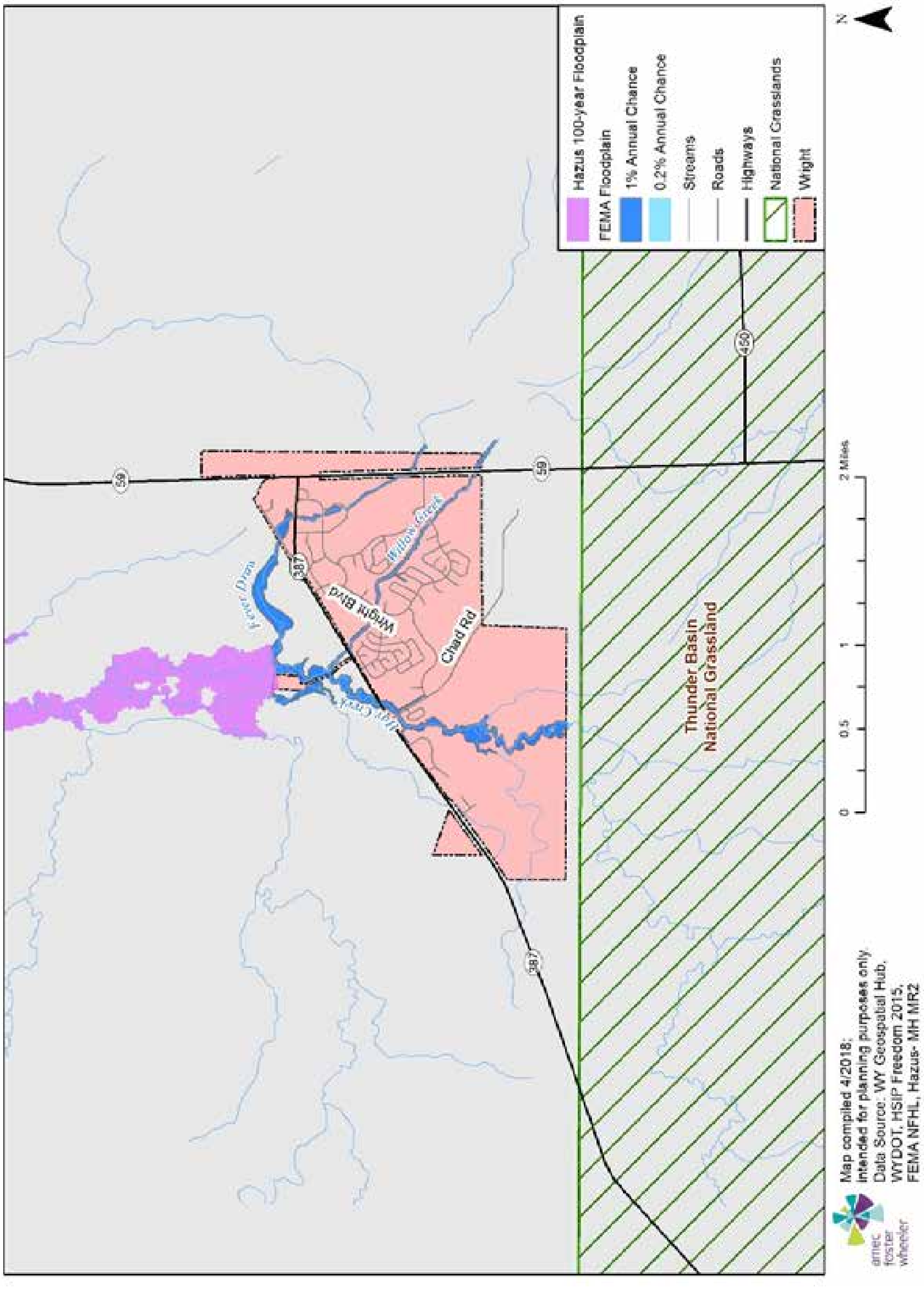
## Figure 4-17 Campbell County Flood Hazards



## Figure 4-18 Gillette Flood Hazards and Parcels at Risk



## Figure 4-19 Wright Flood Hazards



***Crook County***

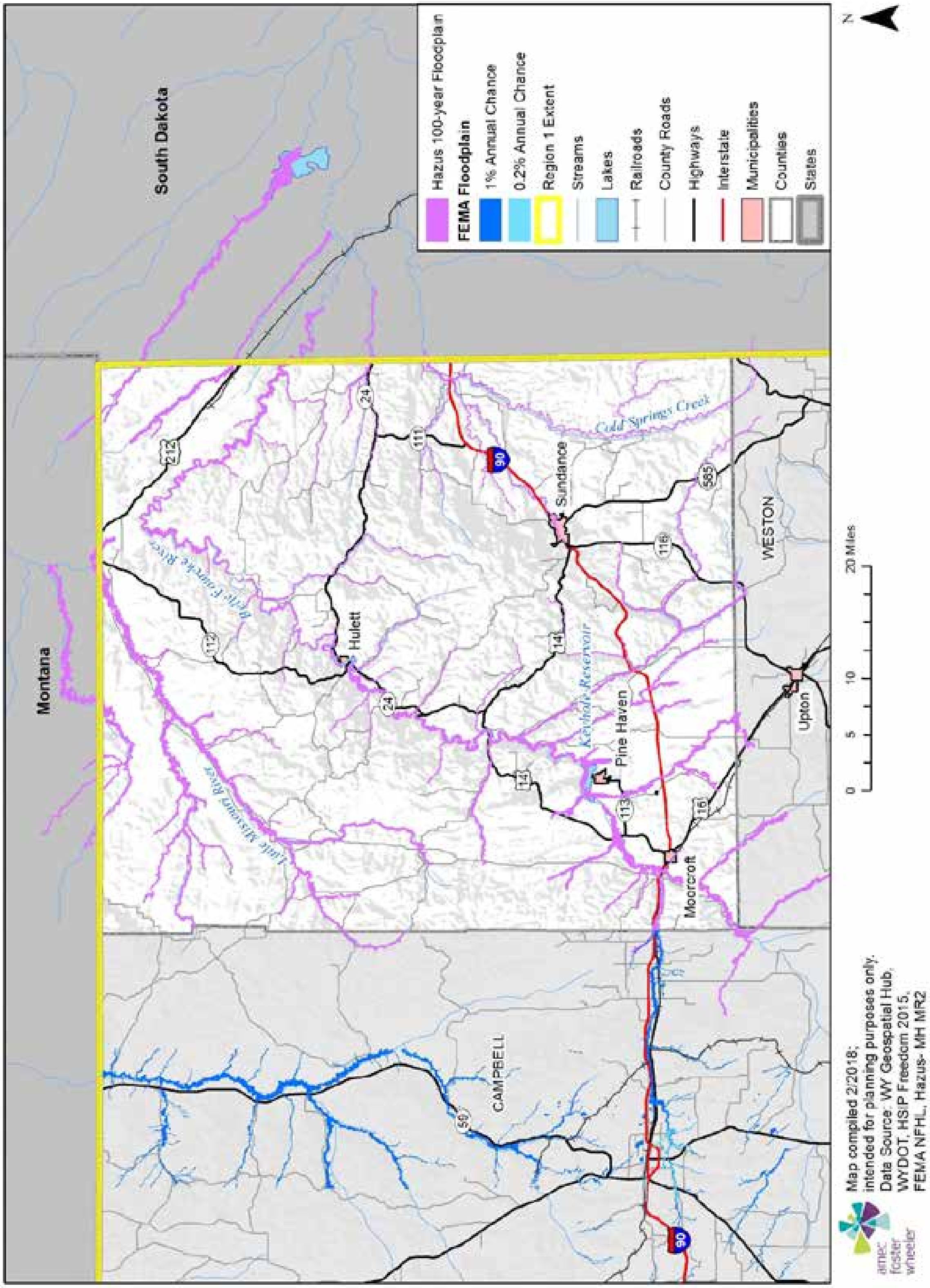
Sources of flooding in Crook County include the Little Missouri River, Belle Fourche River, Sundance Creek, and potentially the Keyhole Reservoir (potentially applicable under a dam failure situation, and hence more thoroughly covered in Section 4.2.2 Dam Failure). Most reported flooding has taken place near Moorcroft and Sundance as well as surrounding unincorporated areas including Aladdin, Colony, Lightning Flat, Oshoto, and New Haven. A total of $266,000 has been lost in property damages since 2001. The sources of the flooding were all heavy rains.

During early June of 2008 there was riverine flooding of the Belle Fourche River, Oak Creek, Hay Creek, and other smaller streams north of Aladdin, which caused inundation of many roads.

In 2013 there were two events affecting New Haven. One started May 31 of 2013, and the other a day after, on June 1st. These two days' flooding combined caused $160,000 in property damages, due to several creeks and streams across the county flooding. Several areas of the Belle Fourche River were reported to have reached a stage of 7.5 feet, which is three feet above the flood stage level. Below are maps of FEMA and HAZUS designated floodplains showing Crook County first, then its jurisdictions.

Below are maps of FEMA and HAZUS designated floodplains overlaid by the parcels/infrastructure at risk of flooding (displayed as parcel centroid dots). Crook County is shown first, then its jurisdictions.

## Figure 4-20 Crook County Flood Hazards



## Figure 4-21 Hulett Flood Hazards and Parcels at Risk

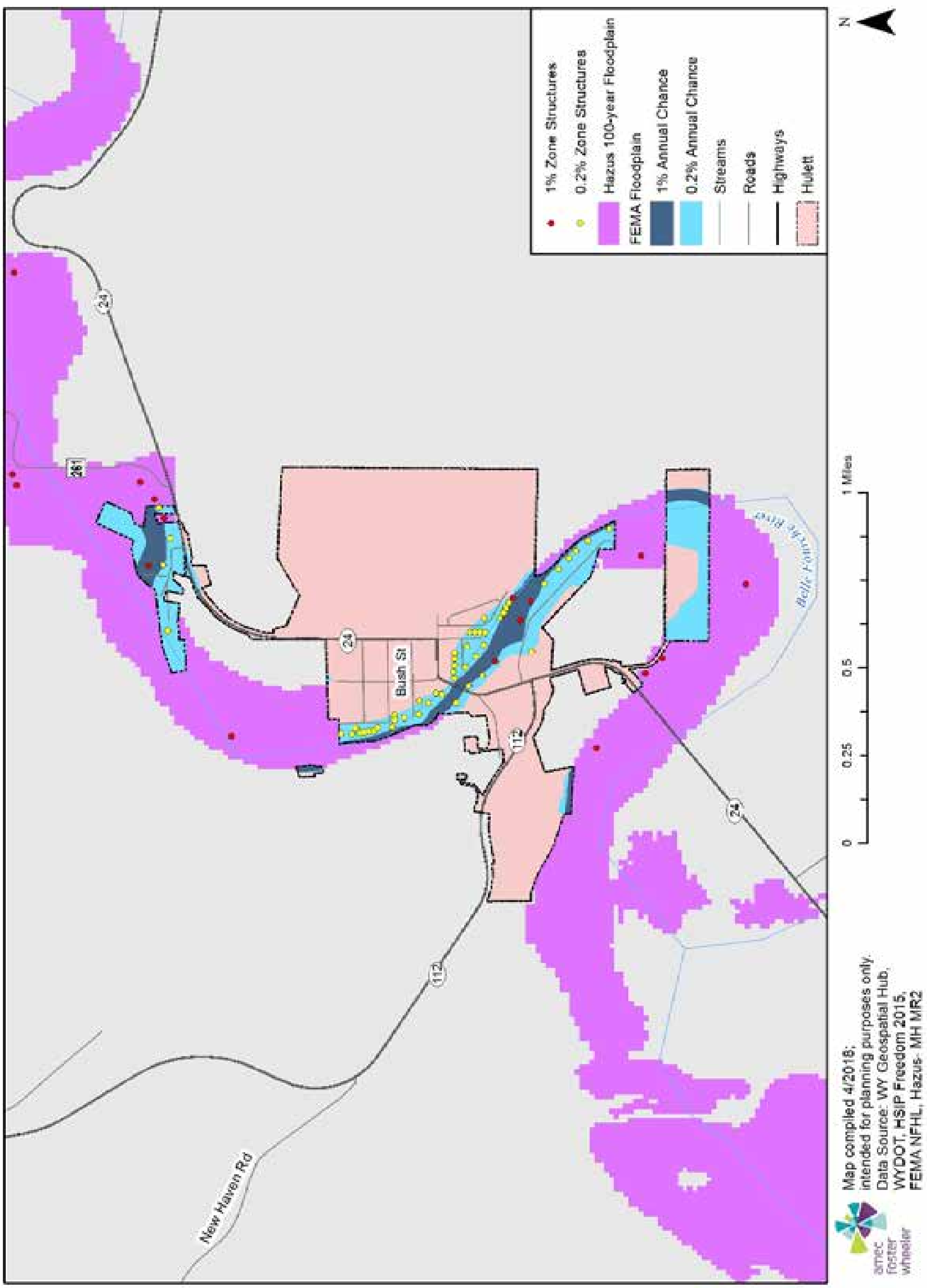
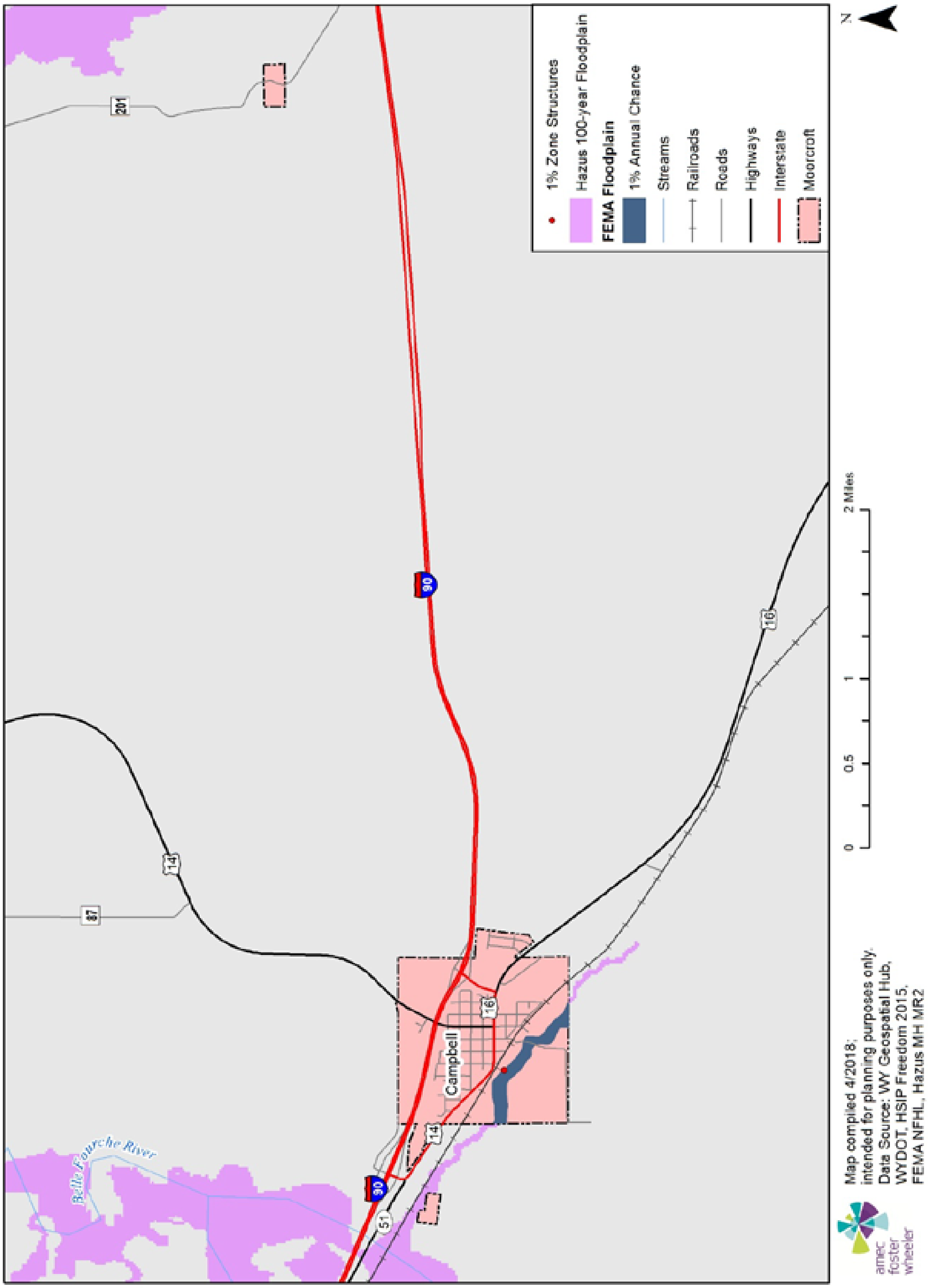
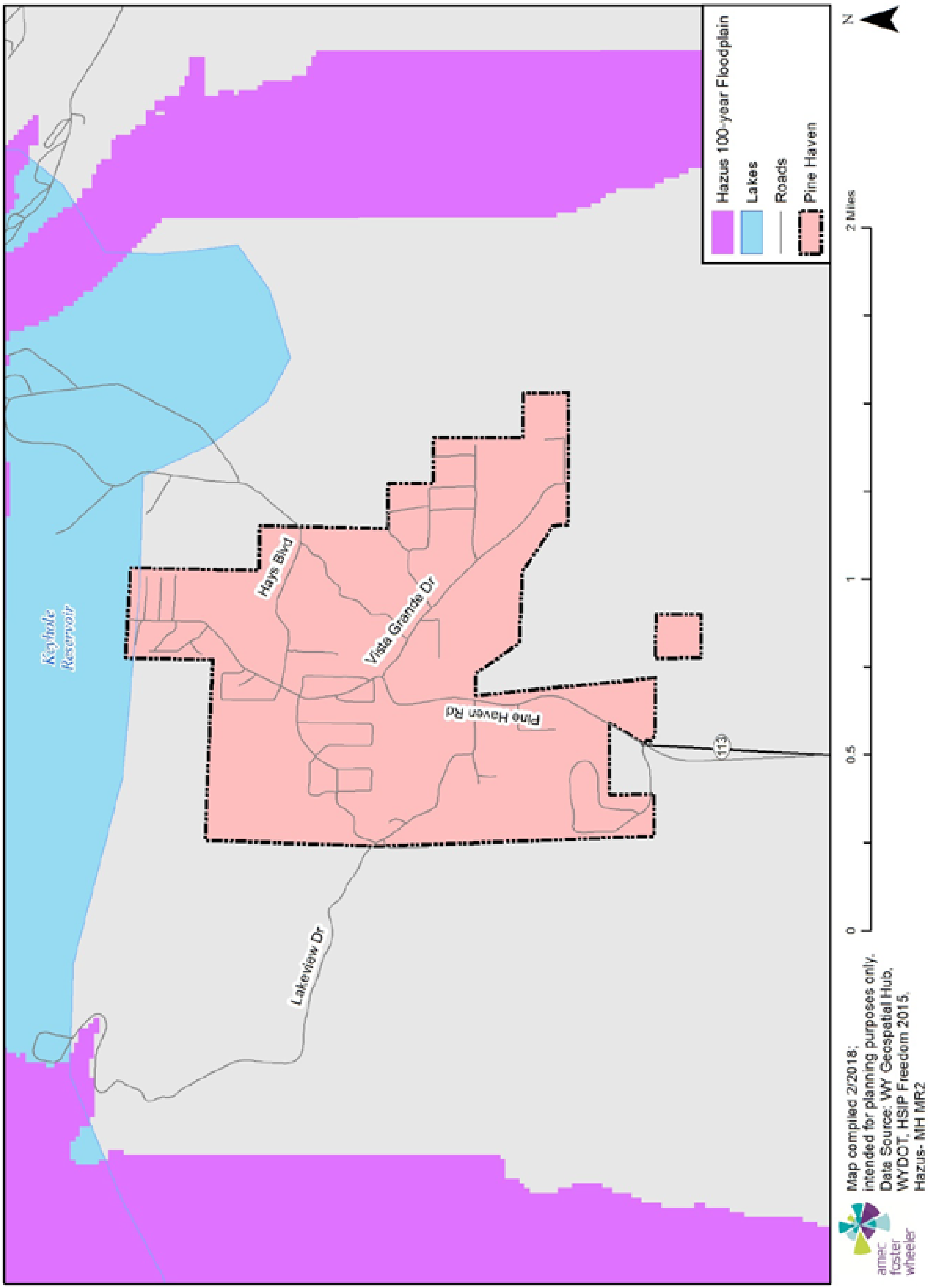


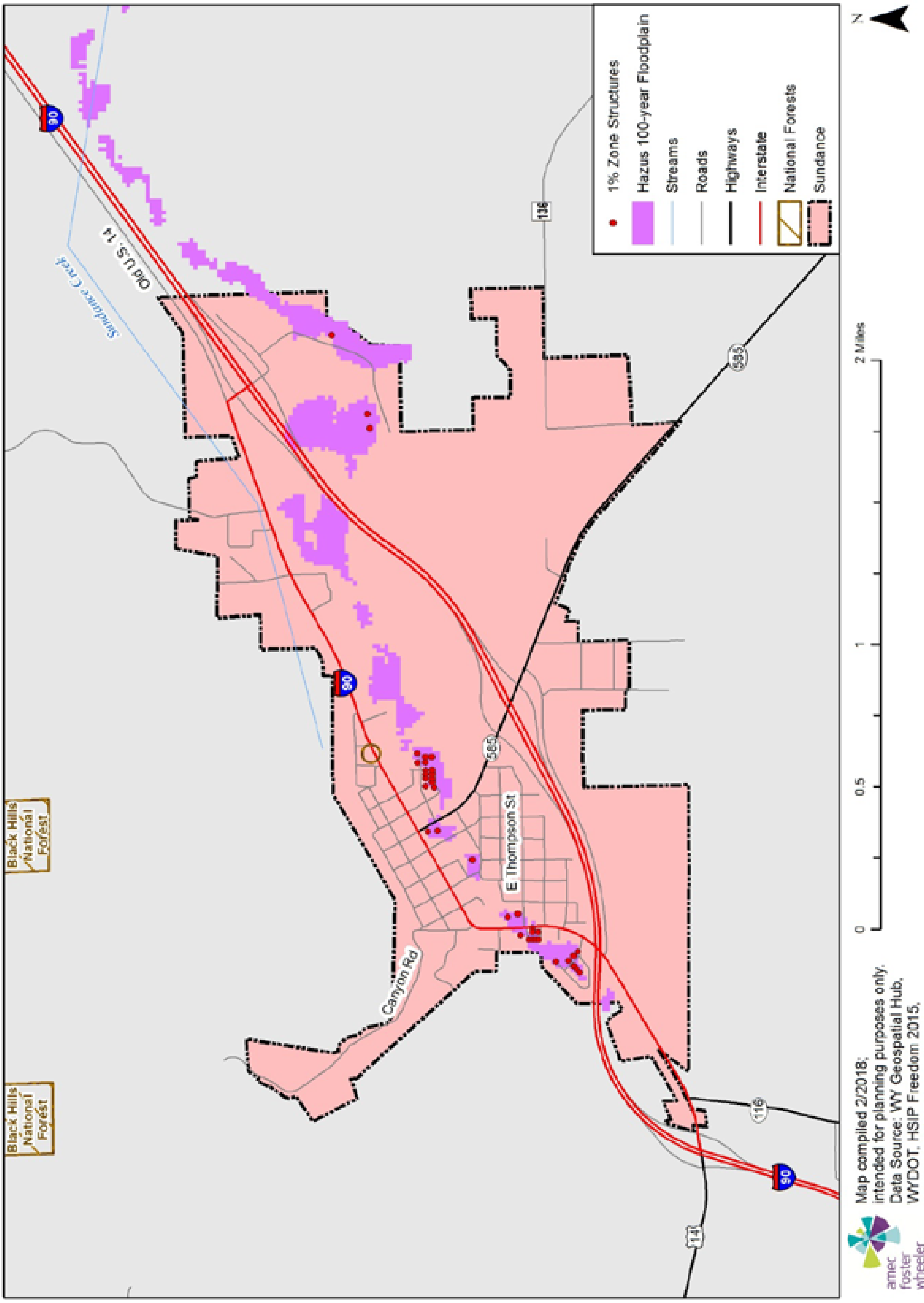
**Figure 4-22 Moorcroft Flood Hazards and Parcels at Risk**



## Figure 4-23 Pine Haven Flood Hazards



## Figure 4-24 Sundance Flood Hazards



### *Johnson County*

Johnson County has had the highest flood related losses in the Region, with 33 events reported and a total of $2,260,400 in property damages, and $262,000 in crop damages. Flooding has been reported almost every year since 1996, though no human deaths or injuries have taken place. Flooding sources in the county primarily include Rock Creek, French Creek, Clear Creek, the Middle Fork Powder River, Beaver Creek, Crazy Woman Creek, Piney Creek, and the Powder River.

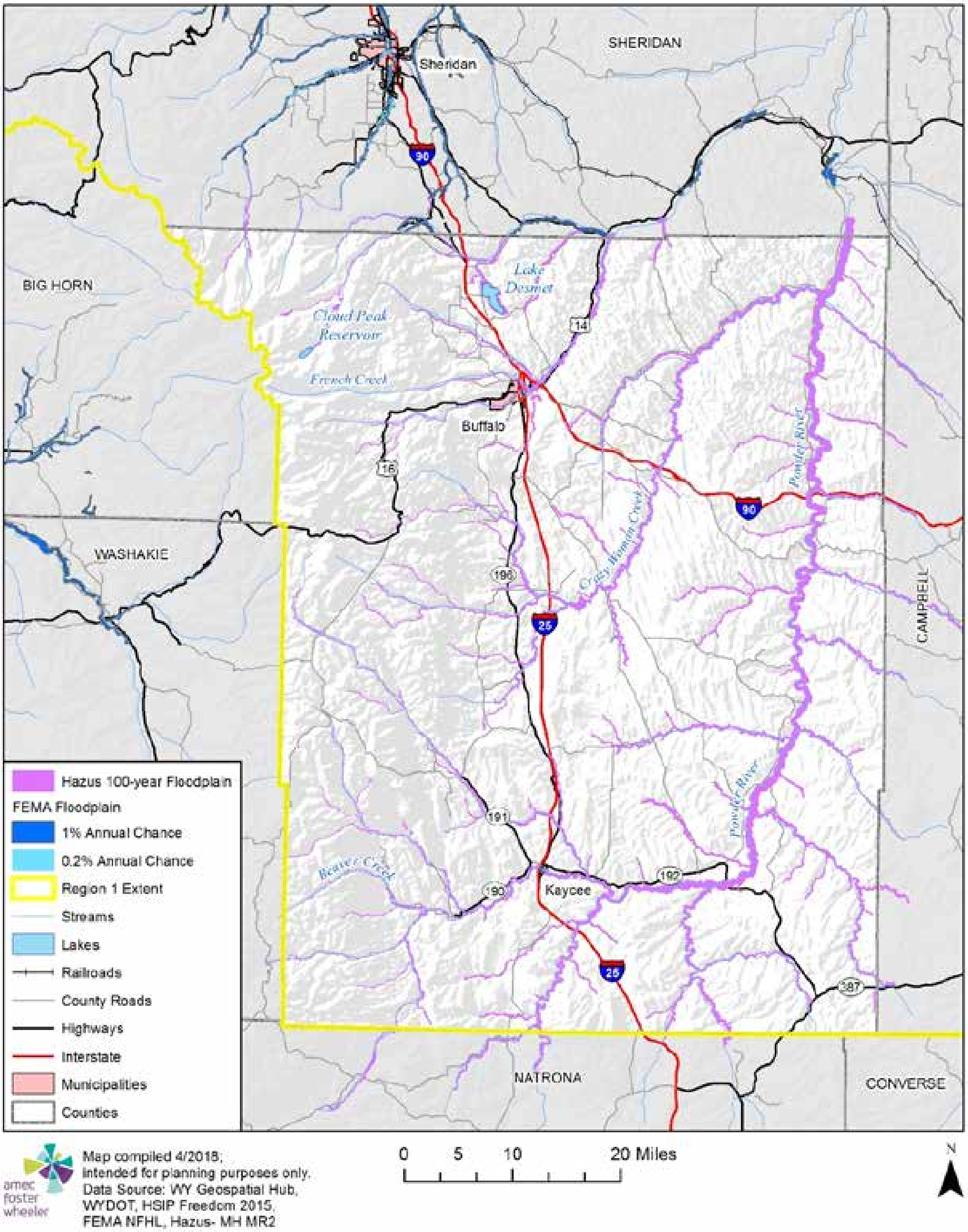
The most damaging recent flash flood (costing $1,500,000 in property damages) took place June 3 of 2015, starting around 8pm near Buffalo. A series of thunderstorms brought heavy rains, causing areas such as the Johnson County Airport to measure almost 1 inch in less than 25 minutes. Saturated soils could not absorb the rapidly incoming precipitation, causing inundation through streets and overfilling streams. Five Buffalo homes were declared destroyed, with reports claiming over four feet high flooding in low-lying areas. Some roads and private bridges were washed out as well.

Kaycee alone has suffered property damages of $627,000 and crop damages of $252,000. The main cause is flash flooding, with the costliest event taking place late August of 2002. During this event, a stationary thunderstorm brought flash flooding and an estimated three inches of rain to Kaycee. The flooding did damage to 19 trailers and 22 houses. In addition, 12 businesses reported losses, including the post office, the conservation district office, and a telephone company. The force of the water along the Middle Fork of the Powder River resulted in a hotel being broken into three pieces. Nine other flooding events have taken place in Kaycee since the year 2000.

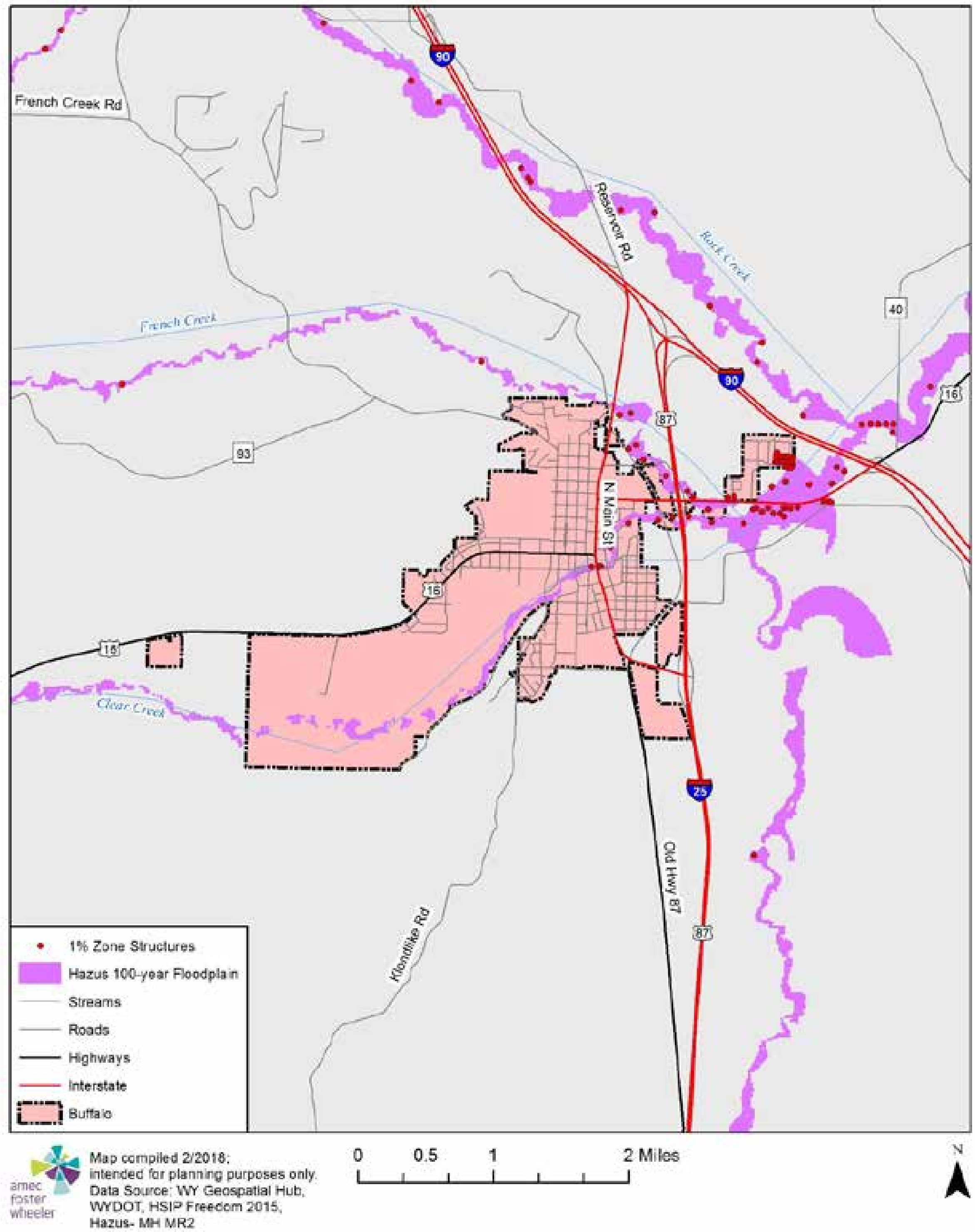
Apart from Buffalo and Kaycee, several unincorporated areas throughout the county also have been historically affected by flooding. These include Barnum, Linch, Mayoworth, and Sussex. A total of 12 floods (mostly caused by flash flooding) have occurred since 1996, with the latest taking place early June of 2015. The total amount in property losses from unincorporated areas in the County add up to $12,000.

Below are maps of FEMA and HAZUS designated floodplains showing Johnson County first, then its jurisdictions.

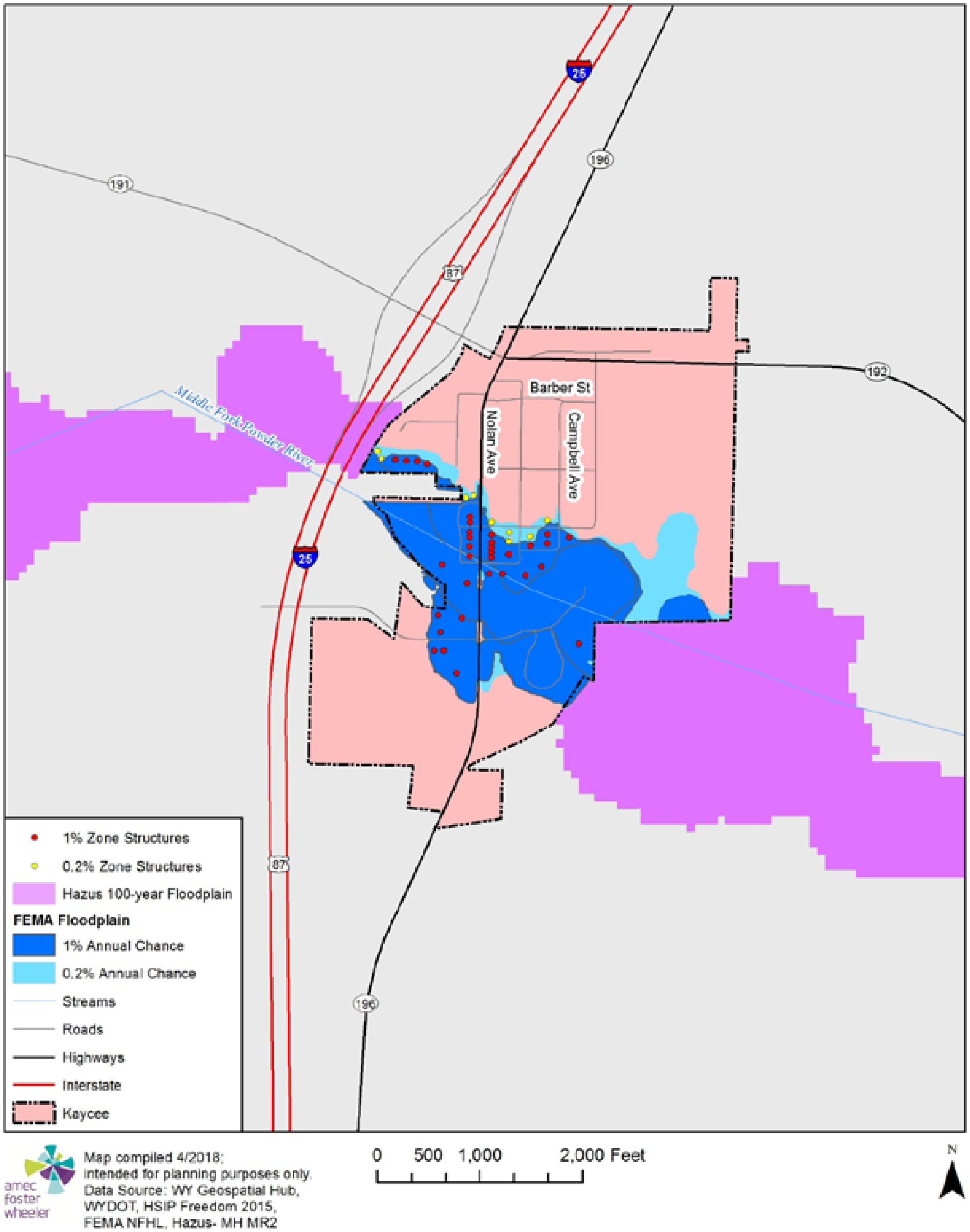
**Figure 4-25 Johnson County Flood Hazards**



## Figure 4-26 Buffalo Flood Hazards



## Figure 4-27 Kaycee Flood Hazards

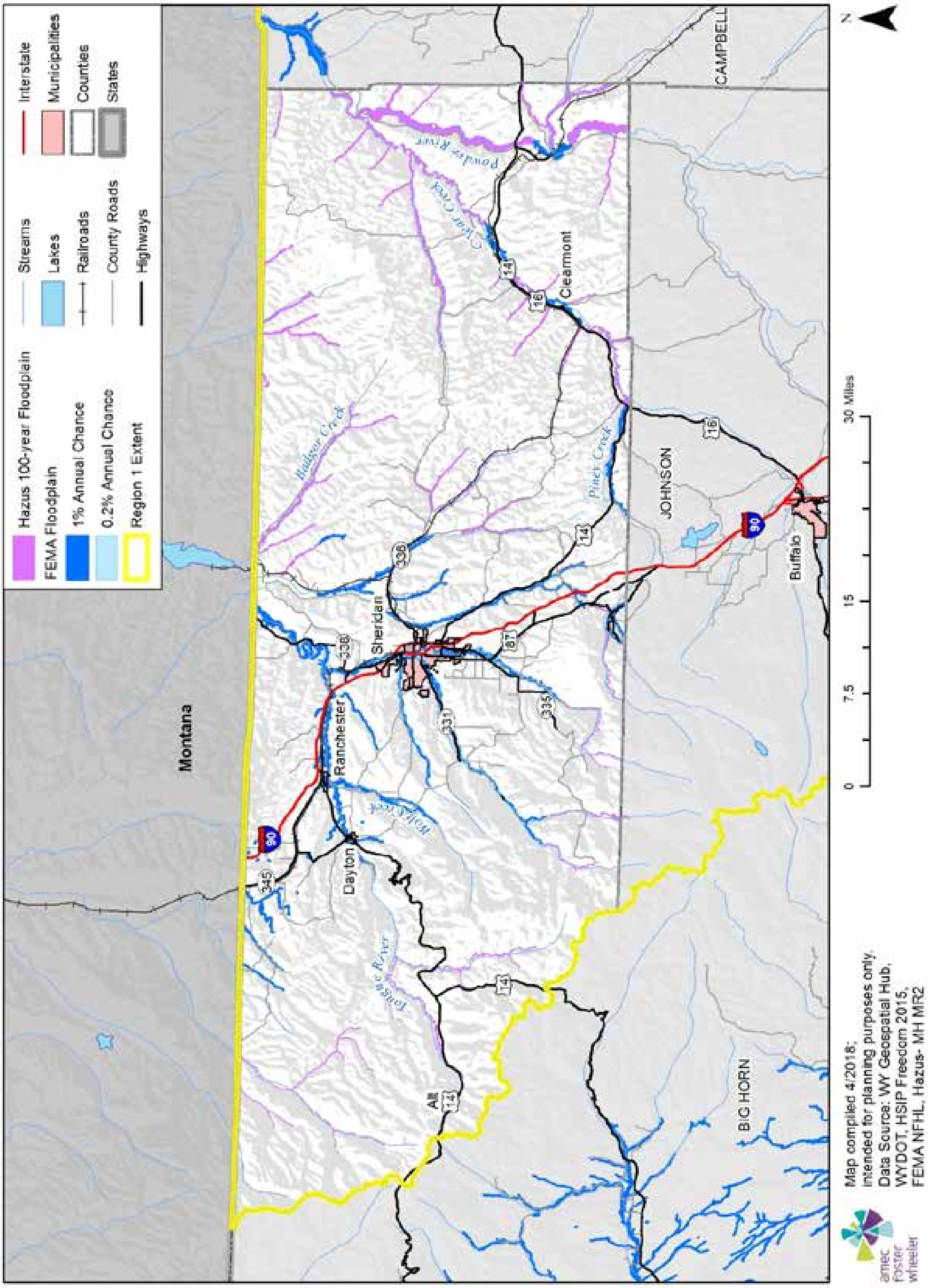


### *Sheridan County*

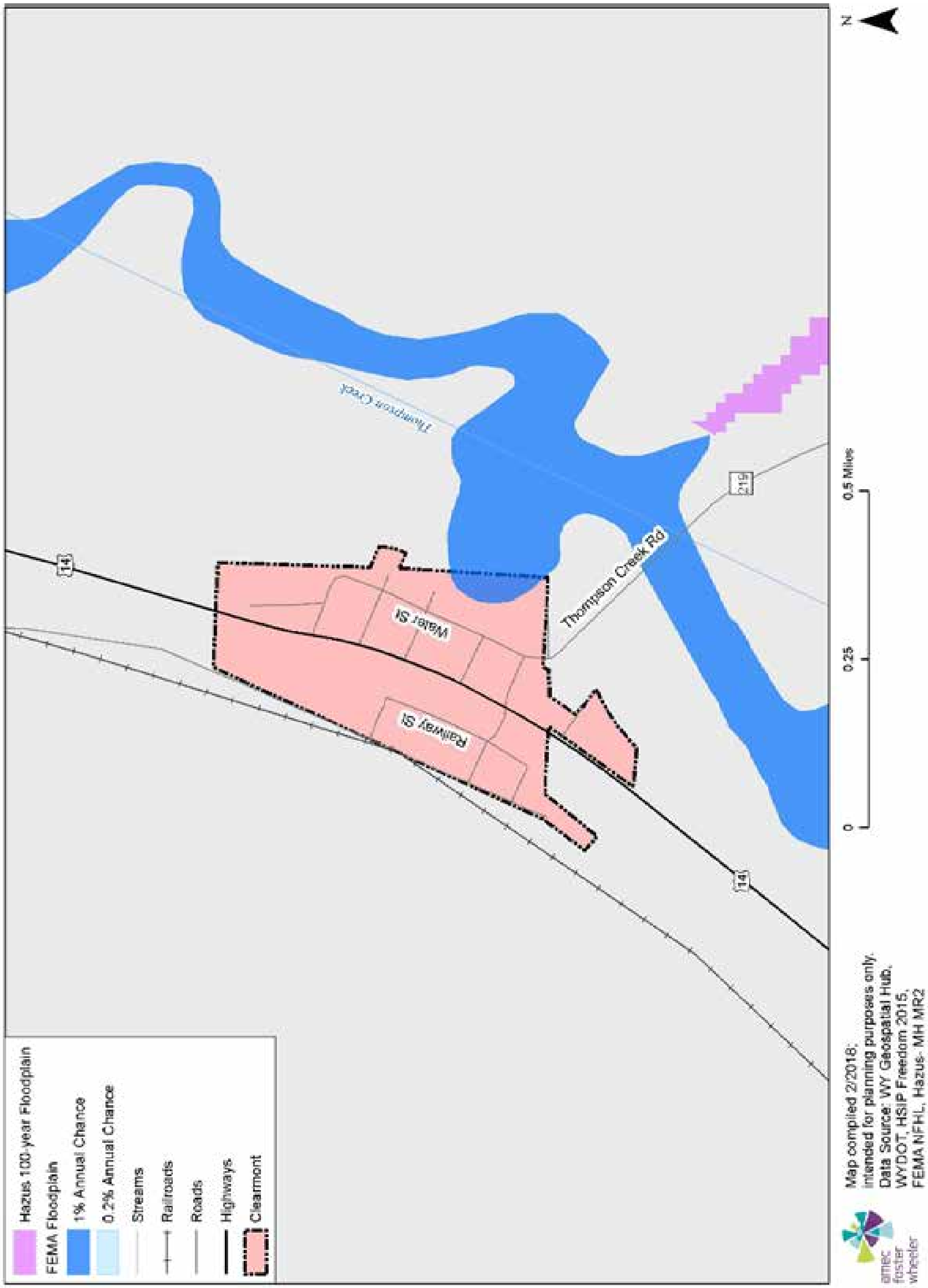
Sheridan County has suffered $540,000 in property losses from flooding since 1996. The main sources of flooding include Thompson Creek, the Tongue River, Big Goose Creek, Little Goose Creek, Soldier Creek, Dry Creek, Wolf Creek, and the Powder River. The most significant recent flood event took place in the unincorporated area of Parkman. This event began May 20 of 2011, due to heavy rains of 3 to 5 inches near the Big Horn Mountains. The downpours caused streams and creeks to rise, resulting in localized riverine flooding and closing of county roads. Flooding was reported along the Tongue River and Little Goose Creek, leading to some culverts being washed out.

The second costliest even took place August 19 of 1998, in the City of Sheridan, causing $20,000 in property damages. Little Goose Creek inundated a small subdivision, when a slow-moving thunderstorm produced over 1.50 inches of rainfall in 20 minutes. A house basement was reported to have been flooded. Twenty other riverine and flash flooding events have taken place across the county mostly due to heavy rains and rapid snow melt, though they did not incur any damage losses. Below are maps of FEMA and HAZUS designated floodplains showing Sheridan County first, then its jurisdictions.

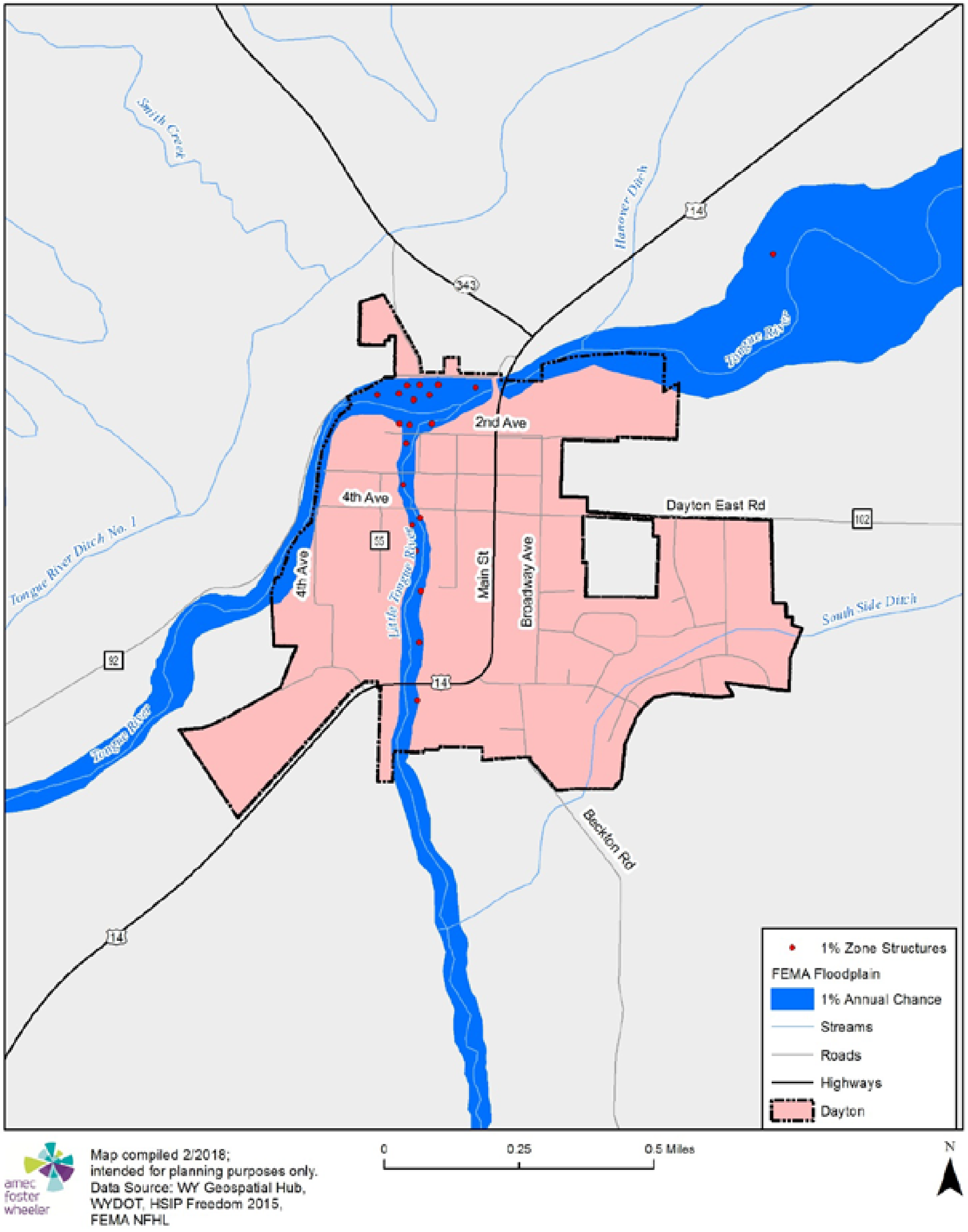
## Figure 4-28 Sheridan County Flood Hazards



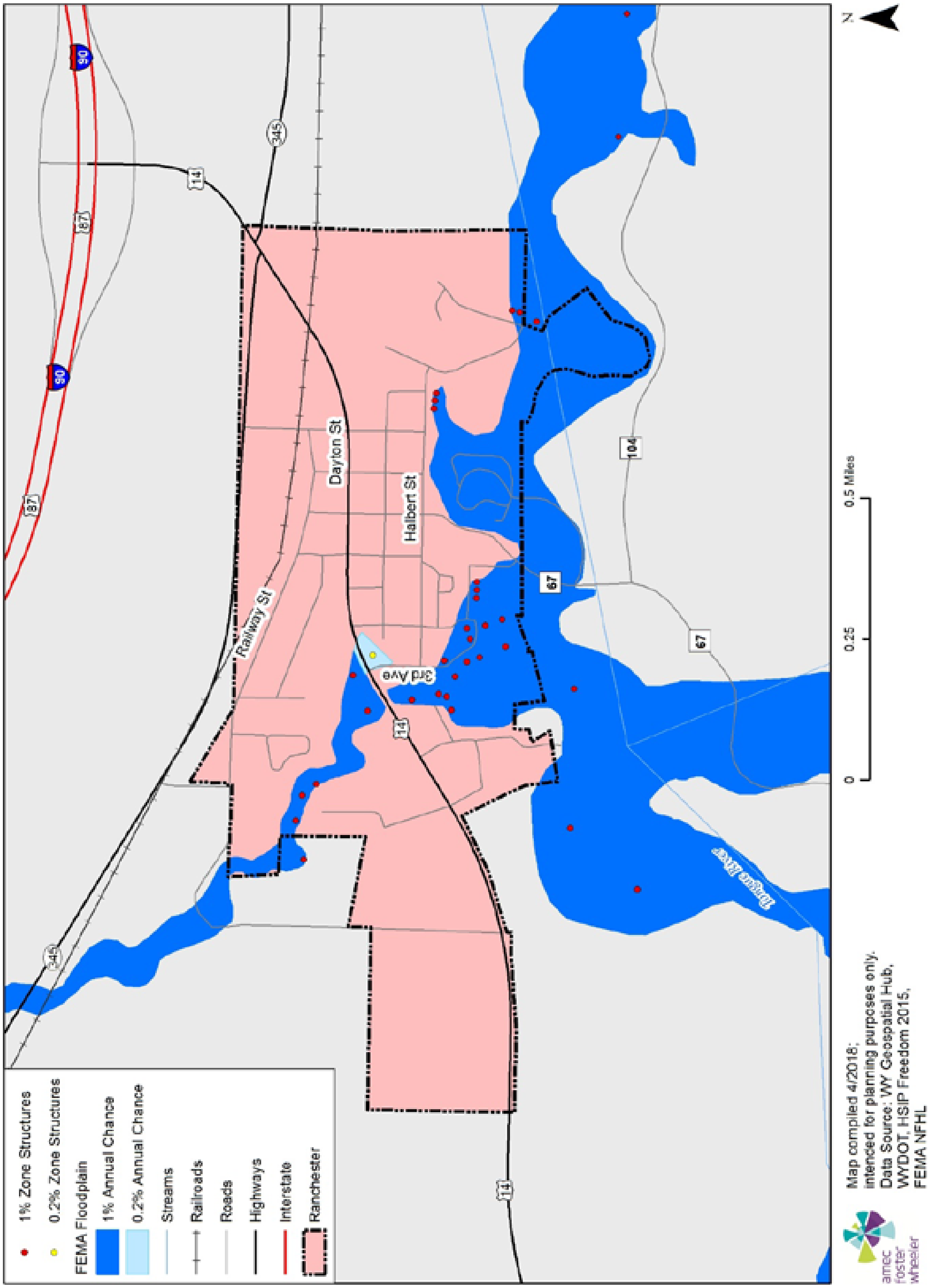
## Figure 4-29 Clearmont Flood Hazards



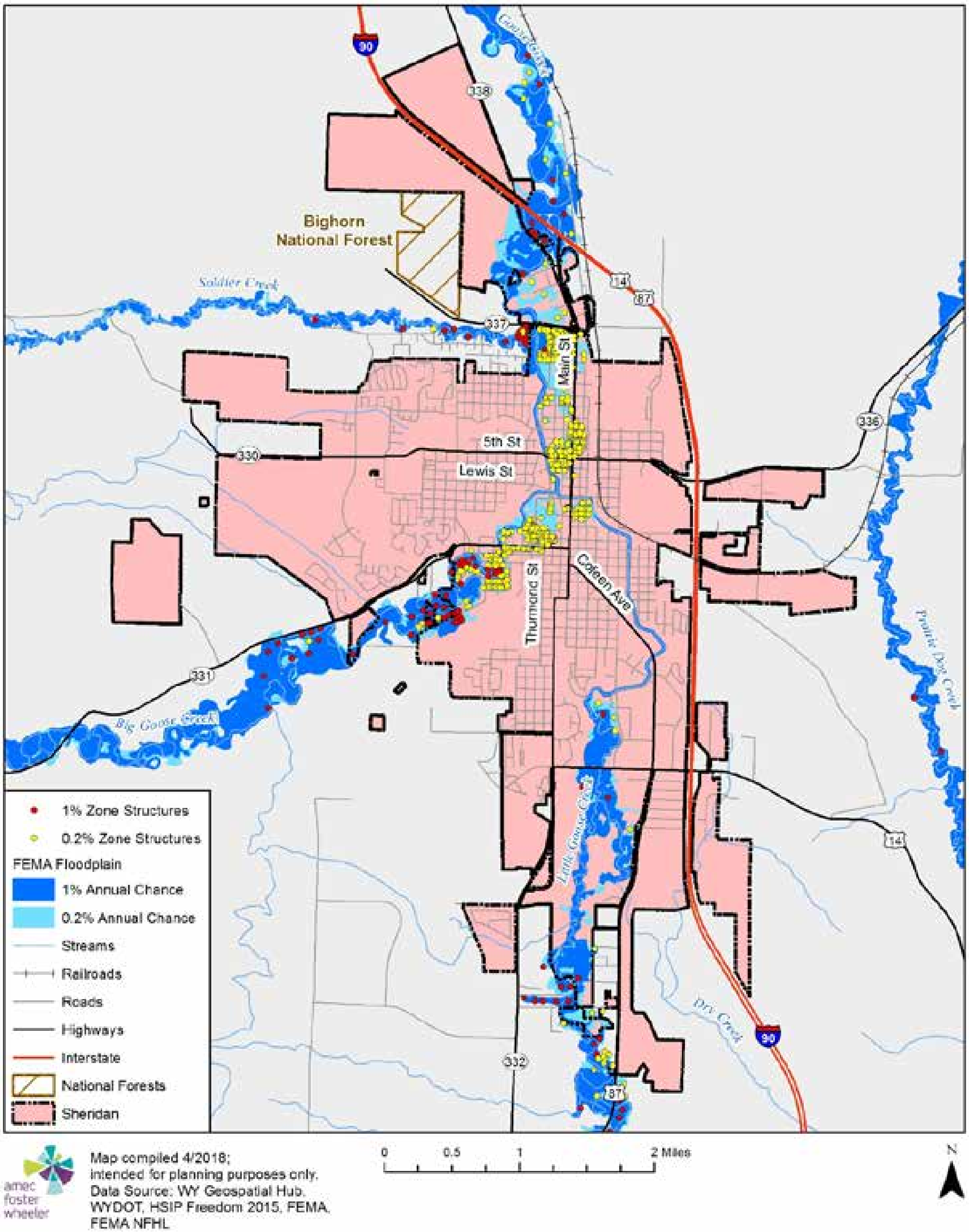
## Figure 4-30 Dayton Flood Hazards



## Figure 4-31 Ranchester Flood Hazards



## Figure 4-32 City of Sheridan Flood Hazards



***Weston County***

Weston County has had 15 flood events reported since 1998. Areas most affected include Upton and Newcastle, and the unincorporated areas of Osage, Four Corners, and Rochelle. The main sources of flooding are Iron Creek, Oil Creek, Buffalo Creek, Beaver Creek, Lodgepole Creek, and Black Thunder Creek. Both riverine and flash flooding have caused a total of $453,000 in property damages throughout the years.

The unincorporated community of Osage has been hit with the costliest flood related damages, amounting to $178,000 just from 2011 to 2013. The most damaging even took place May 9 of 2011, when heavy rains fell over eastern Weston in under two hours, causing flash flooding that also affected Newcastle. Cars and culverts were damaged, sewers clogged, and basements flooded.

The majority of flood events in the county are caused by flash accumulation of water from heavy rains and burn areas. In burn areas, soils become oversaturated easily due to excessive debris and inability from water to soak, causing rapid inundation and runoff that affect public infrastructure, properties, and natural areas. As of 2018 Weston County, with the exception of Upton, has not been mapped by FEMA's National Flood Insurance Program. Below are maps showing HAZUS designated floodplains showing Weston County first, then its jurisdictions. There are not digital Flood Insurance Rate Maps available for Upton.

## Figure 4-33 Weston County Flood Hazards

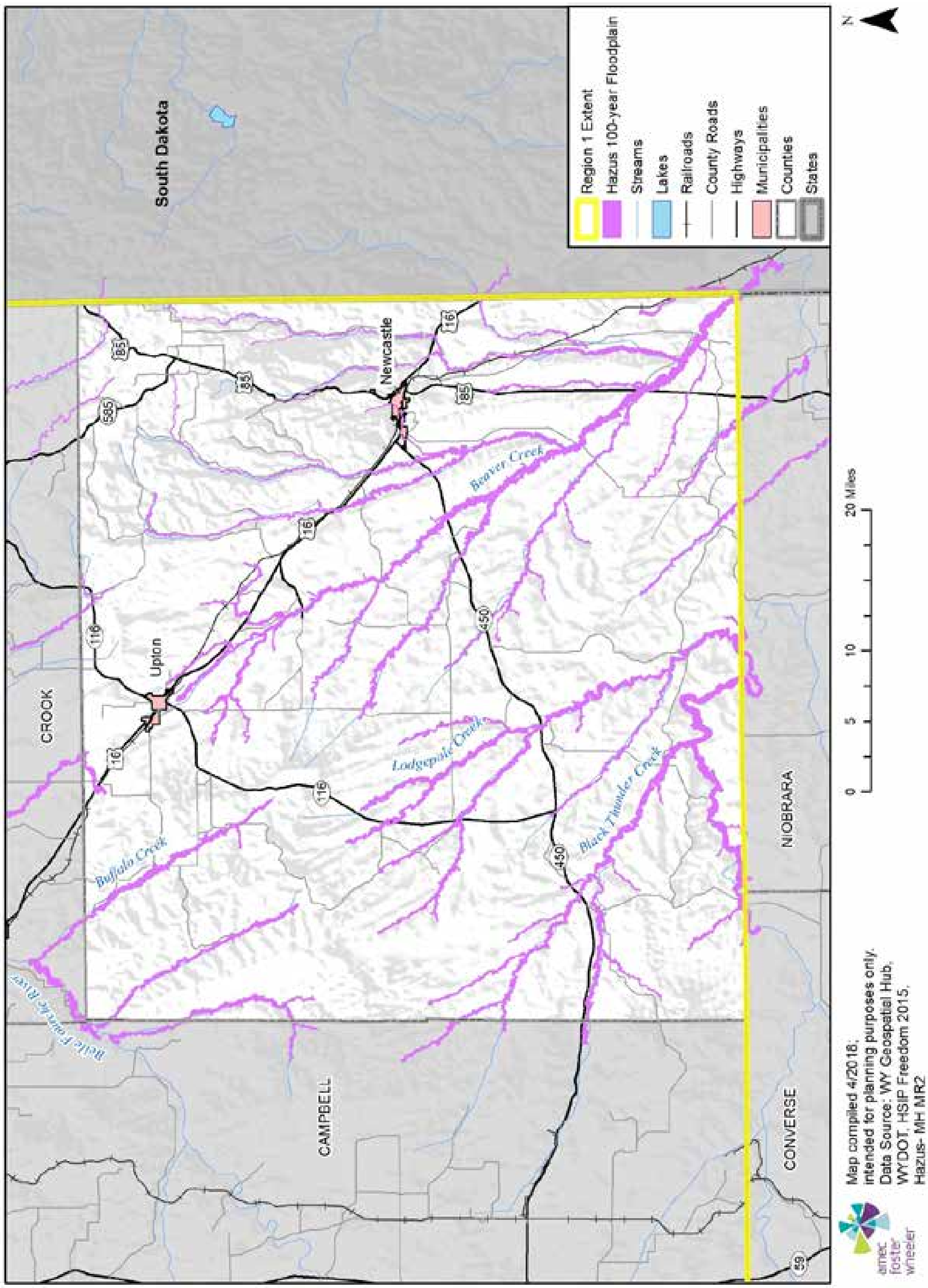
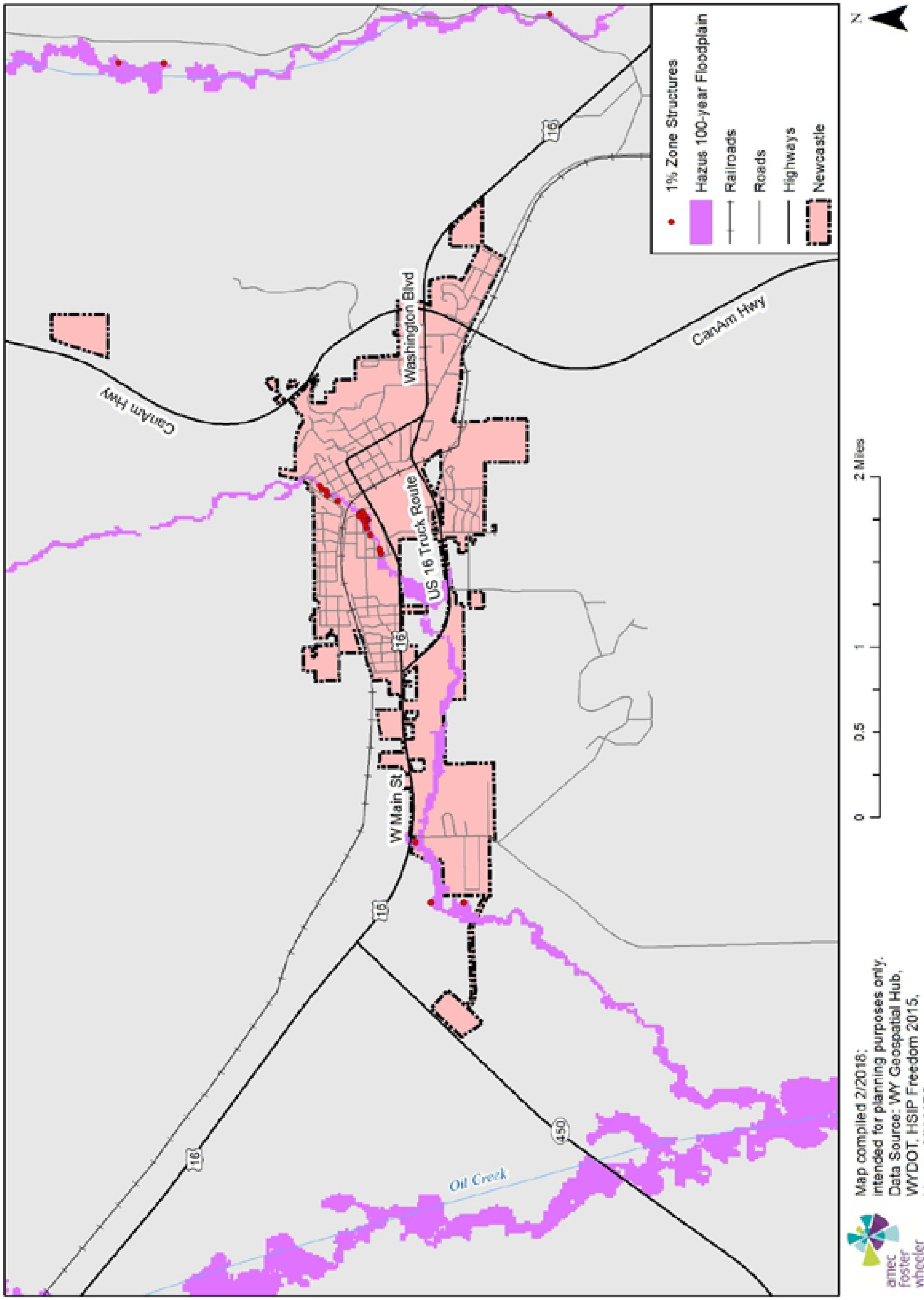


**Figure 4-34 Newcastle Flood Hazards**



## Figure 4-35 Upton Flood Hazards

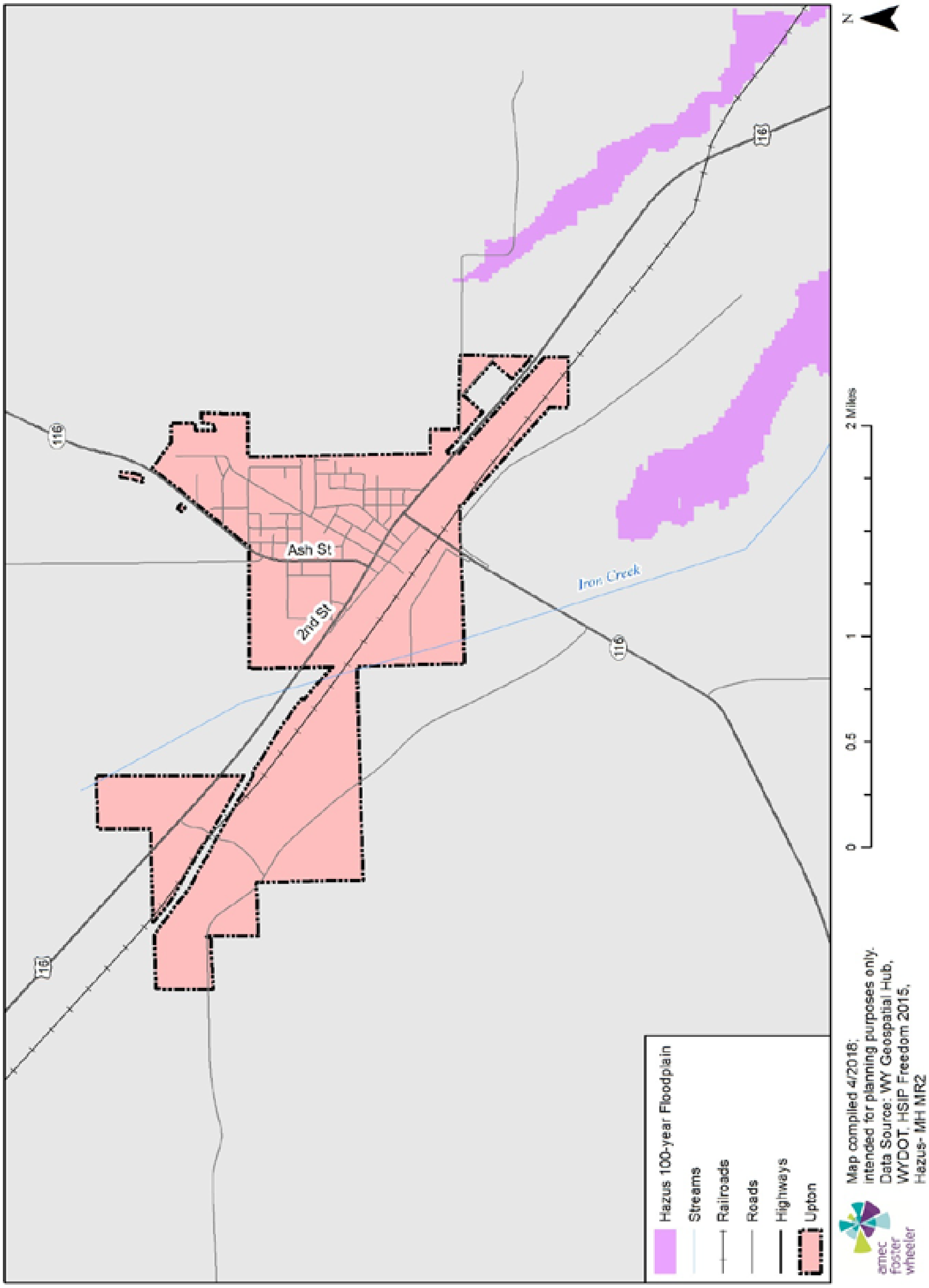


**Table 4-38 Flood Occurrences per County**

| County | Events | Total Property Damage | Total Crop Damage | Period of Record |
|---|---|---|---|---|
| Campbell | 24 | $645,000 | $0 | 1998-2015 |
| Crook | 14 | $266,000 | $0 | 2001--2017 |
| Johnson | 33 | $2,260,400 | $262,000 | 1996-2017 |
| Sheridan | 22 | $540,000 | $0 | 1996-2015 |
| Weston | 15 | $483,000 | $0 | 1998-2015 |
| **TOTAL** | **108** | **$4,194,400** | **$262,000** | **1996-2017** |

Source: NCEI

## Frequency/Likelihood of Occurrence

Judging by the historical flood record for the Region, a flood of at least minimal magnitude occurs once or twice a year, on average, within the planning area. Most of these floods' extents were less than the 100-year flood; the chance of a 100-year flood occurring in any given year in the Region is 1%. Using the guidelines outlined in Section 4.2 a damaging flood has a **Likely** occurrence rating, meaning that a flood has a 10-100% chance of occurrence in the next year somewhere in the Region.

## Potential Magnitude

Magnitude and severity can be described or evaluated in terms of a combination of the different levels of impact that a community sustains from a hazard event. Specific examples of negative impacts from flooding on Region 1 span a comprehensive range and are summarized as follows:

- Floods cause damage to private property that often creates financial hardship for individuals and families;
- Floods cause damage to public infrastructure resulting in increased public expenditures and demand for tax dollars;
- Floods cause loss of personal income for agricultural producers that experience flood damages;
- Floods cause emotional distress on individuals and families; and
- Floods can cause injury and death.

Floods present a risk to life and property, including buildings, their contents, and their use. Floods can affect crops and livestock. Floods can also affect lifeline utilities (e.g., water, sewerage, power), transportation, jobs, tourism, the environment, and the local and regional economies. The impact of a flood event can vary based on geographic location to waterways, soil content and ground cover, and construction. The extent of the damage of flooding ranges from very narrow to widespread based on the type of flooding and other circumstances such as previous rainfall, rate of precipitation accumulation, current conditions in the infrastructure and landscapes, the time of year, and emergency response preparedness.

The magnitude and severity of the flood hazard is usually determined by both the extent of impact it has on the overall geographic area, and by identifying the most catastrophic event in the previous flood history (as an example of the losses that could be incurred during such an event). Sometimes this "example" of a catastrophic event is referred to as the "event of record." The flood of record is almost always correlated to a peak discharge at a gage, because it usually also comes with the worst impacts in terms of property damage, loss of life, etc. The two most damaging events in the Region are used to set the "events of record", in terms of injuries/deaths and property/agricultural damages. A flood in July of 2008 cost Campbell County one human life and three injuries, when heavy rains resulted in flash flooding that washed out infrastructure, leading to a pickup truck driving into a culvert and crashing. With regards to property damages, Johnson County has the highest losses. A flood in early June of 2015 caused $1,500,000 in property damages in Buffalo, due to heavy thunderstorms and rapid flooding of houses, businesses, and infrastructure. Five homes were severely damaged during this event.

The potential magnitude for a flood event in the Region is overall estimated to be **Limited**. An event of limited magnitude can result in some injuries, a shutdown of critical facilities for over a week, and/or damages to more than 10% of the planning area (in terms of property and agricultural losses). This is consistent with the flood event history in the Region. The flood history indicates that damaging floods have occurred consistently in the planning area, particularly in Johnson, Campbell, and Sheridan Counties. Unfortunately, there was one human death and three injuries during a flood event near Recluse, Campbell County, in July of 2008.

### Vulnerability Assessment

During the Map Modernization period, Sheridan County was one of the areas that received a RiskMAP project. FEMA produced new preliminary floodplain maps for Sheridan in 2012 and then in 2013, and additionally the communities received a Flood Risk Report and Flood Risk Database. The goal of the Flood Risk Report and Flood Risk Database is to help inform and enable communities to take action to reduce flood risk. Through the RiskMAP program, FEMA provides communities with updated DFIRMs and Flood Insurance Studies (FIS) that describe the probability of floods and show flood boundaries and elevations. However, given the regional nature of this plan, an in-house vulnerability assessment that takes into account loss estimates and population from both DFIRM and Hazus-derived flood layers was performed for all five counties in Region 1, to supplement the type of study that was performed for Sheridan a few years back.

### *Population*

Vulnerable populations in Region 1 include residents living in known flood prone areas or near areas vulnerable to flash floods. Certain populations are particularly vulnerable. This may include the elderly and very young; those living in long-term care facilities; mobile homes; hospitals; low-income housing areas; temporary shelters; people who do not speak English well; tourists and visitors; and those with developmental, physical, or sensory disabilities. These populations may be more vulnerable to flooding due to limitations in mobility and accessibility, income, challenges in receiving and understanding warnings, or unfamiliarity with surroundings.

During this Regional Plan's preparation, an estimate of the population exposed to flooding was created using a GIS overlay of existing Digital Flood Insurance Rate Maps (DFIRMs), or Hazus 100-year flood hazard areas where DFIRM was not available, to determine potentially flooded parcels. The flood-impacted population for each county in the region was then calculated by taking the number of residential units in the 100-year and 500-year floodplains and multiplying that number by the average household size based on the Census Bureau's estimate for the counties. The average household factor was 2.74 for Campbell County, 2.43 for Crook, 2.32 for Johnson, 2.28 for Sheridan, and 2.18 for Weston County. The results for the Region are displayed below in Table 4-39.

**Table 4-39 Flood Vulnerable Population Estimate in Region 1**

| Type of Flood | Total # of Parcels | Vulnerable Population Estimate |
|---|---|---|
| 100 yr. flood | 1,013 | 1,395 |
| 500 yr. flood | 608 | 1,210 |
| **TOTAL** | **1,621** | **2,605** |

Source: FEMA NFHL, HAZUS analysis, and Census Bureau average household estimates for 2012-2016

### *Property and Economic Losses*

GIS analysis was used to estimate Region 1's potential property and economic losses. The county parcel layers were used as the basis for the inventory of developed parcels. GIS was used to create a centroid, or point, representing the center of each parcel polygon, which was overlaid on the best available floodplain layers. For the purposes of this analysis, the flood zone that intersected the centroid was assigned as the flood zone for the entire parcel. Another assumption with this model is that every parcel with an improvement value greater than zero was assumed to be developed in some way. Only improved parcels, and the value of those improvements, were analyzed and aggregated by jurisdiction, property type and flood zone. The summarized results for the Region are shown below, followed by the summarized results for each community affected by flooding (Table 4-42 through Table 4-46).

The following tables show the count and improved value of all the parcels in the Region, broken up by each county and their jurisdictions, by flood type. Only those parcels which fall within the 100-year, 500-year, or Hazus derived floodplains (which are combined with the 1% annual chance totals) are summarized. The table also shows loss estimate values which are calculated based upon the improved value and estimated contents value. The estimated contents value is 50% of the improved value for residential properties (150% for industrial and 100% for all other non-residential properties); the total exposure value is the sum of the improved and estimated contents values; the loss estimate is 25% of the total value based on FEMA's depth-damage loss curves. For example, a two-foot flood generally results in about 25% damage to the structure (which translates to an estimated loss of 25% of the structure's replacement value).

**Table 4-40 Region 1 Hazus/FEMA 1% Annual Chance Flood Risk Summaries**

| Jurisdiction | Parcel Count | Improved Value | Est. Content Value | Total Exposure | Potential Loss | Population |
|---|---|---|---|---|---|---|
| Campbell | 100 | $17,711,578 | $11,085,306 | $28,796,884 | $7,199,221 | 197 |
| Crook | 180 | $29,171,376 | $18,832,633 | $48,004,009 | $12,001,002 | 284 |
| Johnson | 234 | $36,748,137 | $30,074,637 | $66,822,774 | $16,705,693 | 183 |
| Sheridan | 403 | $78,334,643 | $52,574,984 | $130,909,627 | $32,727,407 | 684 |
| Weston | 96 | $2,142,476 | $1,641,474 | $3,783,950 | $945,988 | 46 |
| **TOTAL** | **1,013** | **$164,108,210** | **$114,209,033** | **$278,317,243** | **$69,579,311** | **1,395** |

**Table 4-41 Region 1 FEMA 0.2% Annual Chance Flood Risk Summaries**

| Jurisdiction | Parcel Count | Improved Value | Est. Content Value | Total Exposure | Potential Loss | Population |
|---|---|---|---|---|---|---|
| Campbell | 24 | $12,599,977 | $10,782,250 | $23,382,227 | $5,845,557 | 47 |
| Crook | 49 | $6,182,617 | $3,178,912 | $9,361,529 | $2,340,382 | 117 |
| Johnson | 9 | $432,393 | $232,197 | $664,590 | $166,147 | 9 |
| Sheridan | 526 | $77,282,789 | $48,579,390 | $125,862,179 | $31,465,545 | 1,037 |
| Weston | - | - | - | - | - | - |
| **TOTAL** | **608** | **$96,497,776** | **$62,772,748** | **$159,270,524** | **$39,817,631** | **1,210** |

**Table 4-42 Campbell County Hazus/FEMA Flood Risk Summary**

**1% Annual Chance Flood Risk**

| Jurisdiction | Property Type | Parcel Count | Improved Value | Est. Content Value | Total Exposure | Potential Loss | Population |
|---|---|---|---|---|---|---|---|
| Gillette | Agricultural | 1 | $5,302 | $5,302 | $10,604 | $2,651 | - |
| | Commercial | 6 | $2,037,832 | $2,037,832 | $4,075,664 | $1,018,916 | - |
| | Residential | 31 | $4,847,565 | $2,423,783 | $7,271,348 | $1,817,837 | 85 |
| | **Total** | **38** | **$6,890,699** | **$4,466,917** | **$11,357,616** | **$2,839,404** | **85** |
| Unincorporated | Agricultural | 19 | $2,381,882 | $2,381,882 | $4,763,764 | $1,190,941 | - |
| | Commercial | 2 | $34,017 | $34,017 | $68,034 | $17,009 | - |

| Jurisdiction | Property Type | Parcel Count | Improved Value | Est. Content Value | Total Exposure | Potential Loss | Population |
|---|---|---|---|---|---|---|---|
| | Residential | 41 | $8,404,980 | $4,202,490 | $12,607,470 | $3,151,868 | 112 |
| | **Total** | **62** | **$10,820,879** | **$6,618,389** | **$17,439,268** | **$4,359,817** | **112** |
| **GRAND TOTAL** | | **100** | **$17,711,578** | **$11,085,306** | **$28,796,884** | **$7,199,221** | **197** |

**0.2% Annual Chance Flood Risk**

| Jurisdiction | Property Type | Parcel Count | Improved Value | Est. Content Value | Total Exposure | Potential Loss | Population |
|---|---|---|---|---|---|---|---|
| Gillette | Commercial | 7 | $8,964,523 | $8,964,523 | $17,929,046 | $4,482,262 | - |
| | Residential | 12 | $1,548,540 | $774,270 | $2,322,810 | $580,703 | 33 |
| | **Total** | **19** | **$10,513,063** | **$9,738,793** | **$20,251,856** | **$5,062,964** | **33** |
| Unincorporated | Residential | 5 | $2,086,914 | $1,043,457 | $3,130,371 | $782,593 | 14 |
| | **Total** | **5** | **$2,086,914** | **$1,043,457** | **$3,130,371** | **$782,593** | **14** |
| **GRAND TOTAL** | | **24** | **$12,599,977** | **$10,782,250** | **$23,382,227** | **$5,845,557** | **47** |

## Table 4-43 Crook County Hazus/FEMA Flood Risk Summary

**1% Annual Chance Flood Risk**

| Jurisdiction | Property Type | Parcel Count | Improved Value | Est. Content Value | Total Exposure | Potential Loss | Population |
|---|---|---|---|---|---|---|---|
| Hulett | Commercial | 1 | $92,013 | $92,013 | $184,026 | $46,007 | - |
| | Residential | 4 | $524,773 | $262,387 | $787,160 | $196,790 | 10 |
| | **Total** | **5** | **$616,786** | **$354,400** | **$971,186** | **$242,796** | **10** |
| Moorcroft | Residential | 1 | $86,953 | $43,477 | $130,430 | $32,607 | 2 |
| | **Total** | **1** | **$86,953** | **$43,477** | **$130,430** | **$32,607** | **2** |
| Sundance | Commercial | 5 | $884,272 | $884,272 | $1,768,544 | $442,136 | - |
| | Duplex | 1 | $134,056 | $67,028 | $201,084 | $50,271 | 2 |
| | Residential | 31 | $4,363,114 | $2,181,557 | $6,544,671 | $1,636,168 | 75 |
| | **Total** | **37** | **$5,381,442** | **$3,132,857** | **$8,514,299** | **$2,128,575** | **78** |
| Unincorporated | Agricultural | 42 | $5,687,728 | $5,687,728 | $11,375,456 | $2,843,864 | - |
| | Commercial | 13 | $1,490,889 | $1,490,889 | $2,981,778 | $745,445 | - |
| | Exempt | 1 | $278,076 | $278,076 | $556,152 | $139,038 | - |
| | Industrial | 1 | $60,912 | $60,912 | $121,824 | $30,456 | - |
| | Residential | 80 | $15,568,590 | $7,784,295 | $23,352,885 | $5,838,221 | 194 |
| | **Total** | **137** | **$23,086,195** | **$15,301,900** | **$38,388,095** | **$9,597,024** | **194** |
| **GRAND TOTAL** | | **180** | **$29,171,376** | **$18,832,633** | **$48,004,009** | **$12,001,002** | **284** |

**0.2% Annual Chance Flood Risk**

| Jurisdiction | Property Type | Parcel Count | Improved Value | Est. Content Value | Total Exposure | Potential Loss | Population |
|---|---|---|---|---|---|---|---|
| Hulett | Commercial | 1 | $175,206 | $175,206 | $350,412 | $87,603 | - |
| | Duplex | 1 | $129,625 | $64,813 | $194,438 | $48,609 | 2 |
| | Residential | 47 | $5,877,786 | $2,938,893 | $8,816,679 | $2,204,170 | 114 |
| | **Total** | **49** | **$6,182,617** | **$3,178,912** | **$9,361,529** | **$2,340,382** | **117** |

## Table 4-44 Johnson County Hazus/FEMA Flood Risk Summary

**1% Annual Chance Flood Risk**

| Jurisdiction | Property Type | Parcel Count | Improved Value | Est. Content Value | Total Exposure | Potential Loss | Population |
|---|---|---|---|---|---|---|---|
| Buffalo | Com Vacant Land | 3 | $85,148 | $85,148 | $170,296 | $42,574 | - |
| | Commercial | 8 | $8,224,478 | $8,224,478 | $16,448,956 | $4,112,239 | - |
| | Industrial | 1 | $106,254 | $106,254 | $212,508 | $53,127 | - |
| | Res Vacant Land | 8 | $74,622 | $37,311 | $111,933 | $27,983 | - |
| | Residential | 22 | $2,192,143 | $1,096,072 | $3,288,215 | $822,054 | 51 |
| | **Total** | **42** | **$10,682,645** | **$9,549,263** | **$20,231,908** | **$5,057,977** | **51** |
| Kaycee | Commercial | 9 | $579,727 | $579,727 | $1,159,454 | $289,864 | - |
| | Res Vacant Land | 8 | $205,090 | $102,545 | $307,635 | $76,909 | - |
| | Residential | 16 | $1,773,425 | $886,713 | $2,660,138 | $665,034 | 37 |
| | **Total** | **33** | **$2,558,242** | **$1,568,985** | **$4,127,227** | **$1,031,807** | **37** |
| Unincorporated | Agricultural | 94 | $11,098,206 | $11,098,206 | $22,196,412 | $5,549,103 | - |
| | Com Vacant Land | 2 | $212,924 | $212,924 | $425,848 | $106,462 | - |
| | Commercial | 14 | $3,094,399 | $3,094,399 | $6,188,798 | $1,547,200 | - |
| | Res Vacant Land | 8 | $828,030 | $414,015 | $1,242,045 | $310,511 | - |
| | Residential | 41 | $8,273,691 | $4,136,846 | $12,410,537 | $3,102,634 | 95 |
| | **Total** | **159** | **$23,507,250** | **$18,956,390** | **$42,463,640** | **$10,615,910** | **95** |
| **GRAND TOTAL** | | **234** | **$36,748,137** | **$30,074,637** | **$66,822,774** | **$16,705,693** | **183** |

**0.2% Annual Chance Flood Risk**

| Jurisdiction | Property Type | Parcel Count | Improved Value | Est. Content Value | Total Exposure | Potential Loss | Population |
|---|---|---|---|---|---|---|---|
| Kaycee | Commercial | 2 | $32,000 | $32,000 | $64,000 | $16,000 | -- |
| | Res Vacant Land | 3 | $55,022 | $27,511 | $82,533 | $20,633 | -- |
| | Residential | 4 | $345,371 | $172,686 | $518,057 | $129,514 | 9 |
| | **Total** | **9** | **$432,393** | **$232,197** | **$664,590** | **$166,147** | **9** |

## Table 4-45 Sheridan County Hazus/FEMA Flood Risk Summary

**1% Annual Chance Flood Risk**

| Jurisdiction | Property Type | Parcel Count | Improved Value | Est. Content Value | Total Exposure | Potential Loss | Population |
|---|---|---|---|---|---|---|---|
| Dayton | Residential | 20 | $1,822,628 | $911,314 | $2,733,942 | $683,486 | 46 |
| | **Total** | **20** | **$1,822,628** | **$911,314** | **$2,733,942** | **$683,486** | **46** |
| Ranchester | Commercial | 3 | $1,179,833 | $1,179,833 | $2,359,666 | $589,917 | - |
| | Residential | 24 | $2,895,045 | $1,447,523 | $4,342,568 | $1,085,642 | 55 |
| | **Total** | **27** | **$4,074,878** | **$2,627,356** | **$6,702,234** | **$1,675,558** | **55** |
| Sheridan | Agricultural | 2 | $1,914,858 | $1,914,858 | $3,829,716 | $957,429 | - |
| | Commercial | 3 | $1,265,962 | $1,265,962 | $2,531,924 | $632,981 | - |
| | Exempt | 2 | $167,646 | $167,646 | $335,292 | $83,823 | - |

| Jurisdiction | Property Type | Parcel Count | Improved Value | Est. Content Value | Total Exposure | Potential Loss | Population |
|---|---|---|---|---|---|---|---|
| | Residential | 30 | $3,889,738 | $1,944,869 | $5,834,607 | $1,458,652 | 68 |
| | **Total** | **37** | **$7,238,204** | **$5,293,335** | **$12,531,539** | **$3,132,885** | **68** |
| Unincorporated | Agricultural | 83 | $18,938,888 | $18,938,888 | $37,877,776 | $9,469,444 | - |
| | Commercial | 5 | $3,246,855 | $3,246,855 | $6,493,710 | $1,623,428 | - |
| | Exempt | 2 | $101,282 | $101,282 | $202,564 | $50,641 | - |
| | Res Vacant Land | 3 | $50,698 | $25,349 | $76,047 | $19,012 | - |
| | Residential | 226 | $42,861,210 | $21,430,605 | $64,291,815 | $16,072,954 | 515 |
| | **Total** | **319** | **$65,198,933** | **$43,742,979** | **$108,941,912** | **$27,235,478** | **515** |
| | **Grand Total** | **403** | **$78,334,643** | **$52,574,984** | **$130,909,627** | **$32,727,407** | **684** |

**0.2% Annual Chance Flood Risk**

| Jurisdiction | Property Type | Parcel Count | Improved Value | Est. Content Value | Total Exposure | Potential Loss | Population |
|---|---|---|---|---|---|---|---|
| Ranchester | Residential | 1 | $384,684 | $192,342 | $577,026 | $144,257 | 2 |
| | **Total** | **1** | **$384,684** | **$192,342** | **$577,026** | **$144,257** | **2** |
| Sheridan | Commercial | 57 | $13,854,745 | $13,854,745 | $27,709,490 | $6,927,373 | - |
| | Exempt | 2 | $1,275,094 | $1,275,094 | $2,550,188 | $637,547 | - |
| | Residential | 394 | $47,381,366 | $23,690,683 | $71,072,049 | $17,768,012 | 898 |
| | **Total** | **453** | **$62,511,205** | **$38,820,522** | **$101,331,727** | **$25,332,932** | **898** |
| Unincorporated | Agricultural | 9 | $2,860,334 | $2,860,334 | $5,720,668 | $1,430,167 | - |
| | Commercial | 3 | $1,885,817 | $1,885,817 | $3,771,634 | $942,909 | - |
| | Residential | 60 | $9,640,749 | $4,820,375 | $14,461,124 | $3,615,281 | 136 |
| | **Total** | **72** | **$14,386,900** | **$9,566,526** | **$23,953,426** | **$5,988,356** | **137** |
| | **Grand Total** | **526** | **$77,282,789** | **$48,579,390** | **$125,862,179** | **$31,465,545** | **1,037** |

## Table 4-46 Weston County FEMA 1% Annual Chance Flood Risk Summary

| Jurisdiction | Property Type | Parcel Count | Improved Value | Est. Content Value | Total Exposure | Potential Loss | Population |
|---|---|---|---|---|---|---|---|
| Newcastle | Commercial | 1 | $54,430 | $54,430 | $108,860 | $27,215 | - |
| | Res Vacant Land | 5 | $48,113 | $24,057 | $72,170 | $18,042 | - |
| | Residential | 14 | $229,662 | $114,831 | $344,493 | $86,123 | 31 |
| | **Total** | **20** | **$332,205** | **$193,318** | **$525,523** | **$131,381** | **31** |
| Unincorporated | Agricultural | 65 | $1,050,640 | $1,050,640 | $2,101,280 | $525,320 | - |
| | Ind Vacant Land | 1 | $35,402 | $35,402 | $70,804 | $17,701 | - |
| | Res Vacant Land | 3 | $177,641 | $88,821 | $266,462 | $66,615 | - |
| | Residential | 7 | $546,588 | $273,294 | $819,882 | $204,971 | 15 |
| | **Total** | **76** | **$1,810,271** | **$1,448,157** | **$3,258,428** | **$814,607** | **15** |
| | **Grand Total** | **96** | **$2,142,476** | **$1,641,474** | **$3,783,950** | **$945,988** | **46** |

Weston County does not have FEMA mapped floodplains in a digital format so 0.2% annual chance floodplain losses were not calculated in this plan.

Based on this analysis, the Region 1 planning area has significant assets at risk to the 100-year and greater floods. There are 1,013 improved parcels within the 100-year floodplain (1% annual chance), for a total improved value of $164,108,210. There are 608 improved parcels within the 500-year floodplain (0.2% annual chance), for a total improved value of $96,497,776. Overall, Region 1 counties potentially face over $109 million in combined content and building improvement losses from flooding both the 100-year and 500-year floodplain estimations. Approximately $69.5 million of that total is based on damage estimates from the 1% annual chance flood alone, with the remaining $39.8 million in damages resulting from the 0.2% annual chance flood.

It was observed that some counties have vacant land property types that have improved values included in the analysis. This is potentially due to assessor data property type classes being out of date or misclassified. Residential vacant land was not used to estimate population, it was assumed that these are only improvements on the land due to the classification and no people lived within these property types.

***NFIP Claims Analysis***

Another method of examining the magnitude and severity of flooding in the Region is to examine the damage losses and payments from the National Flood Insurance Program, or NFIP. This information is not comprehensive, because it only reflects the communities which participate in the NFIP, and properties with flood insurance, but it is another way to analyze flood damages in the region. The information below represents the composite of unincorporated and community-specific policies, claims and payments. According to statistics from the National Flood Insurance Program (http://www.fema.gov/policy-claim-statistics-flood-insurance/policy-claim-statistics-flood-insurance/policy-claim-13) there have been a total of 52 flood insurance claims filed between 1/1/1978 and 11/30/2017 in the Region. The total of the payments made on these claims was $222,850. As of 2/07/2018, there were 210 flood insurance policies in force in the Region, for a total coverage of $53,280,600. More details on National Flood Insurance Program participation can be found within the county annexes.

Crook and Weston Counties' unincorporated areas and some communities are not participating and/or do not have effective FEMA Flood Insurance Rate Maps and therefore have no NFIP policies.

## Table 4-47 NFIP Policy and Insurance Claim Data for Region 1

| Location | Policies | Coverage "Insurance in Force" | # of Claims "Closed Paid Losses" | Paid Losses "$ of closed paid losses" | Repetitive Losses | Substantial Damage claims | # of Policies in A Zones | # of Policies in Non A Zones |
|---|---|---|---|---|---|---|---|---|
| **Campbell** | 2 | $369,800 | 1 | $5,958 | 0 | 0 | 1 | 1 |
| Gillette | 19 | $7,581,000 | 12 | $30,779 | 0 | 0 | 8 | 11 |
| Wright | -- | -- | 1 | $1,350 | 0 | 0 | -- | -- |
| **Crook** | Never Mapped | -- | -- | -- | -- | -- | -- | -- |
| Sundance | 11 | $2,136,100 | -- | -- | -- | -- | 6 | 5 |
| Hulett | 2 | $519,600 | -- | -- | -- | -- | 1 | 1 |
| **Johnson** | 12 | $3,960,000 | 2 | $6,627 | 0 | 0 | -- | 12 |
| Buffalo | 19 | $4,705,700 | 2 | $10,582 | 0 | 0 | 12 | 7 |
| Kaycee | 7 | $1,052,900 | 1 | $4,695 | 0 | 1 | 5 | 2 |
| **Sheridan** | 86 | $21,760,500 | 18 | $114,388 | 3 | 0 | 34 | 52 |
| City of Sheridan | 35 | $7,789,600 | 11 | $25,838 | 0 | 0 | 15 | 20 |
| Ranchester | 7 | $1,579,700 | 3 | $21,462 | 0 | 0 | 3 | 4 |
| Dayton | 6 | $1,160,700 | -- | -- | 0 | 0 | 3 | 3 |
| **Weston** | Never Mapped | -- | -- | -- | -- | -- | -- | -- |
| Newcastle | 4 | $665,000 | 1 | $1,173 | 0 | 0 | -- | 4 |
| **TOTAL** | **210** | **$53,280,600** | **52** | **$222,852** | **3** | **1** | **88** | **122** |

Source: FEMA Policy and Claim Statistics http://www.fema.gov/policy-claim-statistics-flood-insurance and State of Wyoming Department of Homeland Security, NFIP Coordinator as of 2/07/2018

The only community in the Region that has participated in the National Flood Insurance Program's Community Rating System (CRS) is the City of Sheridan, in Sheridan County. The CRS is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community actions. The City of Sheridan entered into the CRS on 10/1/95, but as of October 2016 it had rescinded.

### *Critical Facilities and Community Assets*

GIS analysis of flood hazards in Region 1 indicates that there are 29 critical facilities and/or community assets that are potentially exposed to flood hazards. There are 28 facilities in the 100-year floodplain and one in the 500-year floodplain. The majority of these facilities are electric substations. Table 4-48 below summarize the facilities that are potentially at risk in the 1% and 0.2% annual chance floods; counties not listed in the table do not have any identified critical facilities in the flood zone. One limitation to the HSIP data is a lack of water facilities (water and wastewater). Gaining access to this type of information would enhance the results of the critical facility risk analysis.

**Table 4-48 Critical Facilities within the 1% Chance FEMA Flood Hazard or Hazus Flood Zones**

| Source | Jurisdiction | Facility Type | Facility Count |
|---|---|---|---|
| Hazus 100-year | Campbell | Power | 1 |
| | | **TOTAL** | **1** |
| | Crook | Day Care Facilities | 1 |
| | | Schools | 2 |
| | | **TOTAL** | **3** |
| 1% Annual Chance FEMA | Campbell | Communications | 2 |
| | | EMS Station | 1 |
| | | Fire Station | 1 |
| | | Power | 19 |
| | | **TOTAL** | **23** |
| | Sheridan | Schools | 1 |
| | | **TOTAL** | **1** |
| **GRAND TOTAL** | | | **28** |

**Table 4-49 Critical Facilities within the 0.2% Chance FEMA Flood Zone**

| County | Facility Type | Facility Count |
|---|---|---|
| Campbell | Cellular Towers | 1 |
| | **TOTAL** | **1** |

### *Natural, Historic, and Cultural Resources*

Natural resources are generally resistant to flooding, except where natural landscapes and soil compositions have been altered for human development or after periods of previous disasters such as drought and fire. Wetlands, for example, exist because of natural flooding incidents. Areas that are no longer wetlands may suffer from oversaturation of water, as will areas that are particularly impacted by drought. Areas recently suffering from wildfire damage may erode because of flooding (as has been the case in previous floods in Weston County), which can permanently alter an ecological system.

Tourism and outdoor recreation is an important part of the Region's economy. If part of the planning area were significantly damaged by flooding, tourism and outdoor recreation could potentially suffer. Some downtown areas with historic buildings have risk to flooding, notably in Buffalo and Kaycee in Johnson County.

### Future Development

For NFIP participating communities, floodplain management practices implemented through local floodplain management ordinances should mitigate the flood risk to new development in floodplains. The lack of comprehensive flood hazard mapping in unincorporated areas of Crook, Campbell, Johnson, Weston and Sheridan counties makes floodplain management challenging. No major growth or development in the Region is expected to significantly alter the general area flood risk, but good planning, zoning, and general hazard mitigation practices are always necessary to prevent future development from being heavily impacted by flooding.

### Summary

Overall, flooding is a **medium to high significance** hazard in the region, particularly in Johnson, Campbell, and Sheridan Counties. The Region floods, on average, once or twice a year, having damaged homes, infrastructure (roads, railroads, bridges, culverts), and causing agricultural losses in the past. Flood risk varies by jurisdiction and this risk is detailed further in the county annexes. Table 4-50 below summarizes the specific hazard risks by county.

**Table 4-50 Flood Hazard Risk Summary, by County**

| County | Geographic Extent | Probability of Future Occurrence | Potential Magnitude/ Severity | Overall Significance |
|---|---|---|---|---|
| Campbell | Limited | Likely | Limited | Medium |
| Crook | Limited | Likely | Limited | Medium |
| Johnson | Significant | Likely | Significant | High |
| Sheridan | Significant | Likely | Significant | High |
| Weston | Limited | Likely | Limited | Medium |

## 4.2.7 Hail

### Hazard/Problem Description

Hail causes more than a billion dollars of property damage nationally each year. Damaging hail events occur sporadically throughout Region 1, usually associated with severe summer storms and wind events. Hailstones form when a super-cooled droplet collects a layer of ice and continues to grow, sustained by an updraft. Once the hailstone cannot be held up any longer by the updraft, it falls to the ground. Hail up to 4.25 inches in diameter has been recorded by the NCEI in the Region. Most of this damage is to crops, but hail can also decimate structural sidings, shatter windows, peel paint, and severely damage automobiles and equipment not protected or stored inside.

## Geographic Area Affected

Hail can strike anywhere in the Region, and when they do occur hail storms can impact a Significant portion of the Region.

## Past Occurrences

A comprehensive history of damaging hailstorms historically affecting the counties in Region 1 is included in Table 4-51. The data was derived from the monthly Storm Data reports generated and released by the National Oceanic and Atmospheric Administration's National Climate Center. The data is more accurate after doppler radar was introduced into the Region in the 1990s.

NOAA records any hail events with hailstones that are 0.75 inch or larger in diameter, or any hail of a smaller diameter which causes property and/or crop damage, or casualties. According to the NOAA definition, there have been 1,257 separate hail incidents in the region since 1950, or an average of 18.76 incidents per year. Sixty-nine of those hail incidents caused reported damage or injuries, with a total reported property damage of $78,760,700, and reported crop damage of $50,000. Most public and personal property damage from hail is insured under private property insurance or crop insurance policies, serviced by multiple insurance providers; it is very difficult to get a true cumulative estimate of damage costs caused by hail events. No deaths have been associated with these storms in the region during this timeframe; however, on July 8, 2001 four climbers on Devil's Tower were injured by tennis ball-sized hail. Nationwide, most hail-related injuries are suffered by people caught unsheltered when hail begins to fall. Most hail-related injuries are minor and go unreported. The figures and tables below display past occurrences of hail in the Region.

The HMPCs noted that hail is a serious problem every summer, and the reported damage figures are low. Local media estimated damages from one hail storm in Gillette in 2010 to be as much as $46 million. The Sheridan Police Department sustained $50,000 in damage from one hail storm.

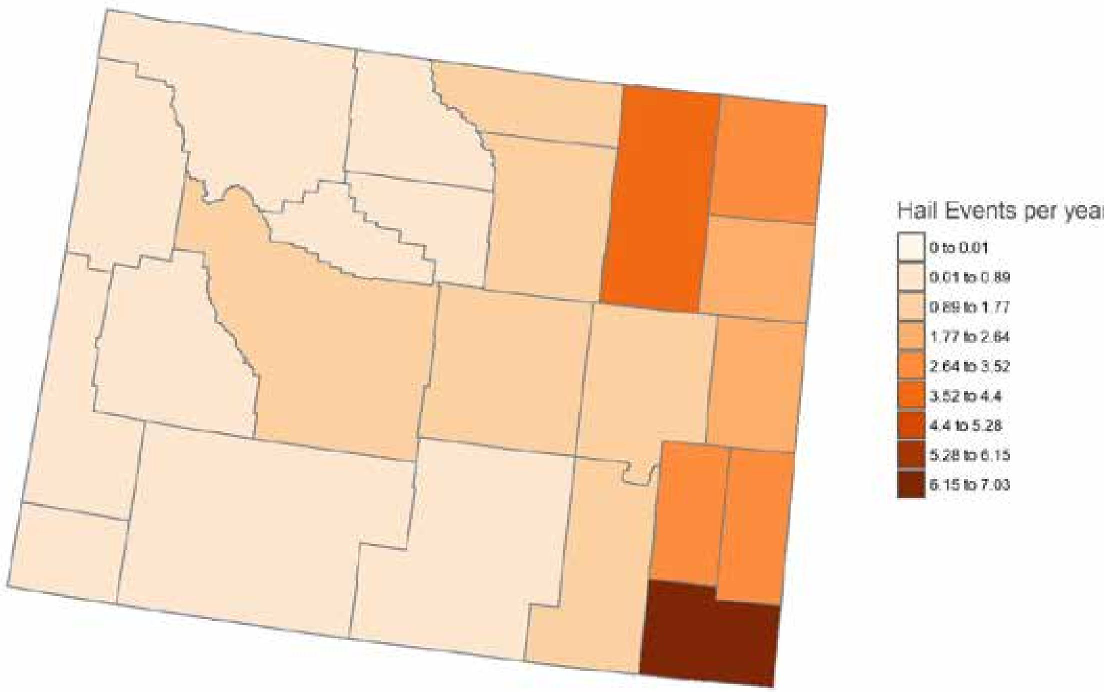
**Table 4-51 Hail History, Region 1 (1950-2016)**

| County | Events | Deaths | Injuries | Property Damage | Crop Damage |
|---|---|---|---|---|---|
| Campbell | 410 | 0 | 0 | $73,640,500 | $0 |
| Crook | 360 | 0 | 4 | $3,570,200 | $20,000 |
| Johnson | 114 | 0 | 0 | $70,000 | $30,000 |
| Sheridan | 159 | 0 | 0 | $50,000 | $0 |
| Weston | 214 | 0 | 0 | $1,530,000 | $0 |
| **Total:** | **1,257** | **0** | **4** | **$78,860,700** | **$50,000** |

Source: NOAA

Figure 4-36 was created by Western Water Assessment based on their analysis of NCEI data; shows the number of hail events in Wyoming per county from 1955-2017.

**Figure 4-36 Hail Events in Wyoming, 1955-2017**




WESTERN WATER ASSESSMENT
A NOAA RISA TEAM

Source: NOAA NCEI Storm Events Database

## Figure 4-37 Region 1 Hail Events

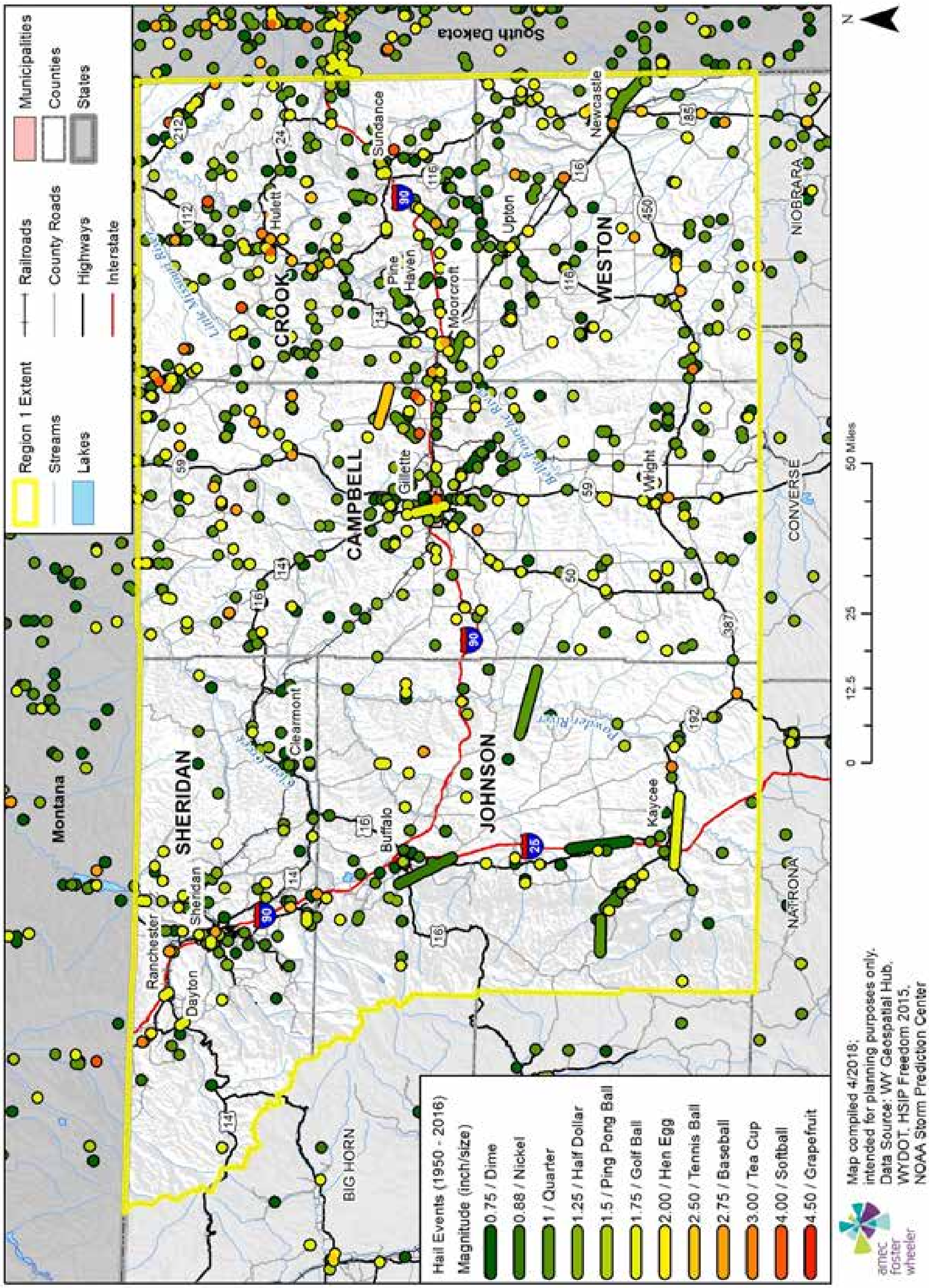


**Table 4-52 Region 1 Damaging Hail Events 1987-2017**

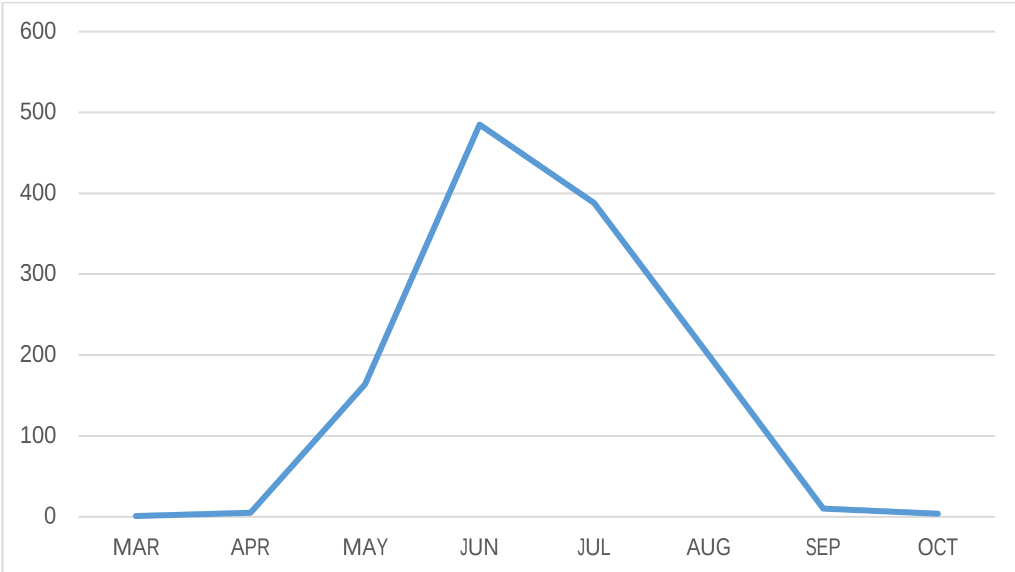
| County | Date | Hail Size | Deaths | Injuries | Property Damage | Crop Damage |
|---|---|---|---|---|---|---|
| Campbell | 1987-07-17 | 0.75 | 0 | 0 | $500 | $0 |
| Crook | 1987-08-11 | 2 | 0 | 0 | $50,000 | $0 |
| Crook | 1987-08-11 | 2 | 0 | 0 | $50,000 | $0 |
| Campbell | 1989-06-16 | 1.5 | 0 | 0 | $5,000 | $0 |
| Johnson | 1990-07-15 | 1.75 | 0 | 0 | $50,000 | $0 |
| Campbell | 1992-07-23 | 1.75 | 0 | 0 | $50,000 | $0 |
| Sheridan | 1993-05-04 | 1 | 0 | 0 | $50,000 | $0 |
| Campbell | 1995-07-15 | 1 | 0 | 0 | $5,000 | $0 |
| Crook | 1999-08-11 | 1.75 | 0 | 0 | $20,000 | $0 |
| Campbell | 2000-07-04 | 2.75 | 0 | 0 | $10,000 | $0 |
| Crook | 2001-07-08 | 2.5 | 0 | 4 | $10,000 | $0 |
| Campbell | 2003-06-21 | 2.75 | 0 | 0 | $17,000,000 | $0 |
| Weston | 2005-08-12 | 1.75 | 0 | 0 | $10,000 | $0 |
| Campbell | 2006-08-18 | 1.75 | 0 | 0 | $10,000 | $0 |
| Crook | 2007-06-25 | 4 | 0 | 0 | $50,000 | $0 |
| Crook | 2007-06-25 | 3.5 | 0 | 0 | $10,000 | $0 |
| Crook | 2007-06-25 | 2.75 | 0 | 0 | $10,000 | $0 |
| Crook | 2007-07-18 | 2.5 | 0 | 0 | $10,000 | $0 |
| Campbell | 2008-06-02 | 2.75 | 0 | 0 | $30,000 | $0 |
| Crook | 2009-05-30 | 1.75 | 0 | 0 | $20,000 | $0 |
| Crook | 2009-07-13 | 2.75 | 0 | 0 | $400,000 | $0 |
| Crook | 2009-07-13 | 4.25 | 0 | 0 | $200,000 | $0 |
| Crook | 2009-07-13 | 4.25 | 0 | 0 | $30,000 | $0 |
| Crook | 2009-07-13 | 2.75 | 0 | 0 | $10,000 | $0 |
| Johnson | 2009-07-20 | 0.88 | 0 | 0 | $0 | $20,000 |
| Campbell | 2009-08-07 | 1.75 | 0 | 0 | $200,000 | $0 |
| Campbell | 2010-05-26 | 1.75 | 0 | 0 | $46,000,000 | $0 |
| Johnson | 2010-06-20 | 2.75 | 0 | 0 | $10,000 | $0 |
| Campbell | 2010-06-30 | 2.5 | 0 | 0 | $10,000 | $0 |
| Crook | 2010-07-19 | 1.75 | 0 | 0 | $800,000 | $0 |
| Weston | 2010-07-19 | 2 | 0 | 0 | $700,000 | $0 |
| Campbell | 2010-07-19 | 4.25 | 0 | 0 | $100,000 | $0 |
| Weston | 2010-07-19 | 1.5 | 0 | 0 | $20,000 | $0 |
| Campbell | 2010-07-19 | 2.75 | 0 | 0 | $10,000 | $0 |
| Campbell | 2011-06-12 | 1.25 | 0 | 0 | $100,000 | $0 |
| Crook | 2011-06-12 | 1.25 | 0 | 0 | $30,000 | $0 |
| Weston | 2011-07-02 | 1.75 | 0 | 0 | $250,000 | $0 |
| Crook | 2011-07-02 | 2.5 | 0 | 0 | $10,000 | $0 |
| Crook | 2011-07-27 | 1.75 | 0 | 0 | $100,000 | $0 |

| County | Date | Hail Size | Deaths | Injuries | Property Damage | Crop Damage |
|---|---|---|---|---|---|---|
| Campbell | 2011-08-05 | 1 | 0 | 0 | $10,000 | $0 |
| Crook | 2012-06-22 | 2.75 | 0 | 0 | $600,000 | $0 |
| Crook | 2012-06-22 | 2.75 | 0 | 0 | $20,000 | $0 |
| Weston | 2012-06-22 | 1.5 | 0 | 0 | $20,000 | $0 |
| Crook | 2012-08-02 | 1.75 | 0 | 0 | $50,000 | $0 |
| Crook | 2012-08-02 | 1.75 | 0 | 0 | $10,000 | $0 |
| Crook | 2013-05-17 | 1.75 | 0 | 0 | $200,000 | $0 |
| Weston | 2013-05-27 | 1.75 | 0 | 0 | $500,000 | $0 |
| Johnson | 2013-07-03 | 0.88 | 0 | 0 | $0 | $10,000 |
| Crook | 2013-07-06 | 1.75 | 0 | 0 | $10,000 | $0 |
| Crook | 2013-07-22 | 1.5 | 0 | 0 | $150,000 | $0 |
| Crook | 2013-07-22 | 1.75 | 0 | 0 | $50,000 | $0 |
| Crook | 2013-07-22 | 1.25 | 0 | 0 | $10,000 | $0 |
| Weston | 2013-07-22 | 1.75 | 0 | 0 | $10,000 | $0 |
| Campbell | 2013-08-01 | 1.75 | 0 | 0 | $10,000,000 | $0 |
| Campbell | 2013-08-01 | 1.75 | 0 | 0 | $10,000 | $0 |
| Campbell | 2013-08-02 | 1.5 | 0 | 0 | $50,000 | $0 |
| Campbell | 2013-08-03 | 1.75 | 0 | 0 | $10,000 | $0 |
| Crook | 2013-08-03 | 1 | 0 | 0 | $0 | $20,000 |
| Campbell | 2013-08-07 | 1.75 | 0 | 0 | $10,000 | $0 |
| Weston | 2013-08-07 | 1.75 | 0 | 0 | $10,000 | $0 |
| Campbell | 2013-09-08 | 1.5 | 0 | 0 | $10,000 | $0 |
| Campbell | 2013-09-08 | 4.25 | 0 | 0 | $10,000 | $0 |
| Crook | 2014-05-22 | 2.5 | 0 | 0 | $300,000 | $0 |
| Crook | 2014-05-22 | 2 | 0 | 0 | $200,000 | $0 |
| Johnson | 2014-06-10 | 3 | 0 | 0 | $10,000 | $0 |
| Crook | 2014-06-17 | 1.5 | 0 | 0 | $150,000 | $0 |
| Weston | 2014-07-22 | 2.75 | 0 | 0 | $10,000 | $0 |
| Crook | 2015-06-24 | 1.75 | 0 | 0 | $10,000 | $0 |
| Crook | 2016-07-16 | 1.25 | 0 | 0 | $200 | $0 |

Source: NOAA

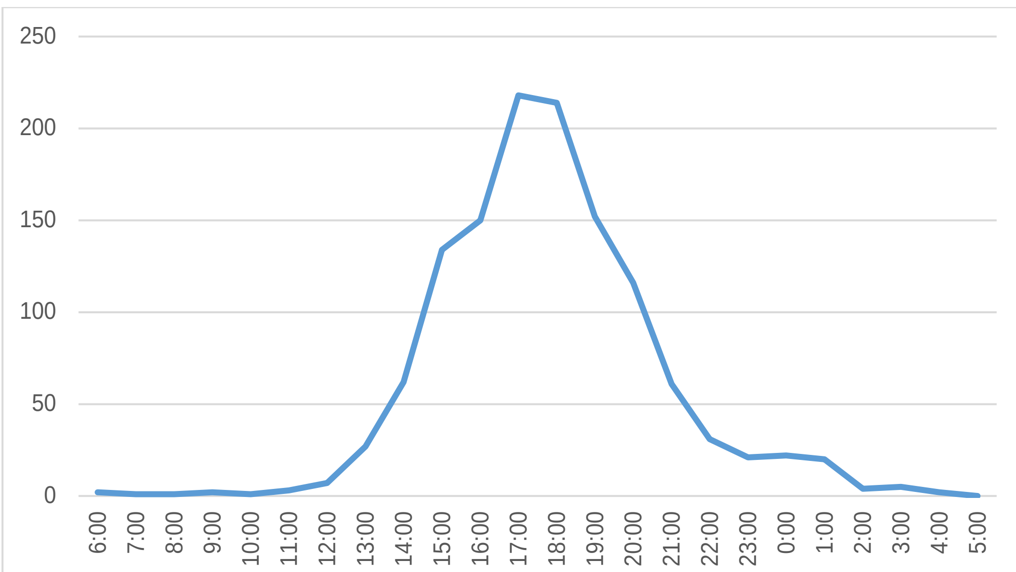
Hail events in Region 1 are most common during the months of May through August, most often between 1 pm and 11 pm. Hail with a diameter less than two inches is most common, although hail up to four inches has been recorded in the Region. While most historical hail storms in the Region don't result in major damage, recordable damage to property and crops could be in the hundreds of thousands of dollars, while extreme events could result in millions of dollars of damage. Insured loss related to hail storms could be in the millions, depending on the location and parameters of the storm.

**Figure 4-38 Number of Region 1 Hail Events by Month, 1950-2016**




Source: NOAA

**Figure 4-39 Number of Region 1 Hail Events by Time of Day, 1950-2016**




Source: NOAA

## Frequency/Likelihood of Occurrence

Based on historical data, the Region has experienced 69 separate damaging hail events between 1950 and 2016, which is roughly one incident a year. Thus, the Region is Likely to suffer damaging hail storms in the future.

## Potential Magnitude

Most public and personal property damage from hail is insured under private property insurance or crop insurance policies, serviced by multiple insurance providers; it is very difficult to get a true cumulative estimate of damage costs caused by hail events. Data collection regarding dollar damage to public and personal property holds significant gaps for this reason. There have been no FEMA disaster or state declarations for the counties in the Region related to damaging hail, and no USDA disaster declarations as a result of hail damage were found. Agricultural losses and claims met by crop insurance carriers due to hail damage are difficult to determine. Since most hail damage is insured, the overall impact for most of the Region is Negligible, but given Campbell County's history of more damaging hail storms, the potential impact for that County is Limited.

## Vulnerability Assessment

Hail can strike anywhere in the region, and all structures are vulnerable. Hail can damage roofs, shingles, windows, siding, unsheltered vehicles and any other property unprotected from the storm. People without shelter can also be injured by exposure to hail storms, though there is very little historical reference for this occurring in the Region. Most injuries caused by hail are minor, and go unreported. Higher levels of property damage are expected in more urban areas, and higher levels of crop damage would be expected in rural areas with more farmland. The HMPC emphasized that hail can ruin crops and have economic impacts to roofs and vehicles all throughout the region.

## Future Development

Hail can strike anywhere in the Region, so any growth or new development in the counties will increase exposure to hail damage. Insurance will be an important tool to offset the potentially substantial dollar losses associated with hail.

## Summary

The counties in Region 1 will continue to experience hail on a regular basis. Hail damage to property is expected to be highest in the municipalities; much of the damage to both property and crops is covered under insurance policies.

**Table 4-53 Hail Hazard Risk Summary**

| County | Geographic Extent | Probability of Future Occurrence | Potential Magnitude/ Severity | Overall Significance |
|---|---|---|---|---|
| Campbell | Significant | Likely | Limited | Medium |
| Crook | Significant | Likely | Negligible | Medium |
| Johnson | Significant | Likely | Negligible | Medium |
| Sheridan | Significant | Likely | Negligible | Medium |
| Weston | Significant | Likely | Negligible | Medium |

## 4.2.8 Hazardous Materials

### Hazard/Problem Description

Generally, a hazardous material is a substance or combination of substances which, because of quantity, concentration, or physical, chemical, or infectious characteristics, may either (1) cause or significantly contribute to, an increase in mortality or an increase in serious, irreversible, or incapacitating reversible, illness; or (2) pose a substantial present or potential hazard to human health or environment when improperly treated, stored, transported, disposed of, or otherwise managed. Hazardous material incidents can occur while a hazardous substance is stored at a fixed facility, or while the substance is being transported.

The U.S. Department of Transportation, U.S. Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA) all have responsibilities in regards to hazardous materials and waste.

The U.S. Department of Transportation has identified the following classes of hazardous materials:

- Explosives
- Compressed gases: flammable, non-flammable compressed, poisonous
- Flammable liquids: flammable (flashpoint below 141 degrees Fahrenheit) combustible (flashpoint from 141 - 200 degrees)
- Flammable solids: spontaneously combustible, dangerous when wet
- Oxidizers and organic peroxides
- Toxic materials: poisonous material, infectious agents
- Radioactive material
- Corrosive material: destruction of human skin, corrodes steel

Region 1 is home to several oil fields, gas plants, refineries, propane storage facilities, mines, and an ammonium nitrate facility. Numerous highways, rail lines, and pipelines run across the Region, creating a likely potential for hazardous materials releases. A commodity flow study being conducted on I-90 and I-25 in Johnson County this summer will provide more detailed data on the type and quantity of hazardous materials being transported through the Region on the Interstates.

### Geographical Area Affected

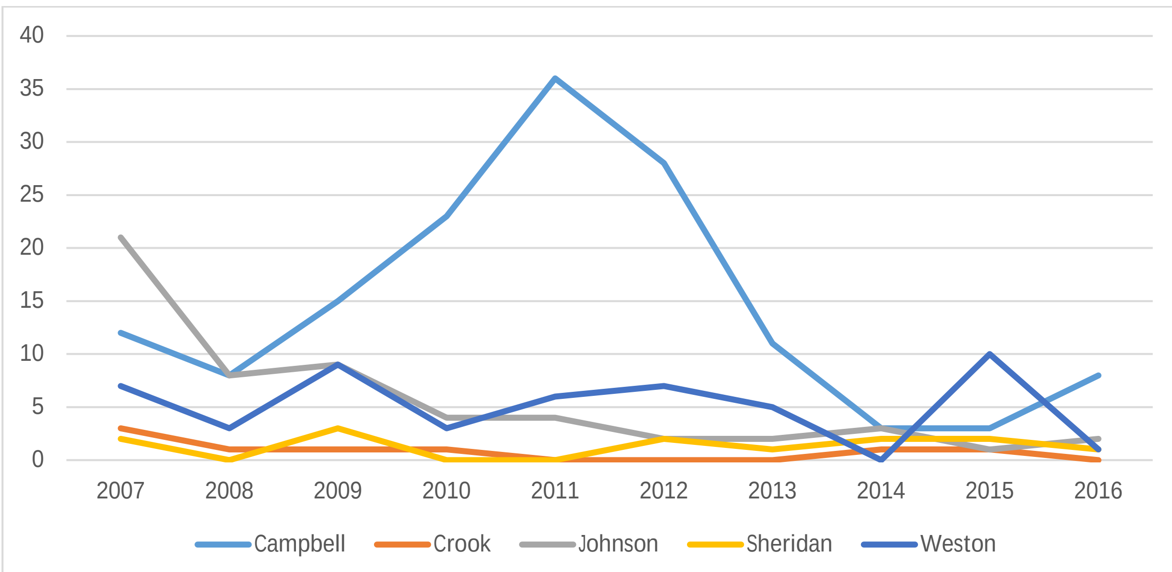
Hazmat incidents can occur at a fixed facility or during transportation. Hazardous materials facilities are identified and mapped by the counties they reside in, along with the types of materials stored there; facilities generally reside in and around communities. Some facilities contain extremely hazardous substances; these facilities are required to generate Risk Management Plans (RMPs), and resubmit these plans every five years. RMP facility information can be found within individual jurisdiction annexes.

In transit, hazardous materials generally follow major transportation routes where possible (including road, rail and pipelines), creating a risk area immediately adjacent to these routes.

### Past Occurrences

There are a variety of mechanisms to get an idea of the number and types of historical hazardous materials spills in the Region. One such repository is the catalog of hazardous materials spill and accident reports at the National Response Center (NRC) as part of the Right to Know Network (RTK NET). The figure below shows a ten-year record for reported incidents in Region 1.

**Figure 4-40 Hazardous Materials Spills/ Accidents Reported to the NRC for Region 1: 2007-2016**




Source: http://www.rtk.net/#rmp

According to the data, during the time period between 2007 and 2016 the Region saw anywhere from 9 to 46 NRC-reported incidents per year, which means that most counties can reasonably expect multiple hazardous materials responses annually. The more extensive oil and gas and mining operations in Campbell County make it the more prone to incidents than other counties in the Region. The county data is further broken down in the table below:

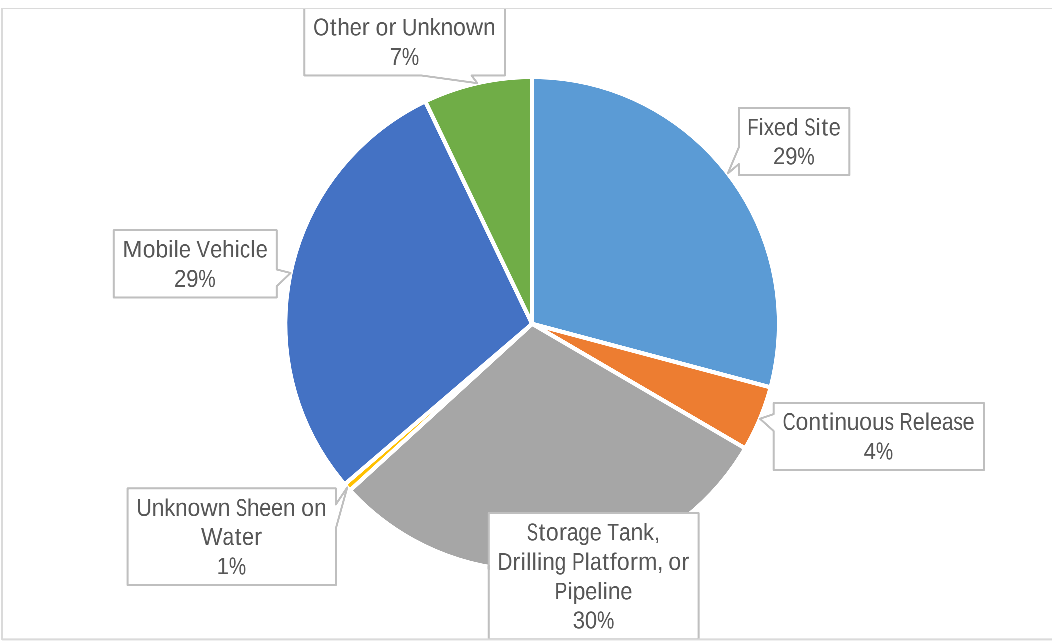
**Table 4-54 NRC-Reported Incidents by County: 2010-2015**

| Year | Campbell | Crook | Johnson | Sheridan | Weston | Total |
|---|---|---|---|---|---|---|
| 2007 | 12 | 3 | 21 | 2 | 7 | 45 |
| 2008 | 8 | 1 | 8 | 0 | 3 | 20 |
| 2009 | 15 | 1 | 9 | 3 | 9 | 37 |
| 2010 | 23 | 1 | 4 | 0 | 3 | 31 |
| 2011 | 36 | 0 | 4 | 0 | 6 | 46 |
| 2012 | 28 | 0 | 2 | 2 | 7 | 39 |
| 2013 | 11 | 0 | 2 | 1 | 5 | 19 |
| 2014 | 3 | 1 | 3 | 2 | 0 | 9 |
| 2015 | 3 | 1 | 1 | 2 | 10 | 17 |
| 2016 | 8 | 0 | 2 | 1 | 1 | 12 |
| **Yearly Average** | 14.7 | 0.8 | 5.6 | 1.3 | 5.1 | 27.5 |

Source: http://www.rtk.net/#rmp

The NRC also tracks incidents by type. The following figure shows the percentage of each type of incident over the 10-year period between January 2007 and December 2016.

**Figure 4-41 Hazardous Materials Incidents Reported to the NRC by Type - Region 1: 2007-2016**




Source: http://www.rtk.net/#rmp

In addition to local first responders, eight Regional Emergency Response Teams (RERT) across the State of Wyoming respond to a variety of incidents, including those incidents involving hazardous materials. The Region 1 RERT is located in Gillette, in Campbell County. The following table shows records of Region 1 RERT mission assignments pertaining to hazardous materials releases, according the 2016 Wyoming State Hazard Mitigation Plan.

**Table 4-55 Region 1 RERT Mission Assignments, Hazmat: 2004-2015**

| Type | Number |
|---|---|
| Fixed Facility | 8 |
| Truck/Highway | 16 |
| Rail | 0 |
| Pipeline | 0 |
| Aircraft | 0 |
| Orphan Drum | 2 |
| **Total** | **26** |

Source: 2016 Wyoming State Hazard Mitigation Plan

According to the HMPCs, small-level hazardous materials incidents occur frequently throughout the year in Region 1. During discussions, the committees noted roads, rail and pipelines throughout the Region. Uranium shipments traverse several of the counties in the Region; while these shipments are regarded as relatively low-risk, the frequency of shipments may increase once the new uranium processing plant starts up. Johnson County expressed concerns over oil pipeline ruptures, and fires at coal bed methane compressor stations. Campbell County reported the main category of hazmat transported through their County are flammables; crude oil and other flammables are also the most numerous at fixed facilities. Crook County recommended upgrading this hazard to High significance, from Medium in their previous mitigation plan.

### Frequency/Likelihood of Future Occurrence

The Region experiences multiple hazardous materials incidents each year, with various degrees of impact; there is effectively a 100% chance that the Region will see a hazardous materials incident in any given year. Hazardous material spills and releases, both from fixed facilities and during transport, will continue to occur in each county in Region 1 annually.

### Potential Magnitude

Impacts that could occur from hazardous waste spills or releases include:

- Injury
- Loss of life (human, livestock, fish and wildlife)
- Evacuations
- Property damage
- Air pollution
- Surface or ground water pollution/contamination
- Interruption of commerce and transportation

Numerous factors go into the ultimate impacts of a hazardous materials release, including method of release, the type of material, location of release, weather conditions, and time of day. This makes it difficult to nail down precise impacts. Materials found in Region 1 will have at least one of the impacts listed above, and probably more.

## Vulnerability Assessment

Region 1 has energy pipelines, railroad tracks which carry many types of hazardous materials, and both state and Interstate highways running through its boundaries. A variety of hazardous materials originating in the Region or elsewhere are transported along these routes, and could be vulnerable to accidental spills. Consequences can vary depending on whether the spill affects a populated area vs an unpopulated but environmentally sensitive area.

The Right-to-Know Network lists 32 licensed hazardous waste handlers in Region 1, as broken down in Table 4-56. There are 18 RMP facilities located in Region 1, as noted in Table 4-57 below. Some of these are discussed in more detail in the Annexes.

**Table 4-56 Hazardous Materials Handlers in Region 1**

| County | Treatment, Storage or Disposal | Large Quantity Generator | Transporter | Total |
|---|---|---|---|---|
| Campbell | 0 | 1 | 14 | 15 |
| Crook | 0 | 0 | 1 | 1 |
| Johnson | 0 | 0 | 3 | 3 |
| Sheridan | 0 | 0 | 4 | 4 |
| Weston | 0 | 7 | 2 | 9 |
| **Total** | **0** | **8** | **24** | **32** |

Source: http://www.rtknet.org/db/erns

**Table 4-57 Risk Management Plan (RMP) Facilities in Region 1**

| County | Community | Number of Facilities |
|---|---|---|
| Campbell | Gillette | 9 |
| Campbell | Wright | 1 |
| Crook | Moorcroft | 4 |
| Johnson | NA | 0 |
| Sheridan | Sheridan | 2 |
| Weston | Newcastle | 2 |
| | **Total** | **18** |

Source: http://www.rtknet.org/db/erns

No specific hazardous materials routes or route restrictions are designated in Region 1; any routes used to carry hazardous materials introduce an element of risk of materials release to the area immediately adjacent to them. The Region noted that many petroleum and other flammable products are transported by truck and rail, and many have mixed payloads that don't list material amounts.

Potential losses can vary greatly for hazardous material incidents. For even a small incident, there are cleanup and disposal costs. In a larger scale incident, cleanup can be extensive and protracted. There can be deaths or injuries requiring doctor's visits and hospitalization, disabling chronic injuries, soil and water contamination can occur, necessitating costly remediation. Evacuations can disrupt home and business activities. Large-scale incidents can easily reach $1 million or more in direct damages.

### Future Development

Stationary facilities with hazardous materials are identified and mapped throughout the Region. Transportation routes are also identified. Special care should be taken to cross-reference any new development areas with identified sources for potential hazardous materials incidents.

### Summary

**Table 4-58 Hazardous Materials Hazard Risk Summary**

| County | Geographic Extent | Probability of Future Occurrence | Potential Magnitude/ Severity | Overall Significance |
|---|---|---|---|---|
| Campbell | Significant | Highly Likely | Limited | Medium |
| Crook | Significant | Likely | Limited | High |
| Johnson | Limited | Highly Likely | Limited | Medium |
| Sheridan | Significant | Highly Likely | Limited | Medium |
| Weston | Significant | Highly Likely | Limited | Medium |

## 4.2.9 High Winds and Downbursts

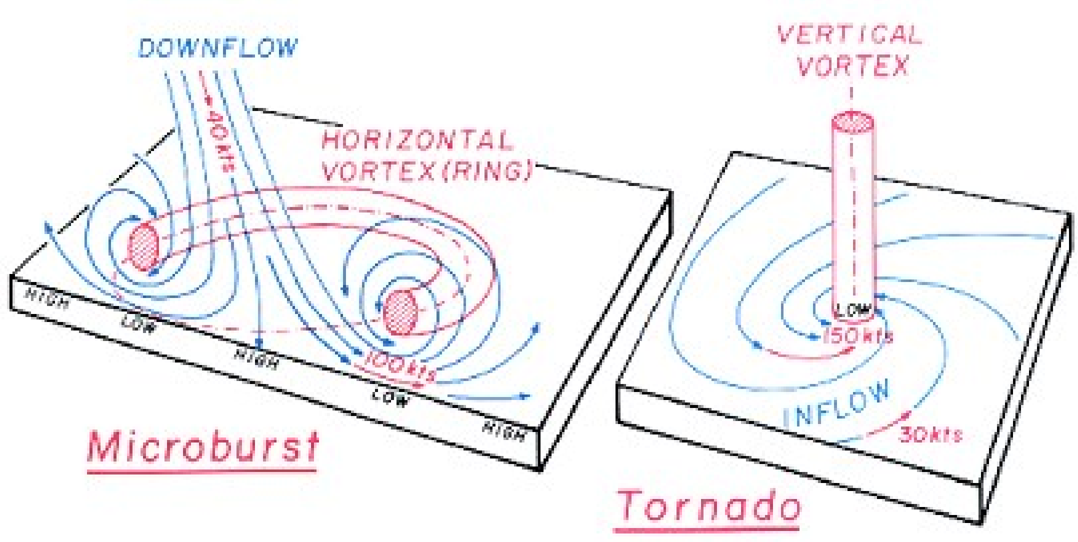
### Hazard/Problem Description

Wind is a nearly constant presence in Wyoming, and can often be overlooked as a hazard. Wyoming's wind is also becoming a positive economic factor, as renewable wind energy is developed around the state.

This profile examines the hazard that high winds present including downbursts, a subcategory of high winds. A downburst is a strong down draft which causes damaging winds on or near the ground. Downbursts are much more frequent than tornadoes, and for every one tornado there are approximately 10 downburst damage reports. Downbursts can be associated with either a heavy precipitation or non-precipitation thunderstorm (dry or wet downbursts), and often occur in the dissipating stage of a thunderstorm. Microbursts and macrobursts are categories of downbursts, classified by length of duration, velocity of wind, and radius of impact.

Microbursts generally last between five and 15 minutes, and impact an area less than three miles wide. Macrobursts can last up to 30 minutes with winds up to 130 miles per hour, and can impact areas larger than three miles in radius. Microbursts and macrobursts may induce dangerous wind shears, which can adversely affect aircraft performance, cause property damage and loss of life.

**Figure 4-42 Schema of Microburst and Tornado**




Source: www.erh.noaa.gov

A downburst can occur when cold air begins to descend from the middle and upper levels of a thunderstorm (falling at speeds of less than 20 miles an hour). As the colder air strikes the Earth's surface, it begins to ‘roll’ outward. As this rolling effect happens, the air expands causing further cooling and having the effect of pulling the shaft of air above it at higher and higher speeds.

Downbursts can be mistaken for tornadoes by those that experience them since damages and event characteristics are similar. Tornado winds can range from 40 mph to over 300 mph. Downbursts can exceed winds of 165 mph and can be accompanied by a loud roaring sound. Both downbursts and tornadoes can flatten trees, cause damage to homes and upend vehicles. In some instances, aerial surveying is the best method to determine what kind of event has taken place. In the following photograph, trees are blown down in a straight line – a very strong indication of a downburst as opposed to a tornado.

**Figure 4-43 Aerial Image of Downburst Damage**

Source: T. Fujita

## Geographical Area Affected

High winds are common throughout the planning area. Figure 4-44 and Figure 4-45 were created by Western Water Assessment based on their analysis of NCEI data; they show the number of high wind and thunderstorm wind events in Wyoming per county from 1996-2017. Note that while the number of non-thunderstorm high wind events reported in the counties of Region 1 are low, the residents of the area are used to high winds and may be less likely to report them as an "event" compared to other parts of the country.

**Figure 4-44 High Wind Events in Wyoming, 1996-2017**

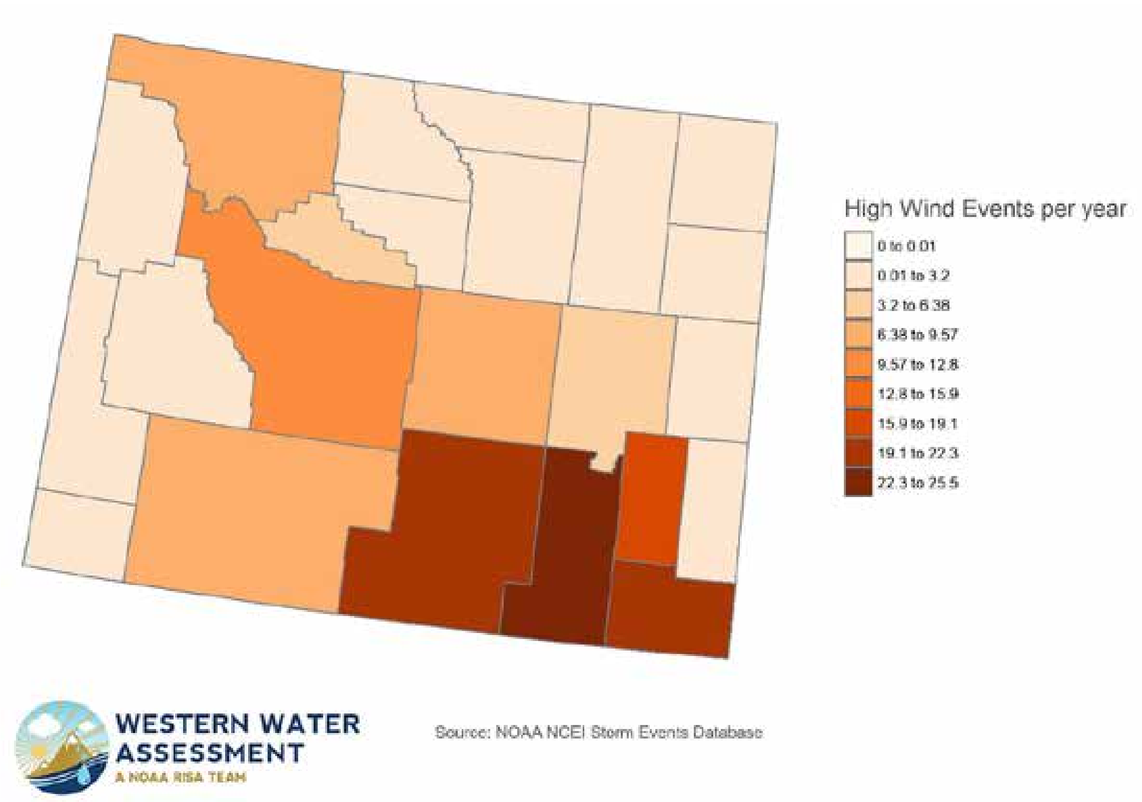
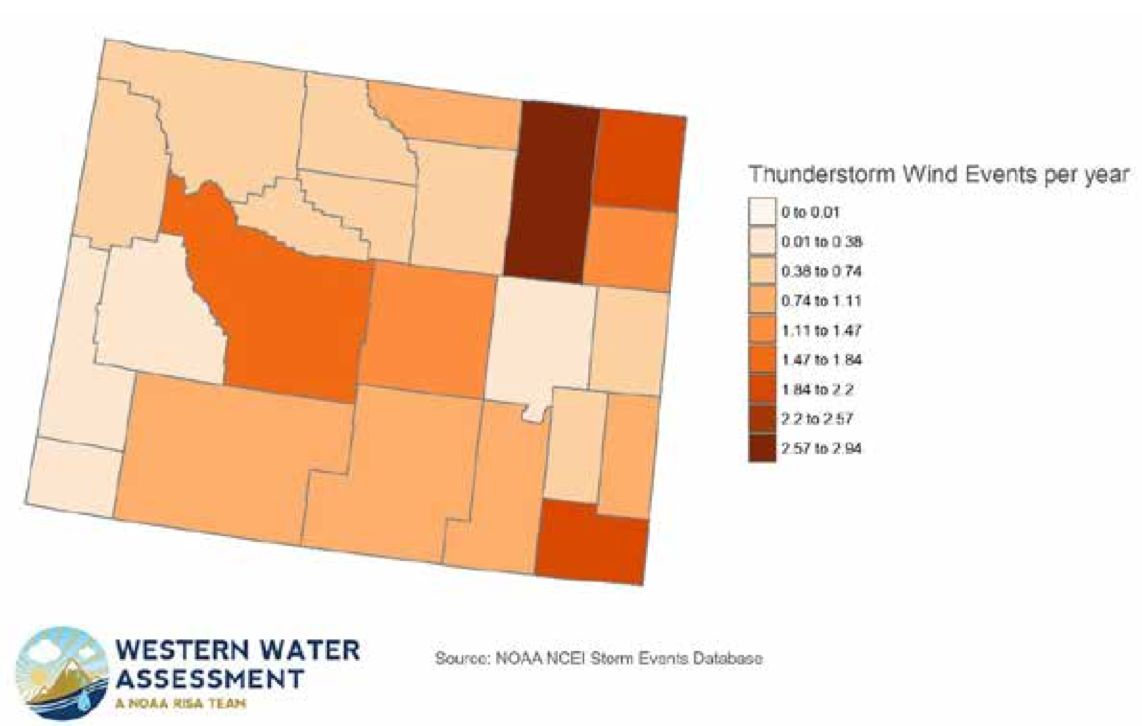



**Figure 4-45 Thunderstorm Wind Events in Wyoming, 1996-2017**



## Past Occurrences

In the counties in Region 1, most documented wind events causing damage typically range between 50 and 76 mph; max wind speeds of up to 91 mph have been recorded. It should be noted that the data is limited by what the NCEI is able to record, and what equipment was in place at the time, and that the timespan of available records for each county differs. The HMPCs observed that the number of high wind events seem to be increasing in recent (2015-2018) years, possibly due to the jet stream dipping further south. Weston County noted a wind event in 2016 resulted in downed power lines and significant damage in Upton and Newcastle.

**Figure 4-46 Summary of Wind Weather Events and Impacts**

| Region 1 (1950-2016) | | | | | | |
|---|---|---|---|---|---|---|
| **Total Number of Wind Events*** | **Total Property Damage** | **Total Crop Damage** | **Total Fatalities** | **Total Injuries** | **Average Recorded Wind Speed** | **Max Recorded Wind Speed** |
| 576 | $10,181,000 | $10,000 | 0 | 8 | 56 mph | 91 mph |
| **Campbell County (1950-2016)** | | | | | | |
| 211 | $6,385,500 | $10,000 | 0 | 7 | 56 mph | 91 mph |
| **Crook County (1950-2016)** | | | | | | |
| 162 | $1,020,000 | $0 | 0 | 0 | 55 mph | 70 mph |
| **Johnson County (1950-2016)** | | | | | | |
| 31 | $30,000 | $0 | 0 | 0 | 56 mph | 70 mph |
| **Sheridan County (1950-2016)** | | | | | | |
| 82 | $515,000 | $0 | 0 | 0 | 57 mph | 83 mph |
| **Weston County (1950-2016)** | | | | | | |
| 90 | $2,230,500 | $0 | 0 | 1 | 57 mph | 90 mph |

Source: NOAA
*It's important to note that more than one event may be associated with a single storm

While high winds can occur anytime, they are most common in the Region during the months of May through September, and between 3:00 and 10:00 pm.

## Figure 4-47 Wind Events, Wyoming Region 1, 1950-2016

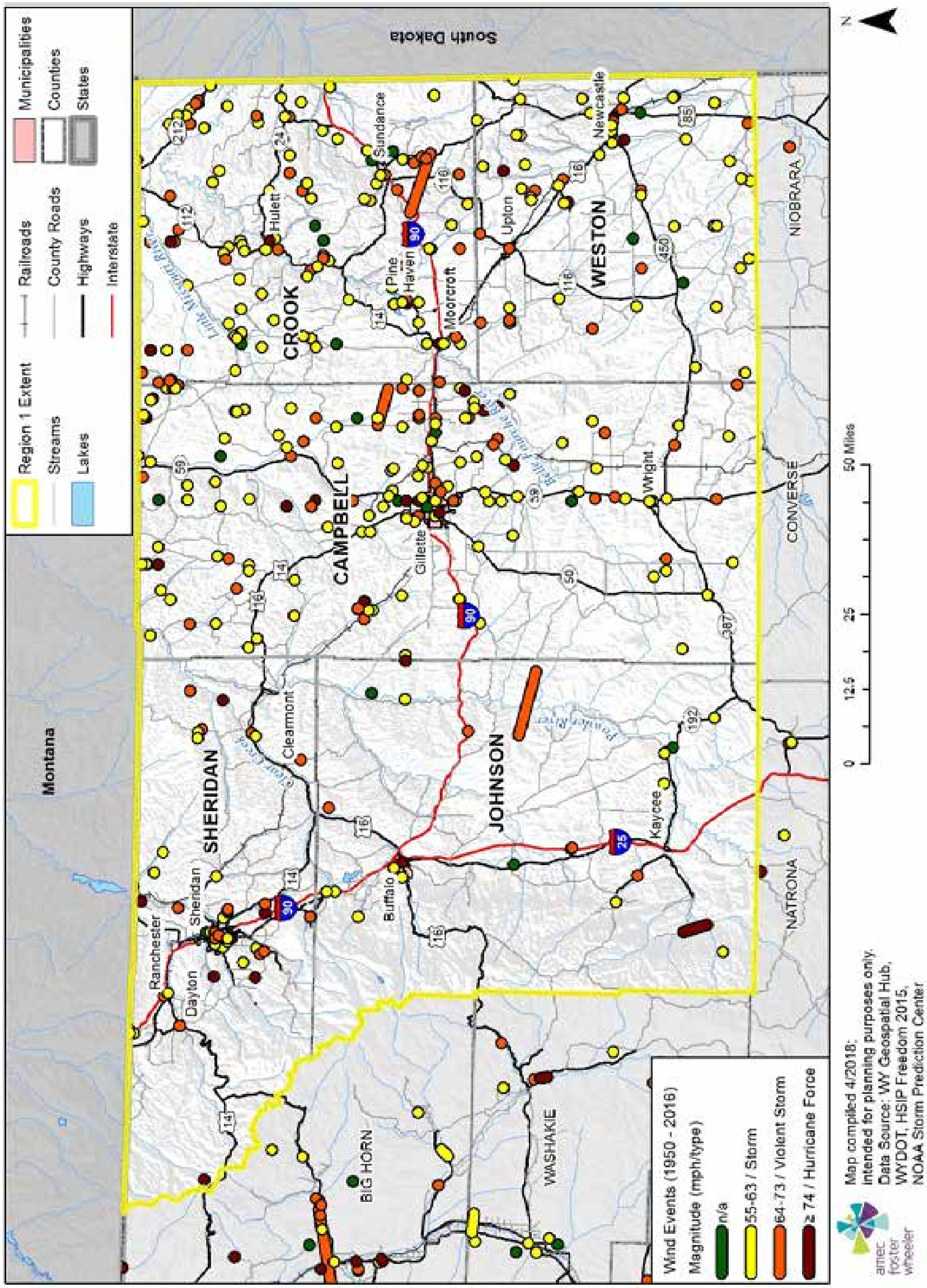
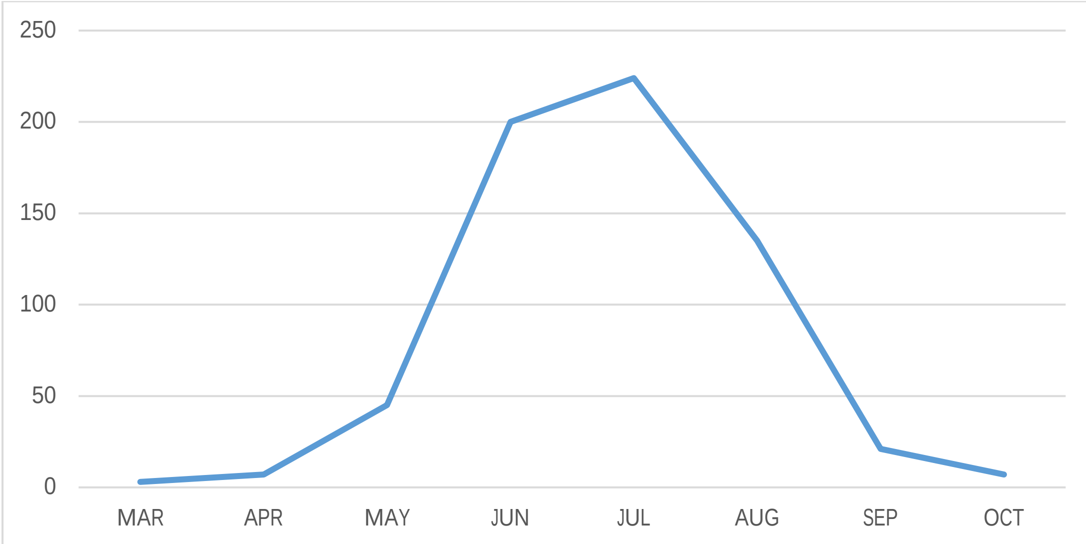
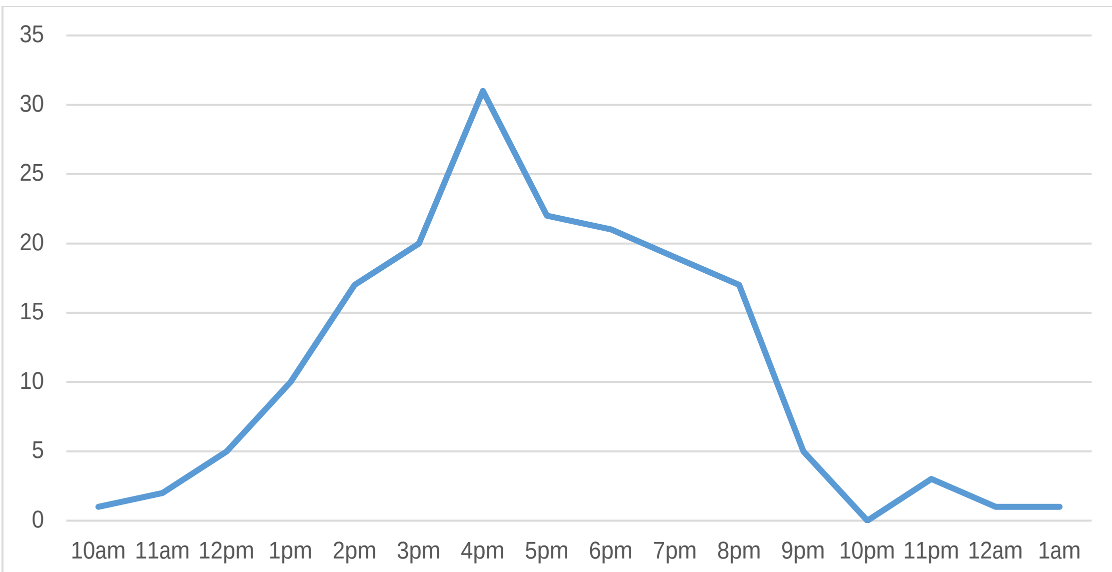


**Figure 4-48 Number of Region 1 High Wind Events by Month, 1950-2016**




Source: NOAA

**Figure 4-49 Number of Region 1 High Wind Events by Time of Day, 1950-2016**




Source: NOAA

## Frequency/Likelihood of Future Occurrences

NOAA records 576 confirmed and documented high wind incidents specifically impacting the Region, or zones tied to the Region since 1950; it should be noted that as technology has improved, the numbers of incidents recorded in more recent years have gone up dramatically.

Total recorded data for Region 1 averages to 8.6 recorded incidents per year. This trend is expected to continue, and the region can expect multiple high wind incidents every year for the foreseeable future.

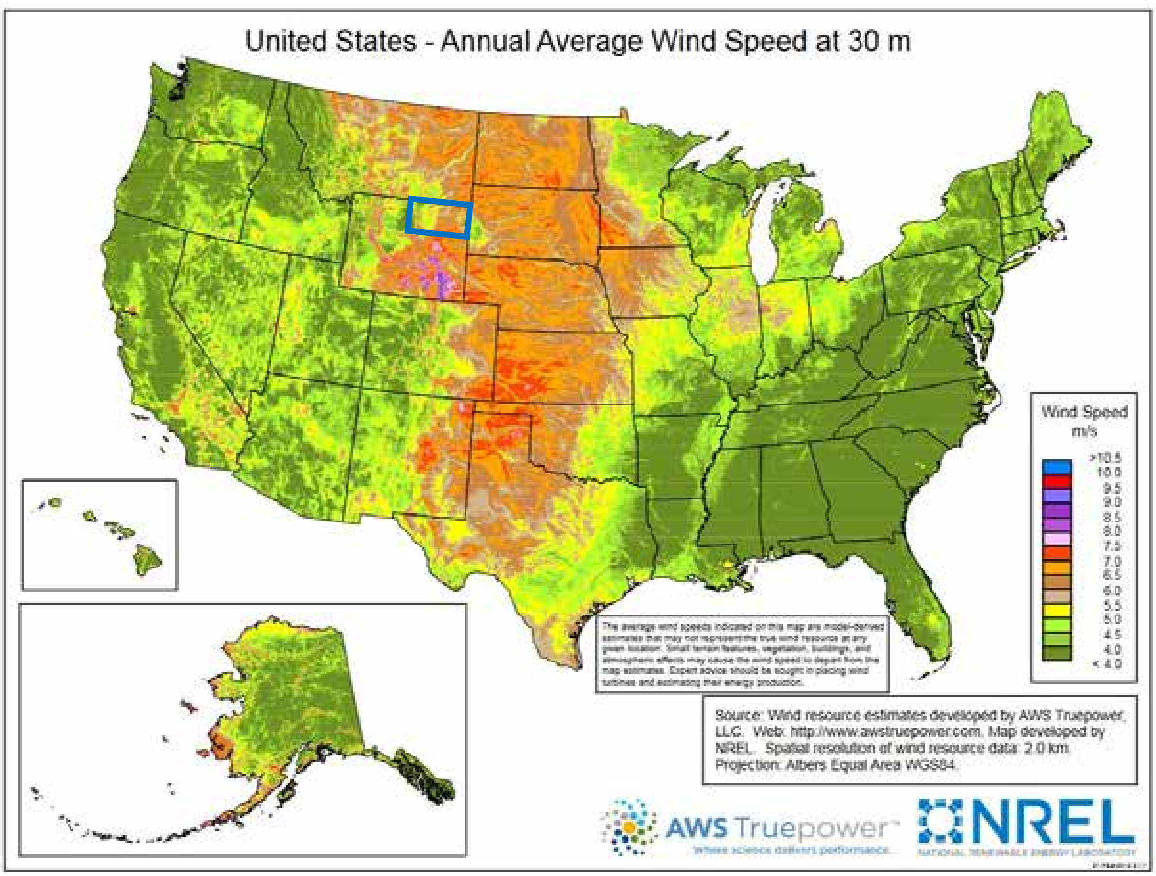
## Potential Magnitude

The 2016 Wyoming State Hazard Mitigation Plan cites SHELDUS and NCEI data to record 287 total damaging wind events between 1960-2015 in Region 1, with $1,793,081 in damage recorded in Campbell County from 84 events; $677,331 in damage recorded in Crook County from 60 events; $181,439 in damage recorded in Johnson County from 42 events; $732,264 in damage recorded in Sheridan County from 39 events; and $877,881 in damage recorded in Weston County from 62 events during this timeframe.

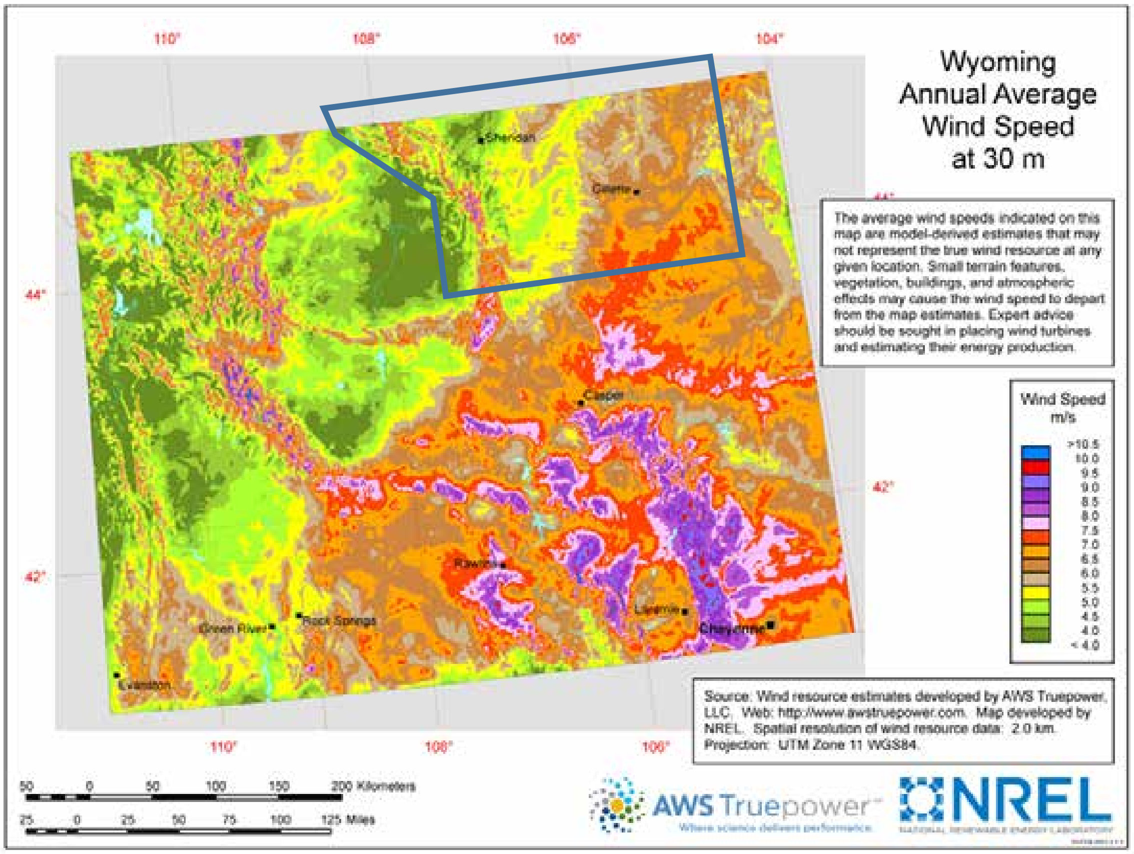
Per NCEI, the most damaging event in the Region caused $200,000 damage to property; the Region has only seen crop damage due to one storm, which caused $4,000 in damage. These incidents can be used as worst case scenarios, though more damage could occur with the right combination of factors.

The following maps show annual average wind speeds across the US and across Wyoming (Figure 4-50 and Figure 4-51). The blue box corresponds to the planning area. Wyoming has some of the highest annual average wind speeds in the nation. While the threat varies across the planning area, all parts of the Region are susceptible to damaging wind events.

**Figure 4-50 Annual Average Wind Speed – United States**



## Figure 4-51 Annual Average Wind Speed – Wyoming




## Vulnerability Assessment

Vulnerability as it relates to location is mostly random, as damaging winds have occurred everywhere in the Region. Damage from high winds is often described in regional or broad areas, but downburst damage will impact a small area most generally less than three miles in diameter. Because state or presidential emergency or disaster declarations have not been necessary in the aftermath of wind events in the Region, and because damage to personal property is dealt with by numerous private insurance companies, it is difficult to estimate actual monetary impacts that have occurred due to damaging winds. See section on Potential Losses for loss estimates based on reported damage.

Specific vulnerabilities from high wind events include damage to poorly constructed buildings, building collapse and damage, flying debris, semi rollovers and car accidents, and downed power lines and electric system damage. Cascading hazards caused by high winds can include power loss; depending on the time of year, winds can also exacerbate snow and blizzards by creating deep snow drifts over roads and affecting the normal flow of traffic. Damages recorded by the NCEI for the county include downed power lines, torn off roofs and building damage, and downed tree limbs and debris. Sheridan County reported that power outages due to high wind are more frequent, although the impact of these events is typically fairly low. In the winter, Chinook winds can create problems with drifting snow.

### Future Development

Historical data demonstrates that the most critical area of the state for high wind hazards is the eastern one third, including much of Region 1. Future residential or commercial buildings will still be exposed to this hazard though growth rates are low to moderate in the Region.

### Summary

Many areas of the United States are prone to damaging wind events, and while the counties of Region 1 may not be counted in a high category for occurrences across the nation, it does have a history of such episodes which should be anticipated for the future. Primary damage is structural and utility-borne. Although minimal deaths and injuries have been reported, the frequency of occurrence is due consideration, as well as the hazard to rural citizens and town populations from falling trees, power poles, and flying debris.

Photos and scattered reports document property damage (including damage to private utilities) occurring as a result of wind events, yet cumulative losses due to wind damage have been negligible.

**Table 4-59 High Winds and Downbursts Hazard Risk Summary**

| County | Geographic Extent | Probability of Future Occurrence | Potential Magnitude/ Severity | Overall Significance |
|---|---|---|---|---|
| Campbell | Significant | Likely | Negligible | Medium |
| Crook | Significant | Likely | Negligible | Medium |
| Johnson | Significant | Likely | Negligible | Medium |
| Sheridan | Significant | Likely | Negligible | Medium |
| Weston | Significant | Likely | Negligible | Medium |

## 4.2.10 Landslide/Rockfall/Debris Flow

### Hazard/Problem Description

A landslide is a general term for a variety of mass movement processes that generate a downslope movement of soil, rock, and vegetation under gravitational influence. Landslides are a serious geologic hazard common to almost every state in the United States. It is estimated that nationally they cause up to $2 billion in damages, and from 25 to 50 deaths annually. Some landslides move slowly and cause damage gradually, whereas others move so rapidly that they can destroy property and take lives suddenly and unexpectedly. Gravity is the force driving landslide movement. Factors that allow the force of gravity to overcome the resistance of earth material to landslide include: saturation by water, erosion or construction, alternate freezing or thawing, earthquake shaking, and volcanic eruptions.

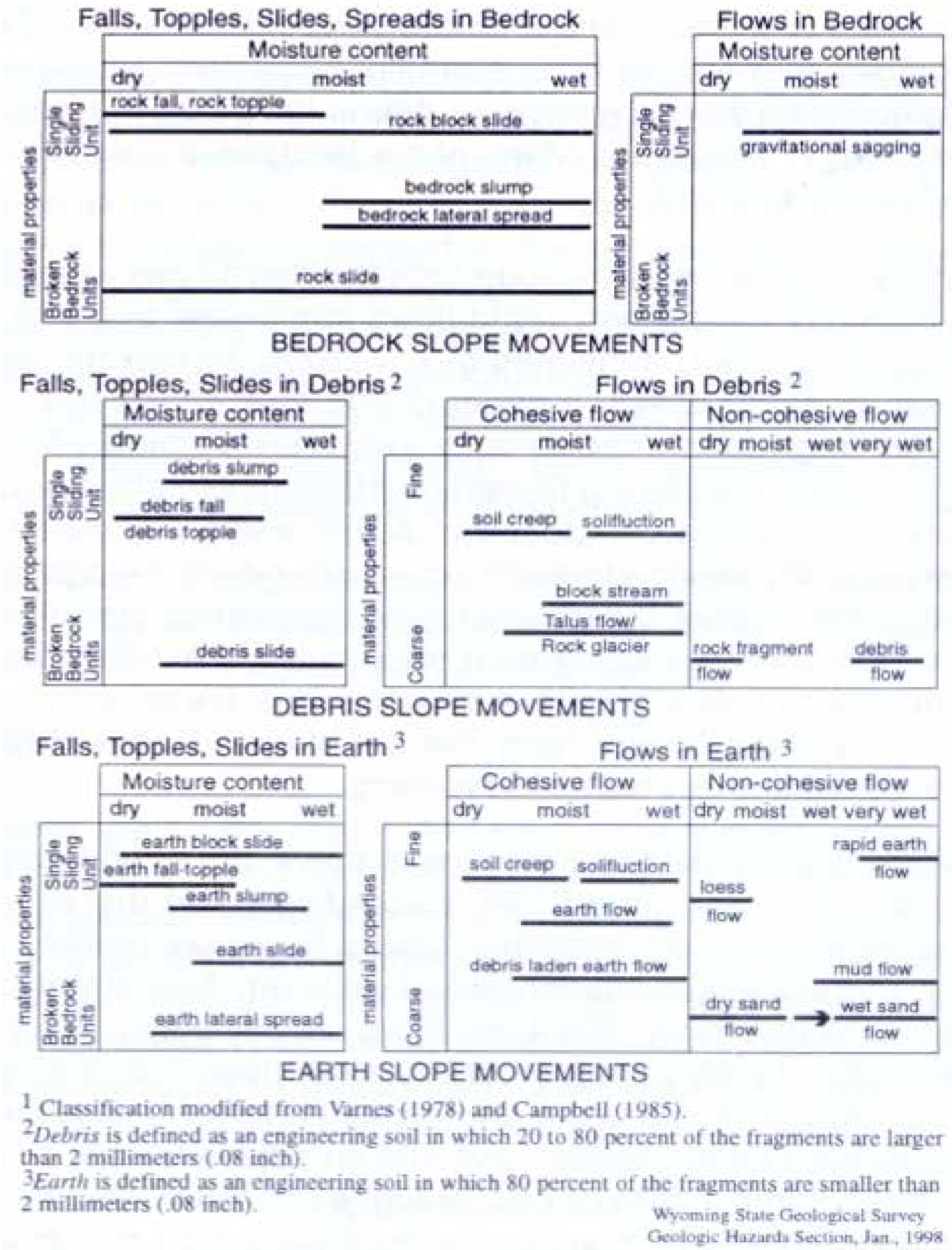
Landslides are typically associated with periods of heavy rainfall or rapid snow melt, and tend to worsen the effects of flooding that often accompany these events. In areas burned by forest and brush fires, a lower threshold of precipitation may initiate landslides. Generally, significant landsliding follows periods of above-average precipitation over an extended period, followed by several days of intense rainfall. It is on these days of intense rainfall that slides are most likely.

Areas that are generally prone to landslide hazards include existing old landslides; the bases of steep slopes; the bases of drainage channels; and developed hillsides where leach-field septic systems are used. Landslides are often a secondary hazard related to other natural disasters. Landslide triggering rainstorms often produce damaging floods. Earthquakes often induce landslides that can cause additional damage.

Slope failures typically damage or destroy portions of roads and railroads, sewer and water lines, homes and public buildings, and other utility lines. Even small-scale landslides are expensive due to clean up costs that may include debris clearance from streets, drains, streams and reservoirs; new or renewed support for road and rail embankments and slopes; minor vehicle and building damage; personal injury; and livestock, timber, crop and fencing losses and damaged utility systems.

There are many types of landslides present in Wyoming. In order to properly describe landslide types, the Geologic Hazards Section developed a landslide classification modified from Varnes (1978) and Campbell (1985). As can be seen in Figure 4-52, there are five basic types of landslides that occur in three types of material. Falls, topples, slides, lateral spreads, and flows can occur in bedrock, debris, or earth. While individual landslide types can occur in nature, most landslides are complex, or composed of combinations of basic types of landslides.

**Figure 4-52 Wyoming Landslide Classifications**




### *Rockfall*

A rockfall is the falling of a detached mass of rock from a cliff or down a very steep slope. Weathering and decomposition of geological materials produce conditions favorable to rockfalls. Rockfalls are caused by the loss of support from underneath through erosion or triggered by ice wedging, root growth, or ground shaking. Changes to an area or slope such as cutting and filling activities can also increase the risk of a rockfall. Rocks in a rockfall can be of any dimension, from the size of baseballs to houses. Rockfalls occur most frequently in mountains or other steep areas during the early spring when there is abundant moisture and repeated freezing and thawing. Rockfalls are a serious geological hazard that can threaten human life, impact transportation corridors and communication systems, and result in other property damage.

Spring is typically the landslide/rockfall season in Wyoming as snow melts and saturates soils and temperatures enter into freeze/thaw cycles. Rockfall and landslides are influenced by seasonal patterns, precipitation, and temperature patterns. Earthquakes could trigger rockfalls and landslides too.

### *Debris Flow*

Debris flows, sometimes referred to as mudslides, mudflows, lahars, or debris avalanches, are common types of fast-moving landslides. They are a combination of fast moving water and a great volume of sediment and debris that surges down slopes with tremendous force. These flows generally occur during periods of intense rainfall or rapid snowmelt and may occur with little onset warning, similar to a flash flood. They usually start on steep hillsides as shallow landslides that liquefy and accelerate to speeds that are typically about 10 miles per hour, but can exceed 35 miles per hour. Figure 4-53 describes identifying characteristics of debris flows. The consistency of debris flow ranges from watery mud to thick, rocky mud that can carry large items such as boulders, trees, and even cars. Debris flows from many different sources can combine in channels, and their destructive power may be greatly increased. When the flows reach flatter ground, the debris spreads over a broad area, sometimes accumulating in thick deposits that can wreak havoc in developed areas. Mudflows are covered under the National Flood Insurance Program; however, landslides are not.

**Figure 4-53 Field Evidence of Debris Flow**

**Deposit Margins/Surfaces**

- No dunes or ripples on surface
- Lobate margins
- Accumulations of coarse clasts at margins (sometimes openwork where matrix washed away); otherwise coarse clast distribution on surface is fairly random
- Positive relief (convex surface morphology where flow "freezing" occurs); otherwise surfaces flat, commonly studded with boulders

- Flow levees common but not always formed
- Consolidated sediments packed into "nooks and crannies" – e.g., between roots in root wads, in cavities in trees, buildings, stream banks, etc.
- Commonly dammed locally by small log jams or boulder clusters
- Fragile clasts may be present on surface (e.g., soil clasts, glass bottles)
- Sandy mud coatings on boulders, logs, banks
- No gravel imbrication

## Geographical Area Affected

Landslides are one of the most common geologic hazards in Wyoming. Figure 4-54 shows mapped landslides in the Region. Note the concentration of landslide deposits in the northwestern portion of Sheridan County, then in the middle of Crook County. Complex slope movements are also known to occur often towards the northeast of Weston County. Many of these slide areas have been studied by the Wyoming Geological Survey, WYDOT and others.

### *Campbell County Landslide Areas*

In Campbell County, the primary areas of concern surround Highway 59 and Highway 14, towards the northern parts of the county; the HMPC noted regular damage to fences in this area. Areas of complex slope movement and slump are particularly noticeable, though some debris and/or earth flow may occur as well in the Highway 59 corridor in the northeast portion of the county. West of highway 50 and north of highway 387, closer to the boundary with Johnson County, are some cases of complex slope movement, debris/earth flow, and slump, about 15 miles from the Town of Wright.

### *Crook County Landslide Areas*

Crook County has a prevalence of slump and complex slope movement kinds of landslides, in particular. While some debris/earth flow movements can also occur throughout the county, slump is common around Hulett, north and west of Sundance, and north of Pine Haven. Complex slope movements can take place around the Black Hills National Forest boundary within Crook, and spread throughout the middle, eastern, and southern parts of the county. Minor areas of unstable rock may also be found between Interstate 90, Highway 111, and Highway 24, for example.

### *Johnson County Landslide Areas*

Johnson County has relatively little landslide risk based on available mapping. However, certain landslide prone areas can be found surrounding the Bighorn National Forest northwest of the county, and near Highway 190, Highway 191, Highway 16, and in the north and west portions of the county. Most landslide risk comes from complex slope movement, though debris/earth flow slides, unstable rocks, and slump areas can also be found, all west of Interstate 25. The HMPC noted impacts on I-90 often leading to closures, particularly between Buffalo and Sheridan.

### *Sheridan County Landslide Areas*

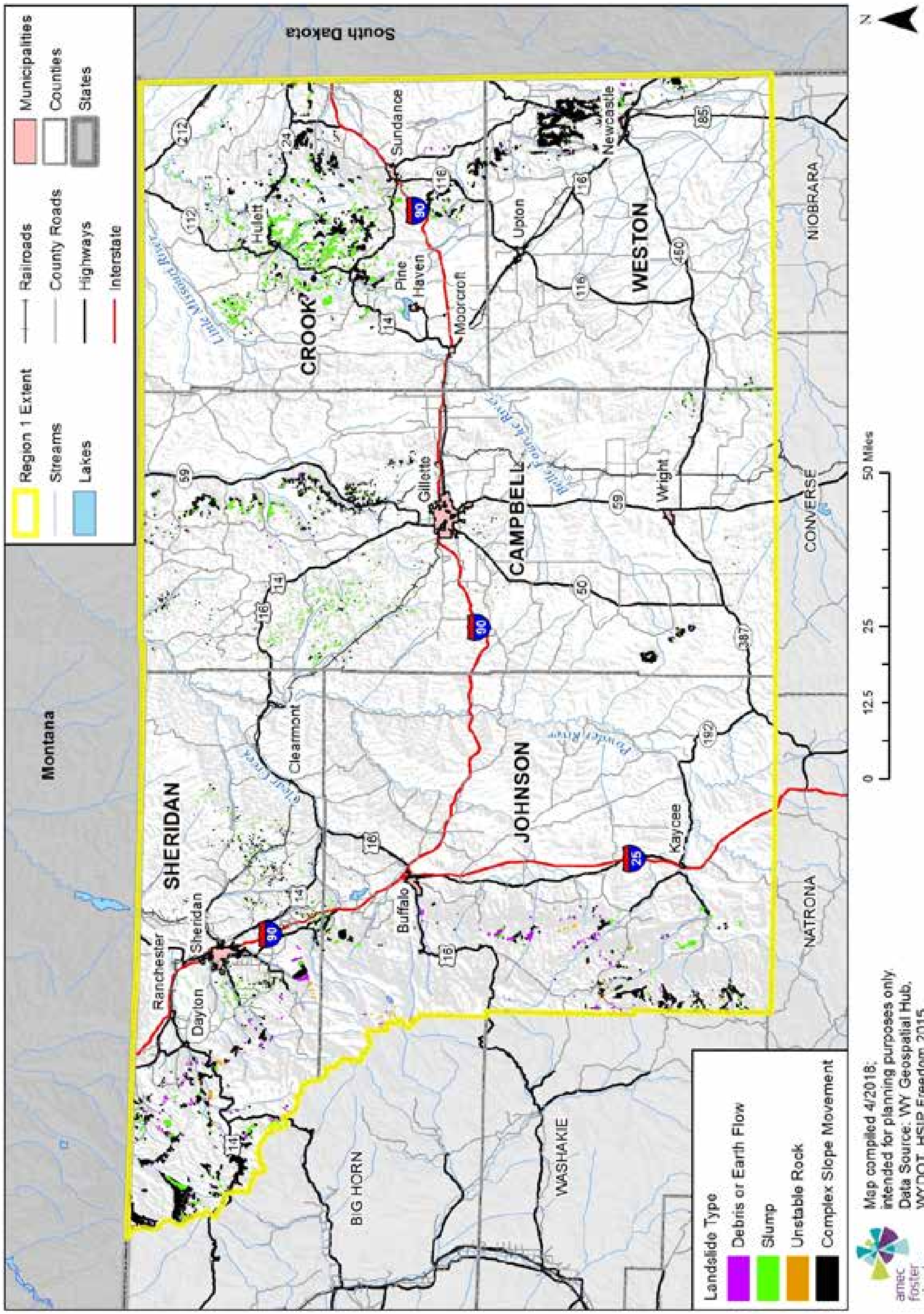
Sheridan County has regions of prevalent complex slope movement, in particular, to the west and sprinkled throughout the middle of the county, along with some minor slump areas. Some slump and debris/earth flow areas can also be found nearing the edges of the

Bighorn National Forest, running through the county in a northwest-southwest fashion. Some unstable rock areas can be seen near Highway 14, near the central-west portion of the county, on the boundary with the Bighorn National Forest, as well as Jim Creek Hill and the Soldier Creek drainage. The HMPC noted impacts on I-90 often leading to closures, particularly between Buffalo and Sheridan. The City of Sheridan has had several landslides in the city, particularly near the Junior High School; a retaining wall was constructed to mitigate this, but they continue to have problems.

***Weston County Landslide Areas***

Weston County's landslide hazard areas are all located on the northeast and east of the county, to the right of Highway 16 up to Newcastle, and to the right of the railway tracks southwest of the county. While complex slope movement types of landslides are the most prevalent, some slump and debris/earth flow areas can also be found on the east and northeast. The HMPC reported landslide incidents affecting Highway 85, and the water line to stock tanks.

## Figure 4-54 Region 1 Landslide Areas



## Past Occurrences

Landslides, debris flows, and rockfalls occur regularly in Wyoming and the Region, though limited information was available on previous occurrences that caused a particular high amount of damage or incurred some other cost or unique impact.

On July 22, 2011, President Obama declared a major disaster for the State of Wyoming for emergency work and the repair or replacement of facilities damaged by the severe storms, flooding, and landslides in Albany, Big Horn, Carbon, **Crook**, Fremont, Goshen, **Johnson**, Lincoln, Platte, **Sheridan**, Sublette, Teton, Uinta, Washakie, and **Weston** Counties. This declaration made Public Assistance funding available.

In Campbell County for example, landslide risk is generally isolated to less populated areas, with most significant risk to transportation facilities, namely roads, highways, bridges and railroad infrastructure, rather than life and property. The most significant impact tends to be when no alternative route exists between populated areas and access is blocked by the presence of a landslide. Highway 59, located in the Moyer Springs Quadrangle, is infrastructure which, if blocked by a landslide, would cause significant disruption of mobility between Gillette and the community of Weston.

In Crook County, WYDOT spent an estimated $7.8 million in between 2004 and 2012, to fix three slide areas that had damaged state highways. There is still ongoing work on a major slide near Devils Tower. Landslides can also damage utility lines and disrupt services around Crook County.

Johnson County, though not heavily prone to landslides, has actually suffered from 2 landslide events that caused a total of $100,500 in property damages. The I-90 corridor between Buffalo and Sheridan in Johnson and Sheridan counties has been prone to recurring landslides. WYDOT has spent an unknown amount of funding to repair and mitigate impacts.

## Frequency/Likelihood of Occurrence

The probability of a landslide causing damage in the Region is difficult to determine because of the poor historic data. However, given analysis of topographic map quadrangles by the USGS, along with landslide prone location data, it is reasonable to assume that damaging events have between 10 and 100% chance of occurrence in next year. Therefore, landslides, rockfalls or debris flows are **likely** to occur. Heavy periods of precipitation or significant development could have an effect on slope stability. Typically, there is a landslide/rockfall ‘season’ that coincides with increased freeze-thaw cycles and wetter weather in the spring and early summer, as previously mentioned.

## Potential Magnitude

There are three measures of future landslide impacts – historic dollar damages, estimated yearly damages, and building exposure values. There are not enough current data to estimate historic or yearly dollar damages. In general terms, landslides can threaten human life, impact transportation corridors and communication systems, and cause damage to property and other infrastructure. Actual losses can range from mere inconvenience based on inability to access roads, to high maintenance costs where even very slow or small-scale destructive slides are involved. The potential magnitude of landslides, rockfall and debris flows would typically be isolated in most counties in the region, giving it a magnitude rating of **limited**. However, even a small isolated event has potential to close state or U.S. highways in the region, resulting in long detours for days or weeks. With the added cost of detours, and the potential for life safety impacts, some landslides could have greater costs.

## Vulnerability Assessment

### *Population*

The overall vulnerability of population is **low**. The general population is not overly vulnerable to landslides, but rockfall can cause serious injury or death, especially near transportation networks or near cities and towns. There are areas prone to rockfall along Interstate 25 near the City of Sheridan, and on Highways 112, 24, 85, 14, and 116 in particular.

### *General Property*

During the 2018 development of this regional plan, a GIS analysis of exposure to landslide hazard areas was performed. The following table shows the building value that is built on or near landslides within each county, based on a parcel-level analysis. The Region has approximately $32.5 million of total exposure value, which takes into account improved values of properties as well as estimated content values. Table 4-60 summarizes landslide exposure broken up by county, based on an intersect of improved parcels with landslide hazard areas. There are 265 total properties potentially within landslide hazard zones based on this analysis. The greatest financial exposure of general property is in Crook County with $11 million, however Weston has the greatest number of properties potentially at risk with 179. A more detailed, site specific analysis would be needed to assess actual risk within the identified parcels.

**Table 4-60 Landslide Exposure by County**

| County | Jurisdiction | Property Type | Parcel Count | Improved Value | Est. Content Value | Total Exposure | Population |
|---|---|---|---|---|---|---|---|
| Campbell | Unincorporated | Agricultural | 1 | $504,084 | $504,084 | $1,008,168 | 0 |
| | | **Total** | **1** | **$504,084** | **$504,084** | **$1,008,168** | **0** |
| Crook | Unincorporated | Agricultural | 23 | $1,139,329 | $1,139,329 | $2,278,658 | 0 |
| | | Commercial | 3 | $332,877 | $332,877 | $665,754 | 0 |
| | | Residential | 21 | $5,561,073 | $2,780,537 | $8,341,610 | 51 |
| | | **Total** | **47** | **$7,033,279** | **$4,252,743** | **$11,286,022** | **51** |
| Johnson | Unincorporated | Agricultural | 15 | $625,311 | $625,311 | $1,250,622 | 0 |
| | | Res Vacant Land | 4 | $509,525 | $254,763 | $764,288 | 0 |

| County | Jurisdiction | Property Type | Parcel Count | Improved Value | Est. Content Value | Total Exposure | Population |
|---|---|---|---|---|---|---|---|
| | | Residential | 8 | $2,570,804 | $1,285,402 | $3,856,206 | 19 |
| | | **Total** | **27** | **$3,705,640** | **$2,165,476** | **$5,871,116** | **19** |
| Sheridan | City of Sheridan | Residential | 4 | $431,828 | $215,914 | $647,742 | 9 |
| | | **Total** | **4** | **$431,828** | **$215,914** | **$647,742** | **9** |
| | Unincorporated | Agricultural | 2 | $513,351 | $513,351 | $1,026,702 | 0 |
| | | Residential | 5 | $1,924,231 | $962,116 | $2,886,347 | 11 |
| | | **Total** | **7** | **$2,437,582** | **$1,475,467** | **$3,913,049** | **11** |
| Weston | Unincorporated | Agricultural | 36 | $616,050 | $616,050 | $1,232,100 | 0 |
| | | Res Vacant Land | 107 | $3,545,852 | $1,772,926 | $5,318,778 | 0 |
| | | Residential | 36 | $2,200,421 | $1,100,211 | $3,300,632 | 78 |
| | | **Total** | **179** | **$6,362,323** | **$3,489,187** | **$9,851,510** | **78** |
| **GRAND TOTAL** | | | **265** | **$20,474,736** | **$12,102,869** | **$32,577,605** | **169** |

Source: Amec Foster Wheeler analysis of WGS and Wyoming Department of Revenue data

### *Essential Infrastructure, Facilities, and Other Important Community Assets*

Transportation networks are the most exposed aspect of the Region to rockfall, landslide and debris flow incidents. Residents and visitors alike are impacted by landslides when roads are damaged by landslides. The loss of transportation networks could potentially cause secondary damage to the overall Region's infrastructure, including revenue, transportation availability, emergency response mechanisms, and other essential capabilities by preventing the means of these resources from activating or moving between locations

## Future Development

The severity of landslide problems is directly related to the extent of human activity in hazard areas. Human activities such as property development and road construction can also exacerbate the occurrence of landslides. Landslide areas tend to be picturesque and often within mountainous locations, and therefore attract development and recreation. Development in landslide areas frequently consists of vacation homes and represents a potential risk for injury, loss of life and property.

## Summary

Overall, landslides, rockfalls and debris flows range from **low** to **medium** significance hazards in the region. Landslides have the potential for direct property impacts including residential structures, but more likely infrastructure corridors including roads and highways, power line corridors, and gas lines.

**Table 4-61 Landslide Hazard Risk Summary by County**

| County | Geographic Extent | Probability of Future Occurrence | Potential Magnitude/ Severity | Overall Significance |
|---|---|---|---|---|
| Campbell | Limited | Unlikely | Limited | Low |
| Crook | Significant | Occasional | Limited | Low |
| Johnson | Limited | Occasional | Significant | Medium |
| Sheridan | Limited | Occasional | Significant | Medium |
| Weston | Limited | Unlikely | Limited | Low |

## 4.2.11 Lightning

### Hazard/Problem Description

Lightning is a danger across Wyoming. Lightning is a sudden electrical discharge released from the atmosphere that follows a course from cloud to ground, cloud to cloud, or cloud to surrounding air, with light illuminating its path. Lightning's unpredictable nature causes it to be one of the most feared weather elements.

Anyone that is caught in an exposed area during a thunderstorm could be at risk to a lightning strike. In Wyoming, outdoor enthusiasts venturing to high and exposed areas should be especially cautious because rapid thunderstorm development with associated lightning can place even the most experienced persons in jeopardy without warning. Lightning strikes can cause power outages. Lightning is also the leading cause of wildland fires in Wyoming, and is indirectly responsible for millions of dollars' worth of fire damage.

### Geographical Area Affected

All of the region is susceptible to lightning impacts, particularly the higher elevation mountainous areas.

### Past Occurrences

Vaisala's National Lightning Detection Network (NLDN) recorded 347,035 cloud to ground lightning flashes in Wyoming in 2015; they also record an average of 279,632 cloud to ground lightning flashes per year between 2006 and 2015 for the state. This ranks Wyoming 39th nationally for flashes per square mile, averaging 2.9 cloud to ground lightning flashes per square mile, per year.

Nationally, Wyoming ranks 36th in number of lightning fatalities, 33rd in injuries, and 40th in property damage from 1959 to 1994 according to the National Oceanic and Atmospheric Administration, National Severe Storms Laboratory (NOAA, NSSL). Wyoming is number one in the nation in lightning deaths per capita according to the National Weather Service in Salt Lake

City. According to the NCEI, lightning has been responsible for 8 deaths, 75 injuries, over $1 million in property damage and $91,000 in crop damage in Wyoming between 1996 and 2015.

The 2016 Wyoming State Hazard Mitigation Plan lists loss-causing lightning events from 1960-2015, collected from SHELDUS and NCEI events databases. 39 incidents are recorded for the counties in Region 1, resulting in a total of 22 injuries, 2 deaths, and a total of $491,730 in property and crop damage; these incidents are listed in Table 4-62.

**Table 4-62 Region 1 Lightning History 1960– 2015**

| County | Number of Events | Injuries | Fatalities | Property Damage | Crop Damage | Total Damage |
|---|---|---|---|---|---|---|
| Campbell | 10 | 4 | 0 | $ 89,432 | $ 0 | $ 89,432 |
| Crook | 10 | 2 | 0 | $ 293,382 | $ 500 | $ 293,882 |
| Johnson | 10 | 14 | 1 | $ 42,795 | $ 0 | $ 42,795 |
| Sheridan | 5 | 2 | 1 | $ 31,739 | $ 0 | $ 31,739 |
| Weston | 4 | 0 | 0 | $ 33,882 | $ 0 | $ 33,882 |
| **Total** | **39** | **22** | **2** | **$ 491,230** | **$ 500** | **$ 491,730** |

Source: 2016 Wyoming State Hazard Mitigation Plan

On July 9, 2001, a lightning strike ignited a sporting goods store in Moorcroft; most of the building was destroyed in the fire. On July 11, 2010, a 63-year-old man was struck by lightning in the Big Horn Mountains; he died from cardiac arrest the following day in a Billings hospital.

The HMPCs reported that lightning strikes are very common, and have led to losses of livestock, damage to houses, fences, and a hay stack fire that led to $6M in damages. Lightning has at least twice struck communications towers, knocking out radio systems. The City of Buffalo lost power for five hours due to a lightning strike in 2018; damage from this strike was informally estimated at around $25,000. Livestock strikes are more common than strikes to humans. Crook County's HMPC felt this hazard should be raised to High significance due to past damages and potential for wildfire starts.

The Campbell County Emergency Manager provided additional information on lightning injuries and damages during the period of 2005-2015:

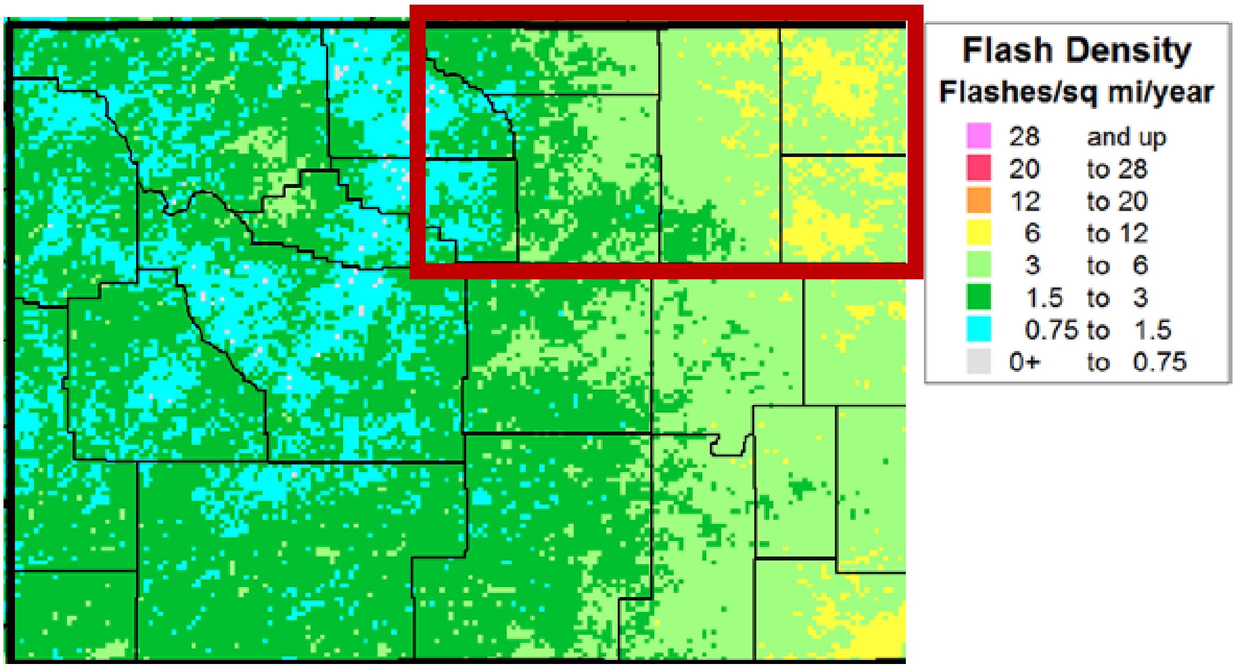
- Two people were directly struck by lightning, one while mowing his lawn in Gillette in 2015, and one while driving his motorcycle near the Port of Entry in 2005; both were hospitalized.
- Three vehicles have been struck while driving, and the driver of one truck was hospitalized because of the strike.
- During the 10-year period, lightning has caused fire or damage to six homes and two businesses.

### Frequency/Likelihood of Occurrence

Nationwide, lightning strikes are routinely monitored by Vaisala, Inc. with accuracies to within a 0.625-mile (1 kilometer) resolution. The Wyoming annual lightning strike frequency is depicted in Figure 4-55 for the period of 2005 through 2014. Clearly the eastern plains have more than three times the cloud to ground lightning strikes as the western half of the state. Region 1's flash density varies considerably, ranging from 0.75 to 6 flashes per square mile per year in Sheridan and Johnson Counties, to 3 to 12 flashes per square mile per year in Crook and Weston Counties, some of the highest in the state. Despite annual variation, the locations of maximum and minimum strikes do not change much from year to year.

(Source: Science Magazine, http://www.sciencemag.org/content/346/6211/851.abstract;)

**Figure 4-55 Average Annual Lightning Flash Density (flashes/sq. mi./year) 2005-2014 Over Wyoming**




Source: Illustration courtesy of Vaisala Inc.

U.S. statistics show that one in 345,000 lightning flashes results in a death and one in 114,000 results in an injury nationwide. According to meteorologists at Vaisala, Inc., the odds for an American being hit by lightning sometime in the course of an 80-year lifespan is about 1 in 3,000. Any persons caught in the open without cover during a lightning storm are vulnerable to strikes.

Although lightning strikes occur with high frequency throughout Region 1, Table 4-62 shows that strikes resulting in injuries or reportable damage are somewhat less-common. Based on this data, the chance of a loss or injury-causing lightning strike in any given year ranges from around 7% in Weston County, to 9% in Sheridan County, to 18% in Campbell, Crook & Johnson Counties.

## Potential Magnitude

Lightning can cause deaths, injuries, and property damage, including damage to buildings, communications systems, power lines, and electrical systems. It also causes forest, brush and structural fires. Damage from lightning occurs in four ways:

- Electrocution, severe electrical shock, and burns of humans and animals
- Vaporization of materials in the path of the strike
- Fire caused by the high temperatures associated with lightning
- Power surges that can damage electrical and electronic equipment

When people are struck by lightning, the result is deep burns at the point of contact (usually on the head, neck and shoulders). Approximately 70% of lightning survivors experience residual effects such as vision and hearing loss or neuropsychiatric issues. These effects may develop slowly and only become apparent much later. Death occurs in 20% of lightning strike victims.

Lightning strikes cause intense but localized damage. In contrast to other hazards, lightning does not cause widespread disruptions with the community. Structural fires, localized damage to buildings, damage to electronics and electrical appliances, and electrical power and communications outages are typical consequences of a lightning strike. Additionally, indirect fatalities may result via electrocution when a person steps from a vehicle into standing water that was previously "charged" by a live power-line that was knocked loose by a lightning strike.

The indirect social and economic impacts of lightning damage are typically associated with the loss of electrical power. Since society relies heavily on electric power, any disruption in the supply, even for a short time period, can have significant consequences.

Wildfires can also be an indirect result of a lightning strike. Johnson County HMPC reported that lightning is a major cause of wildfires in that county.

Past events in Region 1 indicate that the potential magnitude of lightning events will likely be limited—isolated deaths and/or injuries may occur; major or long-term property damage that threatens structural stability due to structural damage or fires; and/or interruption of essential facilities and services for 24-72 hours due to structural damage or utility outages.

## Vulnerability Assessment

### *Population*

Anyone who is outside during a thunderstorm is at risk of being struck by lightning. Aspects of the population who rely on constant, uninterrupted electrical supplies may have a greater, indirect vulnerability to lightning. As a group, the elderly or disabled, especially those with home health care services relying on rely heavily on an uninterrupted source of electricity. Resident populations in nursing homes, Community Based Residential Facilities, or other special needs housing may also be vulnerable if electrical outages are prolonged. If they do not have a back-up power source, rural residents and agricultural operations reliant on electricity for heating, cooling, and water supplies are also especially vulnerable to power outages.

According to the Vaisala Group and National Lightning Detection Network, Wyoming ranked 37th among the 50 U.S. states, Puerto Rico, and Washington D.C. for overall lightning deaths between 1959 and 2009. This would suggest that lightning is not a major hazard for Wyoming. However, the state had the second highest per capita fatality rate within that same time period at 1.27 deaths per million people.

Nationwide, 85% of lightning victims are children and young men ages 10-35 engaged in outdoor recreation or work. Outdoor recreation is a major economic contributor to Region 1. People may often find themselves outside and need to be especially watchful of the weather during the summer months when afternoon thunderstorms are more common.

Because of concerns over the threat of lightning to citizens involved in outdoor activities, a coalition of governmental entities including the Campbell County School District, City of Gillette, Town of Wright and Campbell County Public Lands Board (Cam-Plex) have contracted with Thorguard Lightning Detector Systems for installation of a predictive sensor and alerting system. This system will cost approximately $100,000 which will cover the major outdoor events and large park areas of Gillette and Wright. The system is scheduled to be installed by September 2018, and will provide predictive warnings of the electrical charge buildup(s) prior to a lightning strike discharge. Those warnings will be issued by a warning siren/strobe system and via text and email alerting.

### *General Property*

According to the event details collected in the NCEI database, the majority of reported damages from lightning are fires to private structures, damage to chimneys or steeples, or small grass fires. Property is more vulnerable to lightning than population because of the exposure ratios. Buildings remain exposed. Mitigation techniques such as choice of building materials or landscaping help reduce the vulnerability of these properties, but there is not data available to segment these properties out of the overall vulnerability assessment.

### *Essential Infrastructure, Facilities, and Other Important Community Assets*

Some essential infrastructures and facilities can be impacted by lightning. Emergency responders, hospitals, government services, schools, and other important community assets are not more vulnerable to lightning than the general vulnerabilities established for property and population. Some aspects of infrastructure are constructed of materials and/or located in places that increase their vulnerability to lightning. Sometimes, communications and infrastructure are interrupted by lightning strikes. These events raise the vulnerability of the essential functions by delaying response times, hindering interagency communication efforts, or endangering or damaging communication networks.

***Natural, Historic and Cultural Resources***

There are no indications that cultural or historic resources are more vulnerable to lightning than as previously accounted for as general structures. Natural resources may be vulnerable to indirect impacts of lightning, such as wild fires caused by lightning strikes. The presence of large areas of water, or of wide, open spaces in natural habitats may increase the danger of lightning strikes to trees, people, or structures, but these vulnerabilities are not directly related to natural resources. Campgrounds are areas where lightning strikes have more dangerous impacts, so populations utilizing the campgrounds may have a higher vulnerability.

Finally, lightning can also have many cascading impacts, including power failure and ignition of wildfires.

### Future Development

Any development built above ground will be susceptible to lightning strikes. Buildings should be built with grounding when possible to prevent the ignition of structure fires.

### Summary

Lightning is an annual occurrence in Region 1, although strikes with recorded damage or injuries are much rarer. Anything that can conduct electricity and is exposed is vulnerable to lightning strikes and their effects. Future impacts from lightning are difficult to determine because of the erratic nature of storms.

**Table 4-63 Lightning Hazard Risk Summary**

| County | Geographic Extent | Probability of Future Occurrence | Potential Magnitude/ Severity | Overall Significance |
|---|---|---|---|---|
| Campbell | Significant | Likely | Limited | Medium |
| Crook | Significant | Likely | Limited | High |
| Johnson | Significant | Likely | Limited | Medium |
| Sheridan | Significant | Occasional | Limited | Medium |
| Weston | Significant | Occasional | Limited | Medium |

## 4.2.12 Mine and Land Subsidence

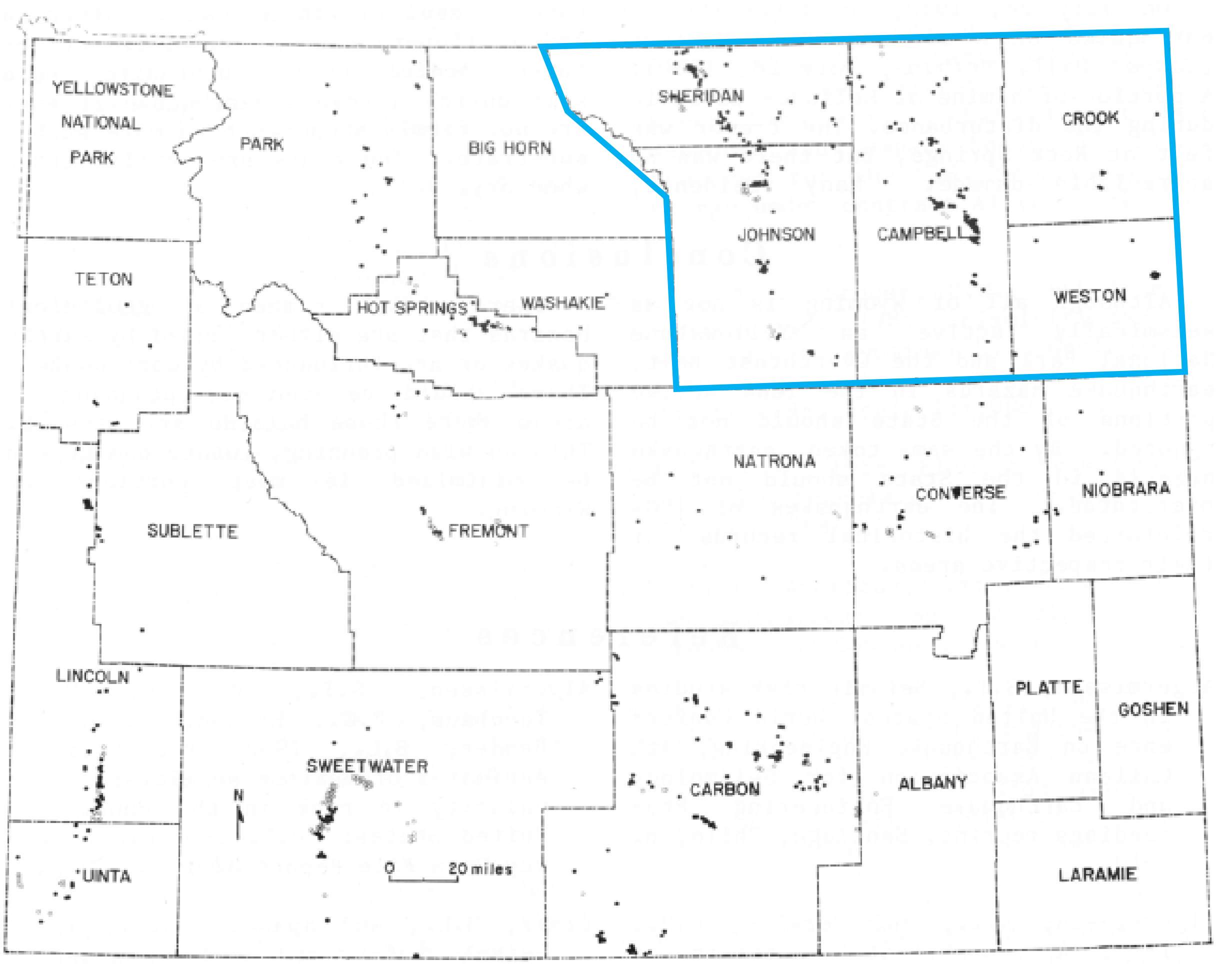
### Hazard/Problem Description

Underground coal mining began in Wyoming during the 1860s. Many of the early coal mines were not designed and constructed well. Many were also shallow, and often had minimal ground support in the form of mine timbers. As a result, the underground pillars can fail. If enough pillars fail, the caprock in the mine will collapse. The effect of the collapse reaches the surface in some cases. If that happens, a subsidence pit, a sinkhole, or a trough forms. Mine subsidence is hence generally defined as the movement of the ground surface as a result of readjustments of the overburden, due to collapse or failure of the underground mine workings. However, not all subsidence from mining is due to poor design. Most underground mines eventually have roof failures due to lack of maintenance and continuous loading of the unsupported rock layers overhead. In some cases, the pillars were pulled as mining retreated from an area. In other cases where fires occurred in the mines, the result is a loss of strength in the pillars and caprock. In addition to mine subsidence cases, general/natural land subsidence is defined as the sinking of the land over manmade or natural underground voids. Examples of natural causes of subsidence include minerals being dissolved by water, which create pockets or voids, or even limestone erosion that can take place alongside other water-soluble materials. The Campbell County HMPC noted that coal seams in the region can catch fire. These fires can burn deep in the subsurface and are extremely difficult to extinguish. The HMPC expressed a concern that subsurface voids caused by underground fires could also be a potential source of subsidence.

## Geographical Area Affected

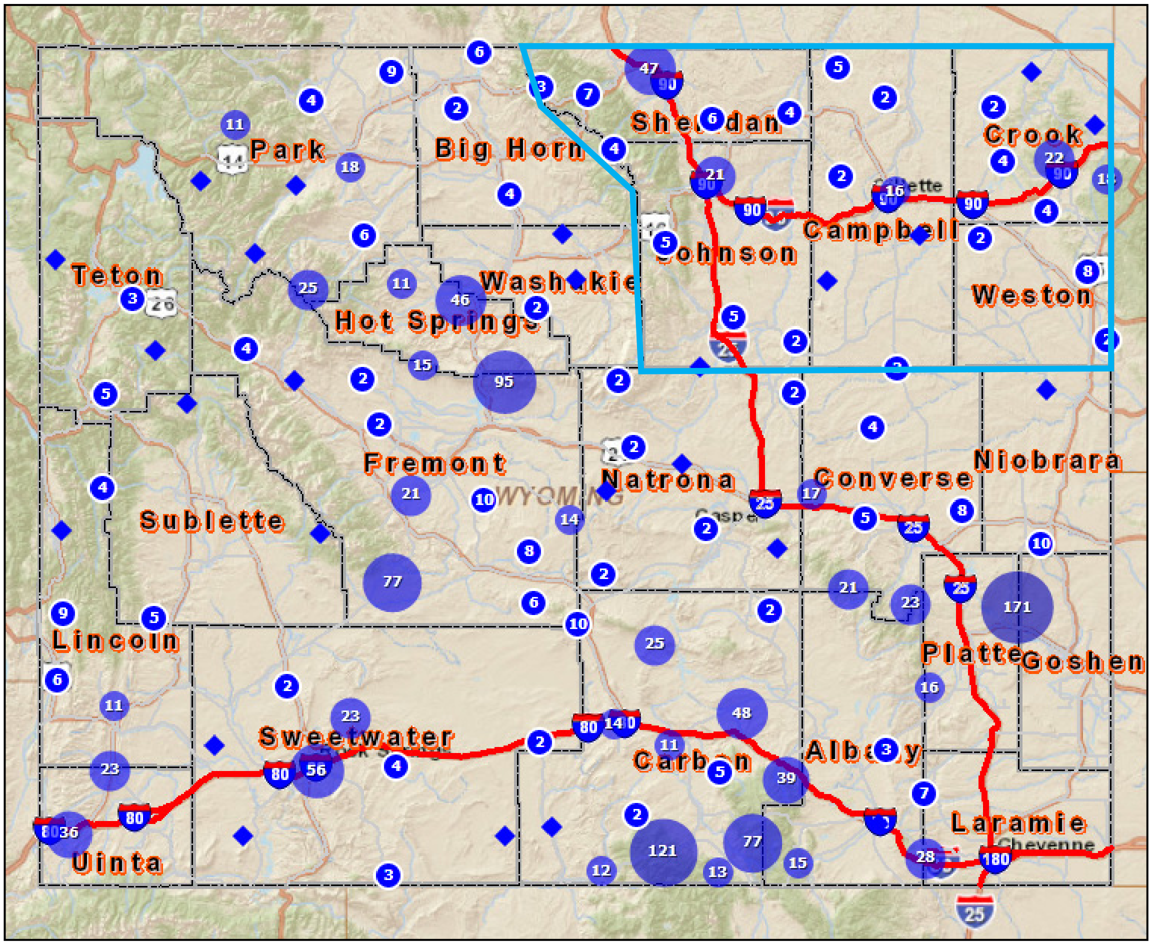
A map showing documented subsidence is shown in Figure 4-56 and Figure 4-57. Gray areas represent mined-out areas with subsidence.

**Figure 4-56 Mine Subsidence in Wyoming**



Solid gray polygons represent mined-out areas where subsidence occurs.
Source: 2016 Wyoming Multi-Hazard Mitigation Plan

**Figure 4-57 Abandoned Mine Sites with Subsidence-Prone Underground Workings**




Source: 2016 Wyoming Multi-Hazard Mitigation Plan

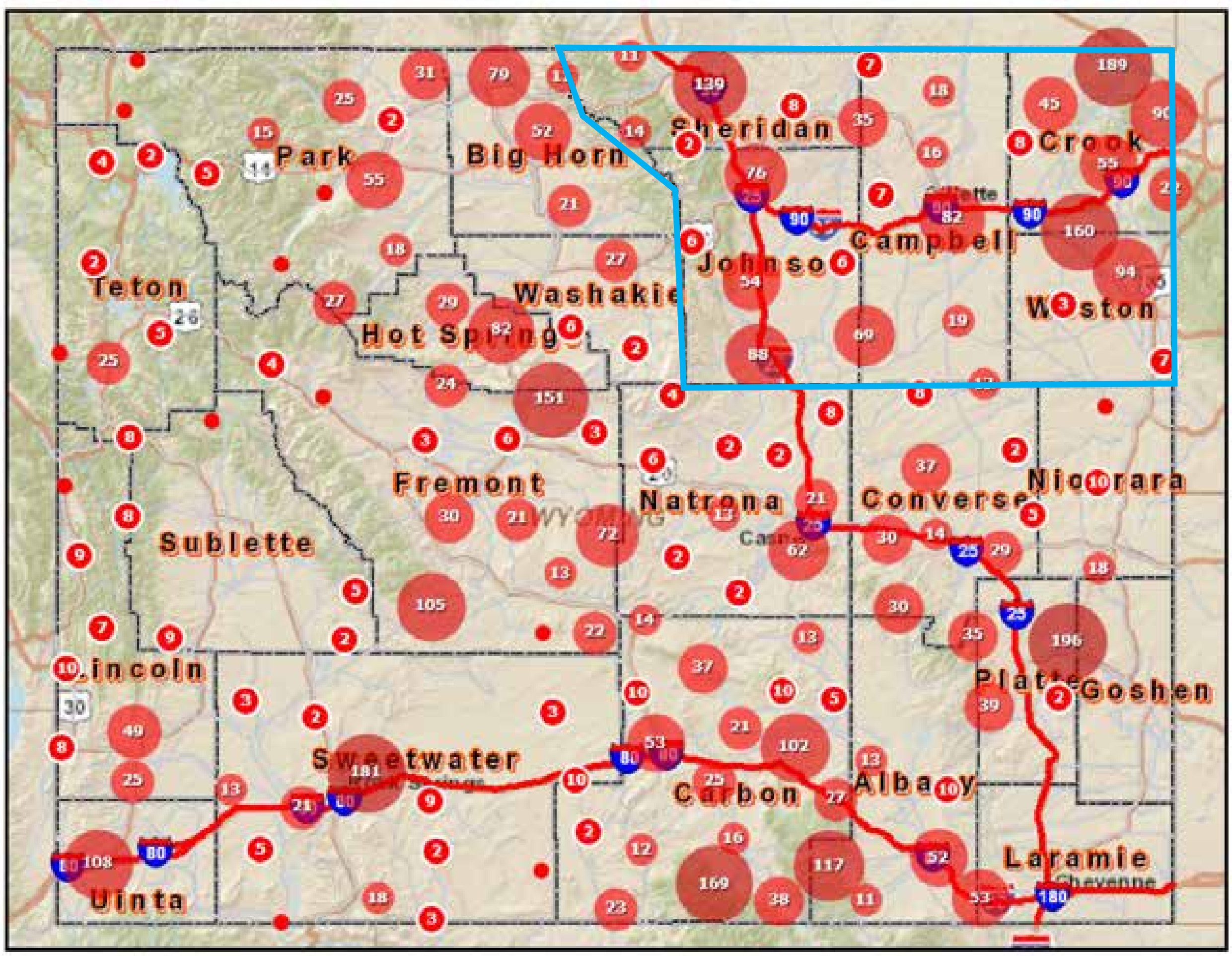
There are numerous abandoned mine sites with subsidence-prone underground workings in Sheridan County, especially in the northern areas close to Interstate 90. Crook and Johnson Counties also have a fair amount of these mine sites, with most also seemingly near major/interstate roads (likely due to the fact that major roads are often built near railroads, which were critical for transportation when the mines were in use). Campbell and Weston have the least number of underground mines, with those in Campbell also located near major roads, and the ones in Weston primarily located in the western edges (though two show up in the northwestern corner of the county).

## Past Occurrences

The 2016 Wyoming Hazard Mitigation Plan addresses mine subsidence, given they do occur occasionally throughout the state. Over the past several years, the Wyoming Abandoned Mine Lands (AML) Program at the Wyoming Department of Environmental Quality (DEQ) has funded a few large subsidence mitigation projects annually. This is in addition to a large number of traditional mine reclamation projects on both coal and non-coal mine sites, along with smaller projects aimed at protecting individual homeowners. Recent subsidence mitigation projects have focused on protecting critical infrastructure.

However, recent events have taken place near the City of Sheridan, Sheridan County, and Gillette, Campbell County. Figure 4-58 below displays the number of mined-out areas and mine subsidence events throughout the Region. Though all counties in the Region show a large number in mine subsidence occurrences, the events may have taken place many years back and not reflect present-day risk potential.

**Figure 4-58 Mined-out Areas and Mine Subsidence Cases in Wyoming**




Source: 2016 Wyoming Multi-Hazard Mitigation Plan

## Likelihood of Future Occurrence

Although many areas of the state have already implemented mitigation projects designed to reduce or remove the impacts from underground mining and subsidence, subsidence may still occur in some areas. The rating for this hazard is **occasional** (between a 1% and 10% probability of occurrence in the next year). The potential for future damage from this hazard could additionally be reduced by mass adoption of a recent state effort, which created an assistance program for mine subsidence threats: the Wyoming Mine Subsidence Insurance Program. This program can help everyday citizens protect their home and business investments, given the insurance is affordable and addresses this specific hazard.

## Potential Magnitude

Many mines in the Region have already been identified and mitigation work undertaken in the past, to remove the threat posed to the surrounding area; many identified mines that remain unmitigated pose little to no threat to infrastructure or property in the surrounding area. Any identified or unidentified mines located under or around buildings, roads, pipelines, or other critical infrastructure can pose higher risk to the surrounding area, including collapse, flooding, and unsettling of the ground. These risks vary by mine and area, though.

## Vulnerability Assessment

There has been property and infrastructure damage associated with mine subsidence in Wyoming communities before. The dollar amounts of the damage are not readily available. Underground coal fires can also happen in abandoned mines.

The dollar impact attributed to these types of events is difficult to predict. An indirect measure of the impacts is the existing cost of mitigating the hazards. The AML Program has spent $303.4 million through 2013, mitigating the effects of mine subsidence alone, as part of the abandoned mine reclamation program. If any of the above mines are found to be unreclaimed and appear to pose a hazard to the public, the Abandoned Mine Lands Program at the Wyoming Department of Environmental Quality should be contacted (Wyoming Hazard Mitigation Plan 2016).

While hundreds of mine subsidence events have taken place across the Region, vulnerability to the hazard is generally **low** due to minimal or no damages incurred by the jurisdictions or the individual populations. However, this risk should be further investigated when siting future development, especially in Crook, Sheridan, and Campbell Counties (though Weston and Johnson could prove fairly vulnerable as well, given their history of events).

## Future Development

Locations where mine subsidence may occur are located throughout the Region in both populated and unpopulated areas. Development in locations where mine subsidence occurs certainly has the potential to impact individual homes or neighborhoods. While it is believed that all mined out areas in Wyoming have been mapped, it is unknown if all locations of potential subsidence have been located appropriately. The uncertainty regarding the locations of more potential subsidence areas means there is the possibility that development may occur in a subsidence-prone location without the knowledge of contractors or developers. Given this fact, there is no way to determine with certainty the likelihood that development will occur in a subsidence-prone location. Therefore, putting a risk factor to this hazard, as it relates to development within Wyoming's borders, is rather complicated.

Businesses seeking to lay pipelines, electrical transmission lines, develop a well site, or build another type of business structure in an area subject to subsidence hazards are typically referred to the AML during the environmental review process. This contact helps ensure new, developing infrastructure can be routed around problem areas, or if more efficient and possible, the area can be mitigated for subsidence hazards before structures or individuals are exposed to the hazard.

### Summary

Overall, the risk of mine subsidence to Region 1 is stated in the table below.

**Table 4-64 Mine Subsidence Hazard Risk Summary**

| County | Geographic Extent | Probability of Future Occurrence | Potential Magnitude/ Severity | Overall Significance |
|---|---|---|---|---|
| Campbell | Significant | Occasional | Negligible | Low |
| Crook | Significant | Occasional | Negligible | Low |
| Johnson | Significant | Occasional | Negligible | Low |
| Sheridan | Significant | Occasional | Negligible | Low |
| Weston | Significant | Occasional | Negligible | Medium |

## 4.2.13 Severe Winter Weather

### Hazard/Problem Description

The National Weather Service defines a storm as "any disturbed state of the atmosphere, especially affecting the Earth's surface, and strongly implying destructive and otherwise unpleasant weather." Winter storms occur during the winter months and produce snow, ice, freezing rain, sleet, and/or cold temperatures. Winter storms are an annual occurrence in climates where precipitation may freeze and are not always considered a disaster or hazard. Disasters occur when the severe storms impact the operations of the affected community by damaging property, stalling the delivery of critical services, or causing injuries or deaths among the population.

Winter storm watches and warnings may be helpful for determining the difference between a seasonal winter storm and a severe winter storm. Warnings are issued if the storm is producing or suspected of producing heavy snow or significant ice accumulations. Watches are usually issued 24 to 36 hours in advance for storms capable of producing those conditions, though criteria may vary between locations. Winter Weather Advisories are issued when a low pressure system produces a combination of winter weather that presents a hazard but does not meet warning criteria. (Source: National Weather Association Online Glossary, http://www.weather.gov/glossary/)

Heavy snow can immobilize the counties in Region 1, isolating communities, stranding commuters, stopping the flow of supplies, and disrupting emergency and medical services. Accumulations of snow can collapse roofs and knock down trees and power lines. In rural areas, homes and farms may be isolated for days, and unprotected livestock may be lost. The cost of snow removal, damage repair, and business losses can have a tremendous impact on cities and towns. Heavy accumulations of ice can bring down trees, electrical wires, telephone poles and lines, and communication towers. Communications and power can be disrupted for days until damages are repaired. Even small accumulations of ice may cause extreme hazards to motorists and pedestrians.

Some winter storms are accompanied by strong winds, creating blizzard conditions with blinding wind-driven snow, severe drifting, and dangerous wind chills. Strong winds with these intense storms and cold fronts can knock down trees, utility poles, and power lines. Blowing snow can reduce visibilities to only a few feet in areas where there are no trees or buildings. Serious vehicle accidents can result with injuries and deaths.

Winter storms in the counties of the Region, including strong winds and blizzard conditions, may cause localized power and phone outages, closures of streets, highways, schools, businesses, and non-essential government operations, and increase the likelihood of winter-weather related injury or death. People may be stranded in vehicles or other locations not suited to sheltering operations or isolated from essential services. A winter storm can escalate, creating life threatening situations when emergency response is limited by severe winter conditions. Other issues associated with severe winter storms include the threat of physical overexertion that may lead to heart attacks or strokes. Snow removal costs can pose significant budget impacts, as can repairing the associated damages caused by downed power lines, trees, structural damages, etc. Heavy snowfall during winter can also lead to flooding or landslides during the spring if the area snowpack melts too quickly.

Extreme cold often accompanies a winter storm, or is left in its wake. It is most likely to occur in the winter months of December, January, and February. Prolonged exposure to the cold can cause frostbite or hypothermia and can become life-threatening. Infants and the elderly are most susceptible. Pipes may freeze and burst in homes or buildings that are poorly insulated or without heat. Extreme cold can disrupt or impair communications facilities. Extreme cold temperatures can destroy crops and cause utility outages, leaving people without water or power until the utility companies are able to restore service.

What constitutes extremely cold temperatures varies across different areas of the United States, based on normal climate temperatures for the time of year. In Wyoming, cold temperatures are normal during the winter. When temperatures drop at least 20 degrees below normal winter lows, the cold is considered extreme and begins to impact the daily operations of the county. Extreme cold/wind chill impacts plants, animals and water supplies.

The effects of extremely cold temperatures are amplified by strong to high winds that can accompany winter storms. Wind-chill measures how wind and cold feel on exposed skin and is not a direct measurement of temperature. As wind increases, heat is carried away from the body faster, driving down the body temperature, which in turn causes the constriction of blood vessels, and increases the likelihood of severe injury or death to exposed persons. Animals are also affected by wind-chill however cars, buildings, and other objects are not.

In 2001, the NWS implemented an updated Wind-Chill Temperature index. This index was developed to describe the relative discomfort/danger resulting from the combination of wind and temperature. Wind chill is based on the rate of heat loss from exposed skin caused by wind and cold. As the wind increases, it draws heat from the body, driving down skin temperature and eventually the internal body temperature.

**Figure 4-59 National Weather Service Wind-Chill Chart**

NWS Windchill Chart

Temperature (°F)

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

Frostbite Times: 30 minutes; 10 minutes; 5 minutes

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

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

*Effective 11/01/01*

Source: NOAA

## Geographical Area Affected

Winter storms are a yearly feature of the Wyoming climate and may occur anywhere in the state. Generally, severe winter storms and extreme cold events are considered regional, which implies the storms impact multiple counties simultaneously, often for extended time periods. It is possible for the geographic extent of the hazard to vary significantly within a single county - a regional storm may directly impact only a small portion of the planning area while still extending over a large portion of the surrounding area. However, even in these instances, while the percent of the planning area directly affected ranges from less than 10% to 100% depending on the specific circumstances, if any portion of the planning area is impacted by the storm then the entire planning area suffers indirect impacts. Therefore, they are considered to have an extensive geographic impact rating.

## Past Occurrences

NCEI data on winter storms and extreme cold events in Region 1 extends from January 1996 through December 2017. During that time, the counties in Region 1 experienced 315 winter weather incidents, including blizzards, extreme cold, heavy snow, ice storms, winter storms and winter weather; the Region experiences an average of 14.3 winter weather incidents annually. There have been four fatalities associated with these incidents, and no reported injuries. (Many minor injuries from winter weather likely go unreported.) Total reported property damages in the Region amounted to $5,700,000. $1,150,000 of this property damage occurred in a single storm on October 3, 2013, that dropped up to two feet of snow in some areas, causing tree damage, power outages and utility damage, and blocked roads.

The most significant blizzard in Wyoming's history occurred from January 2, 1949 to February 20, 1949. Snowfall in parts of eastern and southeastern Wyoming measured up to 30 inches, with drifts 20 to 30 feet high. Seventeen people perished, along with 55,000 head of cattle and over 105,000 sheep. Total economic loss was more than $9 million dollars. In 2009 dollars, the loss would be over $81 million.

The most extreme cold event on record in Wyoming occurred in March 1975, when zero-degree temperatures combined with 40-50 mph winds caused livestock losses worth $12,312,872 (adjusted to 2016). Another cold wave in December 1983 brought low temperatures between -20°F and -40°F, resulting in $6,650,688 in damages, primarily from freezing water pipes.

In late January 1996, record low temperatures were recorded for many areas. Low temperatures in the western Bighorn Mountains dropped to between ten below zero and 45 below zero during this time across the State of Wyoming. On the 1st, strong winds lowered wind chill temperatures to as low as 60 below zero in some locations. Some young livestock were frozen. The cold also froze many pipes and caused some water lines to break or leak. A number of schools and events were cancelled across the state during this time. About forty residences were without natural gas in the Big Horn Basin on the 3rd due to the cold causing a valve malfunction. Many accidents occurred on the 1st due to poor visibility. One person froze to death just north of Buffalo, WY early on the 2nd after walking for help after his car broke down.

On December 30th, 2014, northerly flow following the passage of an Arctic cold front brought brutally cold temperatures and dangerous wind chills to much of western and central Wyoming. The Daniel cooperative observer recorded a low temperature of -48F on the morning of

Wednesday, December 31st.  In addition, many locations across Fremont, Hot Springs, Lincoln, Sweetwater and Washakie counties saw temperatures of -30F to -35F.  Wind chill temperatures of -30F were common.

**Table 4-65 Winter Weather Events Summary 1996-2017**

| County | Winter Storms | Ice Storms | Extreme Cold | Fatalities/ Injuries | Property Damage | Crop Damage | Total Damage |
|---|---|---|---|---|---|---|---|
| Campbell | 86 | 1 | 1 | 0 / 0 | $980,000 | $0 | $980,000 |
| Crook | 126 | 0 | 1 | 0 / 0 | $2,190,000 | $0 | $2,190,000 |
| Johnson | 108 | 0 | 1 | 2 / 0 | $165,000 | $0 | $165,000 |
| Sheridan | 152 | 0 | 0 | 1 / 0 | $1,000 | $0 | $1,000 |
| Weston | 124 | 1 | 1 | 0 / 0 | $2,364,000 | $0 | $2,364,000 |

Source: NCEI. The "Winter Storm" column includes events labelled as blizzards, heavy snow, winter storm or winter weather.

The following table shows regional temperature profiles based on data from the Western Regional Climate Center for sensor locations in each county. The record low for the Region is -46°F in Moorcroft in 1990.

**Table 4-66 Region 1 Temperature Summaries**

| County | Station | Winter[1] Average Minimum Temperature | Summer[1] Average Maximum Temperature | Maximum Temperature | Minimum Temperature | # Days >90°F/ Year | # Days <32°F/ Year |
|---|---|---|---|---|---|---|---|
| Campbell | Dillinger | 9.5°F | 83.4°F | 108°F 07/29/2006 | -45°F 12/22/1990 | 34 | 196 |
| Crook | Moorcroft CAA | 10.3°F | 82.6°F | 108°F 07/09/1989 | -46°F 12/22/1990 | 28 | 189 |
| Johnson | Kaycee | 9.7°F | 84.5°F | 107°F 08/05/1979 | -45°F 01/24/1949 | 34 | 197 |
| Sheridan | Sheridan WSO AP | 11.9°F | 82.8°F | 107°F 07/14/2002 | -37°F 12/24/1983 | 29 | 185 |
| Weston | Newcastle | 13.6°F | 83.9°F | 108°F 07/05/1936 | -37°F 01/17/1930 | 32 | 171 |

Source: Western Regional Climate Center, www.wrcc.dri.edu/
[1]Winter: December, January, February; Summer: June, July, August

## Frequency/Likelihood of Occurrence

Winter storms and extreme cold are an annual occurrence in Wyoming, often occurring multiple times each winter, and affecting entire regions in their size and scope. Since 1996, the Region has averaged 17 days with a recorded severe winter weather incident per year.

It is important to note that the lack of specific historical accounts on extreme cold temperatures does not necessarily indicate a low frequency of occurrence. Residents of Wyoming are used to cold weather, and may be less likely to report events that might be considered extreme in other areas.

## Potential Magnitude

The damages caused by severe winter storms, blizzards and extreme cold vary and are dependent on several factors: the duration of the storm; the geographic extent; the time of year; meteorological factors such as wind, moisture content of the snow, ground and air temperatures; and the advance warning of the storm. Impacts from the storm dictate the magnitude of the event, emphasizing that the amount snow may not always directly correlate to how bad the storm is. Damaged power lines and dangerous or impassable roadways may forestall the delivery of critical services such as medical and emergency assistance, the delivery of food supplies and medications, or even the provision of basic utilities such as heat and running water. When events happen with a long warning time, it is possible to pre-mitigate the effects of insufficient supply levels or to pre-test emergency generators, which may prevent some of the previously described impacts from occurring. Unanticipated storms increase the number of people stranded, both in cars and at public locations, which may increase the number of injuries and deaths attributed to the event (often caused by exposure) and place uneven and unanticipated strains on public sheltering capacities. The weight of the snow, driven by the water content of the fall, increases the potential for damages caused to structures and trees. Lighter snow caused by extreme cold increases the damages caused to livestock, agriculture and landscaping due to freezing conditions. Winter storms which go through periods of thaw and freeze prolong dangerous icy conditions, increasing the likelihood of frozen and damaged water pipes, impassable or dangerous roadways, damaged communication lines, or more extensive damages to infrastructure and structures caused by seeping water freezing under roofs, porches, patios, inside sidings, or causing damage to vehicles. Extreme cold can also impact livestock and even crops if the event occurs during certain times of the year.

The HMPCs reported that Interstate closures are common during winter storm events, which leads to the need to shelter stranded motorists, can create economic impacts, and can cause problems due to diverted semis on city streets. Access to rural homes can also become an issue, especially during prolonged storms; residents are encouraged to keep a 3-day supply of food, medication, and oxygen. Impacts on livestock and wildlife are also a major concern.

The Sheridan County HMPC reported that they average 73” of snowfall annually. Building collapses are common, especially during Fall and Spring snow storms.

The HMPCs noted power outages often result from severe winter weather. In March 2007, power was knocked out to Story for 3-4 days due to tree branches falling on power lines. Impact to older bridges was a concern for the HMPCs, specific bridges have not been identified. Newer bridges typically have mitigation built into the design.

The HMPCs also observed that supplying oxygen to home care individuals becomes problematic, as the locations of these individuals are not mapped. Home oxygen users are directed to notify the power company to prioritize restoration for them. Alternative supplies are available in town.

Extreme cold creates additional problems. The HMPCs reported that -20 °F winds are common, and temperatures as low as -40 °F have been seen in the planning area. This causes water mains to freeze up, especially in the transitional seasons. Gas lines can crack, which has caused one house explosion. Extreme cold puts pressure on the electric grid and natural gas supply. Home electrical fires from space heaters are common.

The HMPCs noted that ice jams are also an issue, and can lead to major flooding problems; there was a major one near Dayton in 2016. While sometimes the jam resolves itself, they have sometimes had to use backhoes to break it up. Winter storms usually cover a significant part of the state, and as such are easier to describe regionally than on a county by county basis.

Winter storms usually cover a significant part of the state, and as such are easier to describe regionally than on a county by county basis.

## Vulnerability Assessment

### *Population*

Since 1960, the Region has averaged one fatality every 7.3 years from severe winter weather. The threat to public safety is typically the greatest concern during severe winter storms. While virtually all aspects of the population are vulnerable to severe winter weather, there are segments of the population that are more vulnerable to the potential indirect impacts of a severe winter storm than others, particularly the loss of electrical power. As a group, the elderly or disabled, especially those with home health care services that rely heavily on an uninterrupted source of electricity. Resident populations in nursing homes or other special needs housing may also be vulnerable if electrical outages are prolonged. If they do not have a back-up power source, rural residents and agricultural operations reliant on electricity for heating and water supplies are also especially vulnerable to power outages.

Extreme cold/wind chill pose the greatest danger to outdoor laborers, such as highway crews, police and fire personnel, and construction. The elderly, children, people in poor physical health, and the homeless are also vulnerable to exposure. Overall, the population has a medium exposure to severe cold.

Severe winter weather also increases the vulnerability of the commuting population. While there is no way to quantify which of these accidents occur during severe winter storms versus regular winter storms, the numbers indicate that winter driving conditions raise the vulnerability of the commuting population.

Wyoming is becoming a preferred retirement area in the US. Sheridan county and other locales in Region #1 rank among the top destinations in the state. Those who have lived in areas with more temperate climates, are leaving due to cost of living/tax burden issues, upon retirement. As a result, folks with no prior knowledge of (or experience dealing with) cold weather/snow conditions are moving into this area. This retirement influx, and “aging in place syndrome” will exacerbate the scope of “vulnerable populations.” Due to expectations/demand from the influx of these retirees, local governments will likely see increased pressure and demands for winter/cold weather-related request for assistance.

### *General Property*

Since 1960, the Region has sustained an average of $259,000 in property damage per year from severe winter weather. Property vulnerabilities to severe weather include damage caused by high winds, ice, or snow pack and subsequently melting snow. Vehicles may be damaged by the same factors, or temporarily un-useable due to the driving conditions created by severe winter weather. Contents of homes, storage units, warehouses and storefronts may be damaged if the structures are compromised or fail due to the weather, or during potential flooding caused by melting snow. Very wet snow packs down densely and is very heavy. This may create strains on structures, causing partial or entire collapses of walls, roofs, or windows. This is impacted both by architecture and construction material, and should be assessed on a building-by-building basis. These records are probably tracked via insurance or other private vendors. Crops, livestock and other agricultural operations are also highly vulnerable to severe winter storms.

Extreme cold/wind chill presents a minimal risk to the structures of Region 1. Property damage occurs occasionally when water pipes freeze and break. Homes without adequate insulation or heating may put owners at a higher risk for damages or cold-related injury. In cases of periods of prolonged cold, water pipes may freeze and burst in poorly insulated or unheated buildings. Vehicles may not start or stall once started due to the cold temperatures and the risks of carbon monoxide poisoning or structure fires increases as individuals attempt to warm cars in garages and use space heaters. Stalled vehicles, or those that fail to start, may result in minor economic loss if individuals are unable to commute between work, school, and home. Driving conditions may deteriorate if extreme cold/wind chill prolongs icy road conditions, which will impact commutes and emergency response times as well. Landscaping and agricultural products may be damaged or destroyed by unseasonable occurrences of extreme cold/wind chill, causing plants to freeze and die. This may increase the indirect vulnerabilities to severe cold by causing greater economic costs and losses for the year. The overall vulnerability of general property is low.

### *Essential Infrastructure, Facilities, and Other Important Community Assets*

The physical structures which comprise essential infrastructure are as vulnerable as those outlined in the General Property subsection of this profile. Severe winter weather may also disrupt the availability of services from essential infrastructure, including utility delivery (gas, electric and water), telephone service, emergency response personnel capabilities, road plowing, and childcare availability. Severe winter storms may even halt the operation of an area for periods of time, making the vulnerability of the counties even higher.

Like general property, extreme cold/wind chill events have a limited impact on the physical property of essential infrastructures and facilities. Communications lines such as fiber optic cables can freeze. There may be incidents of delayed emergency response due to stalled vehicles, delays in dispatching due to frozen communications lines, or an increased volume in calls. Hospitals may see an increase in cold-related injuries directly or injuries associated as secondary effects of the cold (traffic accidents, broken bones or severe cuts due to slips, etc.) and a prolonged extreme cold/wind chill event may impact hospital personnel capabilities. Personnel working in the cold, such as firefighters, EMTs, police officers and construction workers, have a higher vulnerability due to exposure times, and response capabilities may be hindered. Human services programs that care for at-risk individuals and families may be stressed, but usually can still adequately provide services through the duration of the extreme cold/wind chill event. Unusually high volumes of individuals seeking shelter or food may overwhelm some facilities if the event is prolonged. There may be an increased number of displaced individuals or families due to flooding caused by ruptured pipes, which may strain local aid organizations such as the Red Cross. Older venues or historical properties suffer the same vulnerabilities associated with private and general properties that are older, with the added vulnerability of damaging historic and often irreplaceable property in the process. If the event is extremely extended and impacts multiple other counties and states, which in turn impacts the availability of mutual assistance, the risk factors may increase. The overall vulnerability of essential infrastructure and community assets is medium.

As mentioned previously, ice or heavy accumulations of snow, particularly with blowing and drifting, can temporarily impact the roadway system. These accumulations also require vast amounts of overtime for county highway and local streets departments to remove snow and melt ice. Ice storms or high winds in winter storms can cause extensive loss of overhead utility lines due to buildup either on the lines or on adjacent trees that either collapse due to the weight or blow down onto the utility lines. Services such as telephone, electricity, and cable TV are frequently affected by winter storms. The overall vulnerability of essential infrastructure is medium.

***Natural, Historic and Cultural Resources***

Natural resources may be damaged by the severe winter weather, including broken trees and death of unsheltered wildlife. Unseasonable storms may damage or kill plant and wildlife, which may impact natural food chains until the next growing season. Historical areas may be more vulnerable to severe winter storms due to construction and age of structures. Cultural resources generally experience the same vulnerabilities outlined in General Property, in addition to lost revenue impacts due to transportation impacts. The overall vulnerability of these resources is medium.

## Future Development

Where building codes are applicable, future residential or commercial buildings built to code should be able to withstand snow loads from severe winter storms. Future power outages or delays in power delivery to future developments may be mitigated by construction considerations such as buried power lines. Future development will also require future considerations for snow removal capacity including equipment, personnel, and logistical support. Adequate planning will help establish the cost-effective balance.

Due to the relative prevalence of cold incidents across the Region, it is common practice to build infrastructure with the appropriate safeguards to protect it from extreme cold incidents. This practice will continue as infrastructure is built to face the realities of living in Wyoming.

Public education efforts may help minimize the risks to future populations by increasing knowledge of appropriate mitigation behaviors, clothing, sheltering capacities, and decision making regarding snow totals, icy roads, driving conditions, and outdoor activities (all of which are contributors to decreased public safety during severe winter storms). New establishments or increased populations who are particularly vulnerable to severe winter storms (such as those with health concerns or those who live in communities that may be isolated for extended periods of time due to the hazard) should be encouraged to maintain at least a 72-hour self-sufficiency as recommended by FEMA. Encouraging contingency planning for businesses may help alleviate future economic losses caused by such hazards while simultaneously limiting the population exposed to the hazards during commuting or commerce-driven activities.

### Summary

Residents of the Region are generally well-adapted to severe winters and cold temperatures. Nevertheless, Severe Winter Storms are generally a high significance hazard in the Region due to the widespread nature, severity, and potential impacts to life and property.

**Table 4-67 Winter Weather Hazard Risk Summary**

| County | Geographic Extent | Probability of Future Occurrence | Potential Magnitude/ Severity | Overall Significance |
|---|---|---|---|---|
| Campbell | Significant | Highly Likely | Limited | High |
| Crook | Significant | Highly Likely | Limited | High |
| Johnson | Significant | Highly Likely | Limited | High |
| Sheridan | Significant | Highly Likely | Limited | High |
| Weston | Significant | Highly Likely | Limited | High |

## 4.2.14 Tornado

### Hazard/Problem Description

A tornado is a swirling column of air extending from a thunderstorm to the ground. Maximum winds in tornadoes are often confined to extremely small areas, and vary tremendously over very short distances, even within the funnel itself. Tornadoes can have wind speeds from 40 mph to over 300 mph, the majority displaying wind speeds of 112 mph or less. Erratic and unpredictable, they can move forward at up to 70 miles per hour, pause, slow down and change directions. Most have a narrow path, less than 100 yards wide and a couple of miles long. However, damage paths from major tornadoes can be more than a mile wide and 50 miles long.

Based on national statistics for 1970 – 1980, for every person killed by a tornado, 25 people were injured and 1,000 people received some sort of emergency care. Tales of complete destruction of one house next to a structure that is totally unscathed are well documented. Within a building, flying debris or missiles are generally stopped by interior walls. However, if a building has no partitions or has any glass, brick or other debris blown into the interior, the tornado winds can be life threatening. In order to examine tornado activity and the potential impact on the Region and its residents, it is important to understand how tornadoes are rated.

### *Rating a Tornado*

In 1971, Dr. T. Theodore Fujita of the University of Chicago devised a six-category scale to classify U.S. tornadoes into intensity categories, F0 through F5. These categories are based upon the estimated maximum winds occurring within the funnel. The Fujita Tornado Scale (or the "F Scale") became the definitive scale for estimating wind speeds within tornadoes based upon the damage done to buildings and structures. It was used extensively by the National Weather Service in investigating tornadoes, and by engineers in correlating damage to building structures and techniques with different wind speeds caused by tornadoes.

**Table 4-68 Fujita Scale Description**

| F-Scale Number | Intensity Phrase | Wind Speed | Type of Damage Done |
|---|---|---|---|
| F0 | Gale tornado | 40-72 mph | Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages signboards. |
| F1 | Moderate tornado | 73-112 mph | The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed. |
| F2 | Significant tornado | 113-157 mph | Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated. |
| F3 | Severe tornado | 158-206 mph | Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted |
| F4 | Devastating tornado | 207-260 mph | Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated. |
| F5 | Incredible tornado | 261-318 mph | Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles fly through the air in excess of 100 meters; trees debarked; steel reinforced concrete structures badly damaged. |

Source: NOAA

### *Changes to Tornado Rating Scale*

Devastating tornadoes in Jarrell, Texas on May 1997, and Moore/Oklahoma City on May 1999, demonstrated that the wind estimates in the original F-scale may be too high. From 2000 to 2004, the Wind Science and Engineering Research Center at Texas Tech University, in cooperation with numerous expert meteorologists, civil engineers and the National Weather Service (NWS), developed an Enhanced Fujita Scale, or EF-scale. In addition to improving the ranking process, it was essential to the development team that the new EF-scale support and be consistent with the original F-scale. The EF-scale documentation includes additional enhanced descriptions of damage to multiple types of structures and vegetation with photographs, a PC-based expert system, and enhanced training materials.

In February 2007, the Enhanced Fujita scale replaced the original Fujita scale in all tornado damage surveys in the United States. The following table compares the estimated winds in the original F-scale with the operational EF-scale that is currently in use by the NWS.

**Table 4-69 The Enhanced Fujita Tornado Scale**

| Fujita Scale | | | Operational EF-Scale | |
|---|---|---|---|---|
| F Number Fastest | Fastest 1/4 – mile (mph) | 3 Second Gust (mph) | EF Number | 3 Second Gust (mph) |
| 0 | 40-72 | 45-78 | 0 | 65-85 |
| 1 | 73-112 | 79-117 | 1 | 86-110 |
| 2 | 113-157 | 118-161 | 2 | 111-135 |
| 3 | 158-207 | 162-209 | 3 | 136-165 |
| 4 | 208-260 | 210-261 | 4 | 166-200 |
| 5 | 261-318 | 262-317 | 5 | Over 200 |

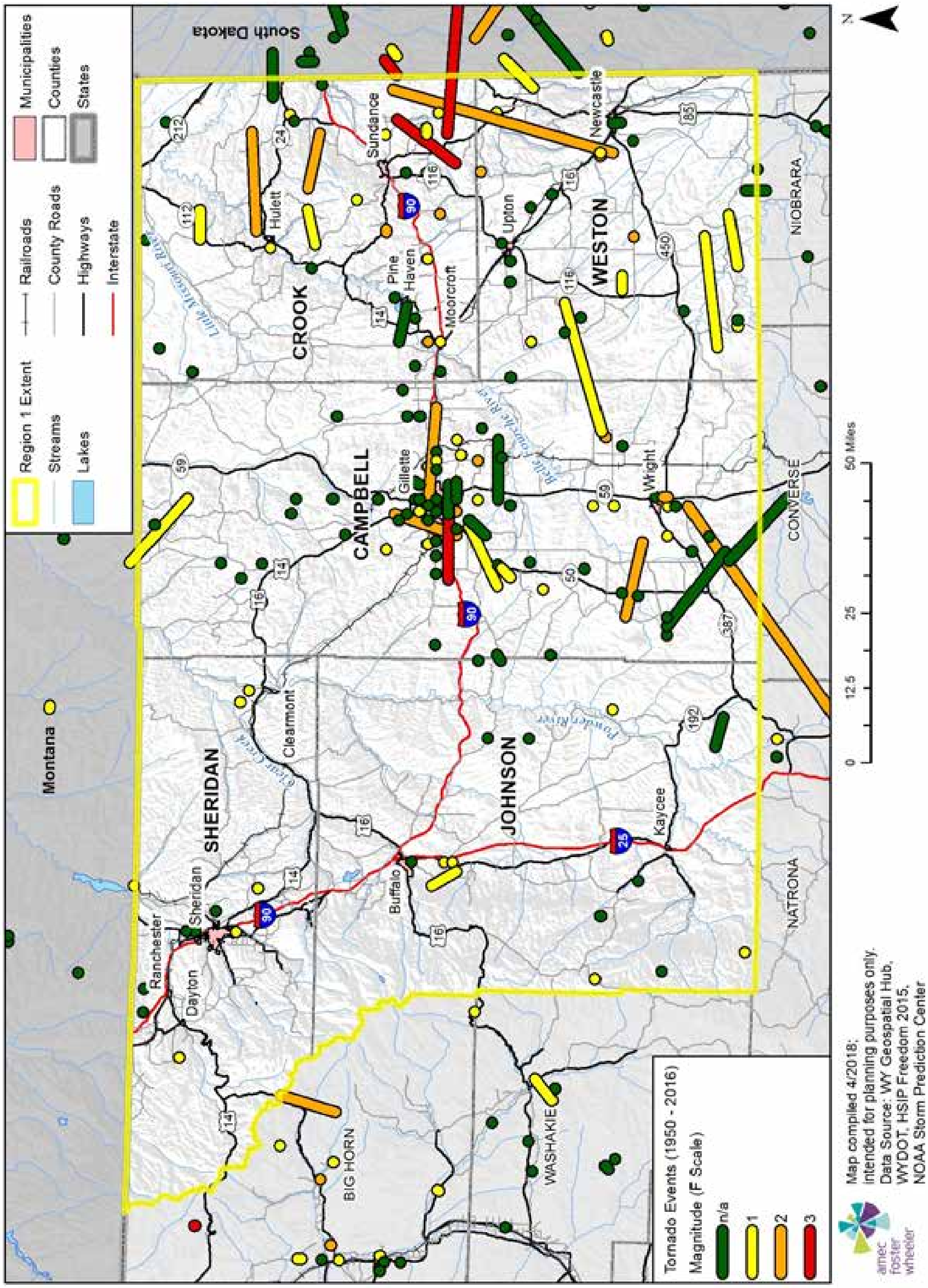
Source: NOAA

Throughout this section, tornadoes prior to 2007 are rated using the F scale; tornadoes after 2007 are rated using the EF scale.

## Geographical Area Affected

The entire area of the Region is susceptible to tornadoes. While some areas may have seen more tornadoes than others, this is more of a statistical anomaly than a causal result.

## Figure 4-60 Region 1 Tornadoes



## Past Occurrences

Tornado statistics, especially prior to the 1970s, must be viewed as incomplete since many twisters have occurred without being witnessed. Wyoming's open rangelands experience little if any damage from these storms, so many go unreported. Many documented tornadoes occurring in the counties in Region 1 are given low ratings on the Fujita Scale (F/EF-0 to F/EF-1) simply because these tornadoes are often formed over open land and result in little or no damage.

Since 1950, there have been 175 tornadoes between the five counties of Region 1, as documented by the National Climatic Data Center. 71 of these tornadoes resulted in damage or injuries, for a total of 2 fatalities, 33 injuries, and $9,730,000 in total recorded property damage in the Region.

**Table 4-70 Tornado History by County, Region 1 (1950-2016)**

| County | Total Incidents | Magnitude (F / EF) | Damage-Causing Incidents | Fatalities | Injuries | Property Damage |
|---|---|---|---|---|---|---|
| Campbell | 90 | 0-3 | 30 | 2 | 26 | $ 7,787,050 |
| Crook | 32 | 0-3 | 19 | 0 | 3 | $ 1,241,200 |
| Johnson | 16 | 0-1 | 6 | 0 | 2 | $ 21,050 |
| Sheridan | 11 | 0-1 | 5 | 0 | 0 | $ 60,100 |
| Weston | 26 | 0-2 | 11 | 0 | 2 | $ 620,600 |
| **Total** | **175** | **0-3** | **71** | **2** | **33** | **$ 9,730,000** |

Source: NOAA

**Table 4-71 History of Damage-Causing Tornadoes, Region 1 (1950-2016)**

| County | Date | Magnitude | Fatalities | Injuries | Property Damage | Crop Damage |
|---|---|---|---|---|---|---|
| Weston | 1950-06-14 | 1 | 0 | 0 | $50 | $0 |
| Weston | 1953-05-28 | 2 | 0 | 0 | $5,000 | $0 |
| Campbell | 1953-06-12 | 2 | 0 | 0 | $5,000 | $0 |
| Campbell | 1956-06-21 | 1 | 0 | 0 | $50,000 | $0 |
| Campbell | 1958-06-03 | 1 | 0 | 0 | $50 | $0 |
| Campbell | 1958-06-03 | 1 | 0 | 0 | $50 | $0 |
| Weston | 1958-06-12 | 2 | 0 | 0 | $50,000 | $0 |
| Crook | 1958-07-10 | 0 | 0 | 0 | $50 | $0 |
| Weston | 1958-07-10 | 1 | 0 | 0 | $50 | $0 |
| Campbell | 1959-05-27 | 2 | 0 | 0 | $50,000 | $0 |
| Crook | 1959-06-25 | 2 | 0 | 0 | $50,000 | $0 |
| Crook | 1961-05-18 | 2 | 0 | 0 | $50,000 | $0 |
| Sheridan | 1961-05-20 | 1 | 0 | 0 | $50,000 | $0 |
| Crook | 1961-07-17 | 1 | 0 | 0 | $500 | $0 |
| Campbell | 1962-06-11 | 2 | 0 | 4 | $50,000 | $0 |
| Weston | 1962-06-11 | 1 | 0 | 0 | $5,000 | $0 |

| County | Date | Magnitude | Fatalities | Injuries | Property Damage | Crop Damage |
|---|---|---|---|---|---|---|
| Campbell | 1962-06-11 | 1 | 0 | 0 | $500 | $0 |
| Weston | 1963-07-14 | 1 | 0 | 0 | $5,000 | $0 |
| Weston | 1964-07-02 | 2 | 0 | 0 | $50,000 | $0 |
| Crook | 1965-07-12 | 3 | 0 | 0 | $500,000 | $0 |
| Campbell | 1966-07-22 | 2 | 0 | 6 | $50,000 | $0 |
| Campbell | 1966-07-28 | 0 | 0 | 0 | $50 | $0 |
| Weston | 1966-08-11 | 1 | 0 | 0 | $500 | $0 |
| Campbell | 1967-04-19 | 1 | 0 | 0 | $500 | $0 |
| Sheridan | 1968-06-07 | 1 | 0 | 0 | $5,000 | $0 |
| Sheridan | 1968-06-11 | 1 | 0 | 0 | $5,000 | $0 |
| Johnson | 1971-06-03 | 1 | 0 | 0 | $5,000 | $0 |
| Johnson | 1974-08-14 | 1 | 0 | 2 | $5,000 | $0 |
| Campbell | 1975-06-25 | 2 | 0 | 1 | $0 | $0 |
| Crook | 1975-06-25 | 3 | 0 | 0 | $50,000 | $0 |
| Crook | 1975-06-25 | 1 | 0 | 0 | $5,000 | $0 |
| Sheridan | 1976-06-04 | 0 | 0 | 0 | $50 | $0 |
| Sheridan | 1976-06-04 | 0 | 0 | 0 | $50 | $0 |
| Campbell | 1976-06-05 | 0 | 0 | 0 | $50 | $0 |
| Campbell | 1976-06-05 | 0 | 0 | 0 | $50 | $0 |
| Campbell | 1976-06-05 | 0 | 0 | 0 | $50 | $0 |
| Campbell | 1976-06-05 | 0 | 0 | 0 | $50 | $0 |
| Crook | 1976-06-05 | 0 | 0 | 0 | $50 | $0 |
| Crook | 1976-06-05 | 0 | 0 | 0 | $50 | $0 |
| Campbell | 1976-06-13 | 0 | 0 | 0 | $50 | $0 |
| Campbell | 1976-06-16 | 0 | 0 | 0 | $50 | $0 |
| Crook | 1976-07-12 | 1 | 0 | 0 | $50,000 | $0 |
| Campbell | 1976-08-15 | 1 | 0 | 0 | $500,000 | $0 |
| Johnson | 1977-05-09 | 1 | 0 | 0 | $500 | $0 |
| Johnson | 1977-06-20 | 1 | 0 | 0 | $50 | $0 |
| Campbell | 1977-06-25 | 1 | 0 | 0 | $50 | $0 |
| Campbell | 1978-05-22 | 1 | 0 | 0 | $500,000 | $0 |
| Campbell | 1978-05-23 | 3 | 0 | 0 | $500,000 | $0 |
| Crook | 1980-06-14 | 1 | 0 | 0 | $500 | $0 |
| Campbell | 1982-06-14 | 1 | 0 | 0 | $500 | $0 |
| Campbell | 1982-06-14 | 0 | 0 | 0 | $50 | $0 |
| Johnson | 1982-07-05 | 0 | 0 | 0 | $500 | $0 |
| Crook | 1982-07-24 | 1 | 0 | 0 | $5,000 | $0 |
| Campbell | 1983-07-17 | 1 | 0 | 0 | $50,000 | $0 |
| Crook | 1984-05-31 | 2 | 0 | 0 | $50,000 | $0 |
| Weston | 1985-05-10 | 2 | 0 | 0 | $5,000 | $0 |

| County | Date | Magnitude | Fatalities | Injuries | Property Damage | Crop Damage |
|---|---|---|---|---|---|---|
| Crook | 1986-07-04 | 1 | 0 | 0 | $50,000 | $0 |
| Campbell | 1988-05-06 | 2 | 0 | 2 | $500,000 | $0 |
| Campbell | 1990-05-24 | 1 | 0 | 0 | $5,000 | $0 |
| Campbell | 1990-05-24 | 0 | 0 | 0 | $5,000 | $0 |
| Weston | 1991-05-12 | 1 | 0 | 0 | $500,000 | $0 |
| Campbell | 1993-08-19 | 1 | 0 | 0 | $500,000 | $0 |
| Crook | 1996-05-07 | 1 | 0 | 0 | $50 | $0 |
| Crook | 1998-06-13 | 1 | 0 | 0 | $20,000 | $0 |
| Johnson | 1999-08-11 | 1 | 0 | 0 | $10,000 | $0 |
| Johnson | 2017-12-06 | 2 | 0 | 0 | $10,000 | $0 |
| Weston | 2001-06-09 | 0 | 0 | 2 | $0 | $0 |
| Campbell | 2005-08-12 | 2 | 2 | 13 | $5,000,000 | $0 |
| Campbell | 2008-06-02 | 0 | 0 | 0 | $10,000 | $0 |
| Crook | 2009-07-13 | 2 | 0 | 2 | $300,000 | $0 |
| Crook | 2014-06-13 | 2 | 0 | 1 | $100,000 | $0 |
| Crook | 2014-06-25 | 1 | 0 | 0 | $10,000 | $0 |
| Campbell | 2014-06-26 | 0 | 0 | 0 | $10,000 | $0 |
| **TOTALS** | | | **2** | **33** | **$9,740,000** | **$0** |

Source: NOAA

**Figure 4-61 Tornado Events in Wyoming, 1950-2017**

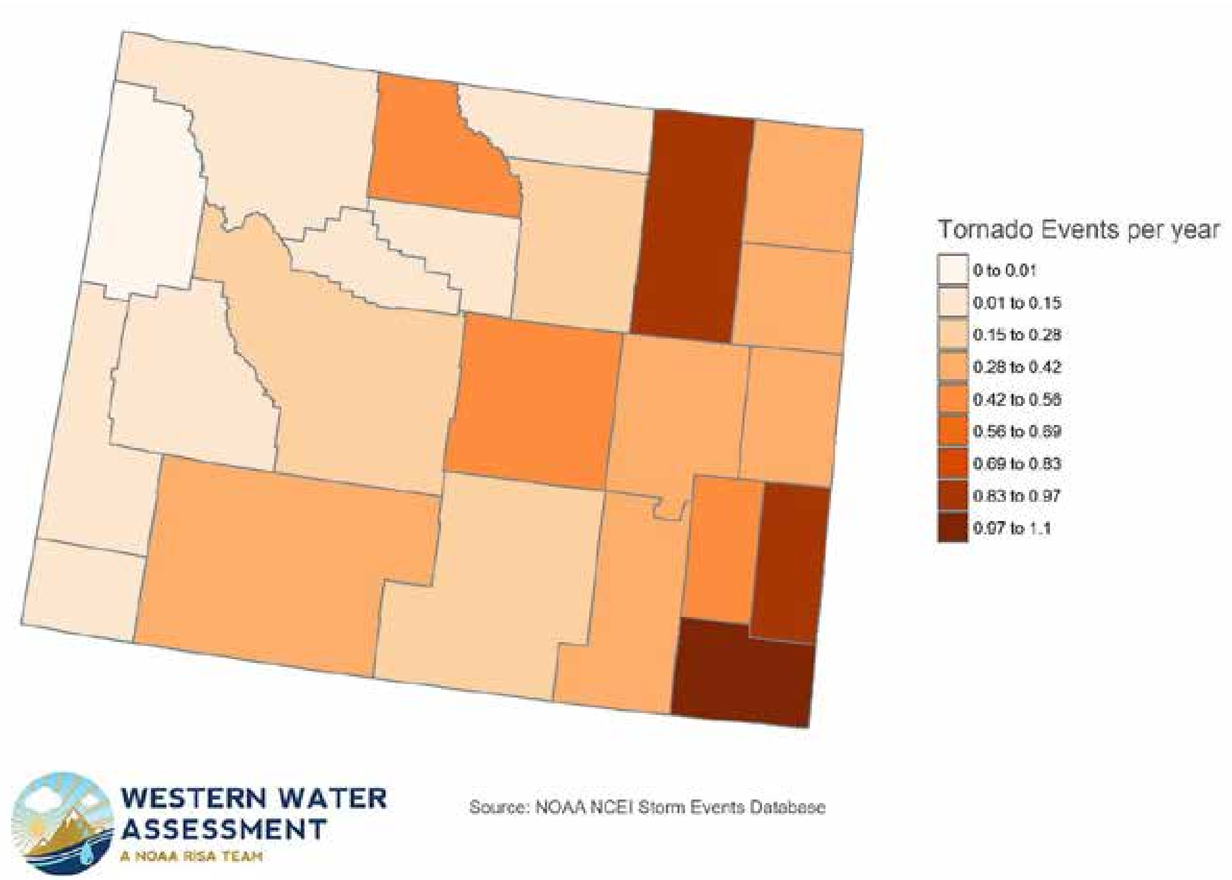
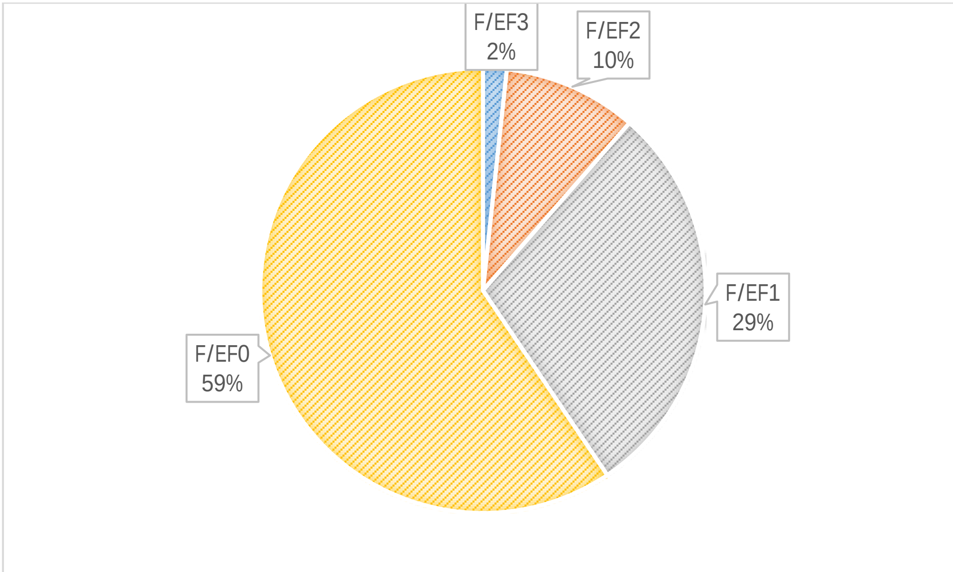



Figure 4-61 was created by Western Water Assessment based on their analysis of NCEI data; shows the number of tornado events in Wyoming per county from 1950-2017.

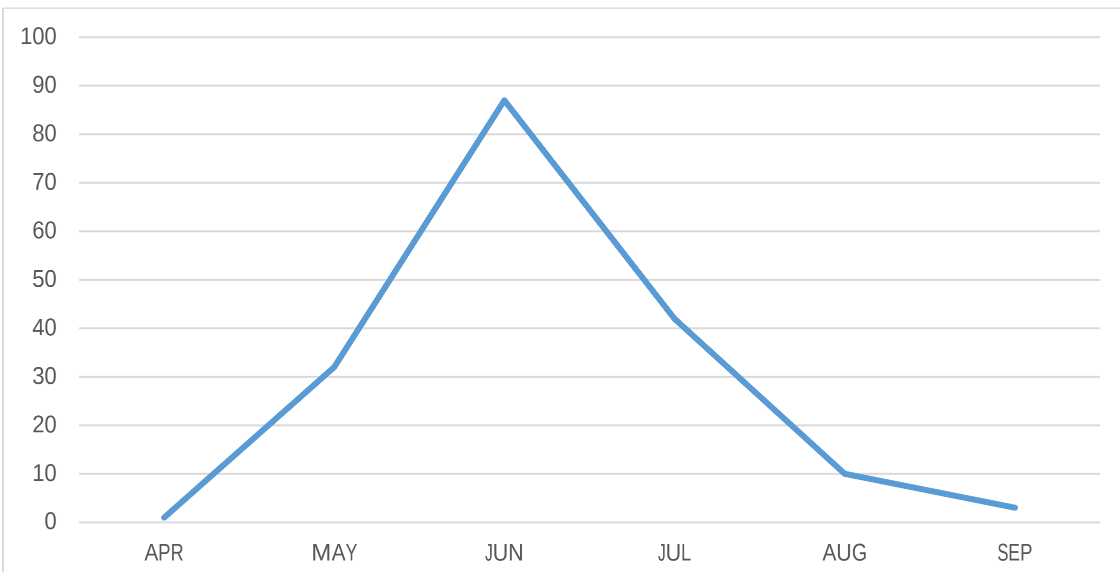
The NOAA data allows for examination and statistical analysis of tornadoes occurring in the Region. The majority of the historical tornadoes in the Region were rated F/EF0; the most powerful tornado recorded in Region 1 was rated as an EF3. The data also allows for the development of profiles on historical time periods of tornadoes. Figure 4-63 and Figure 4-64 give historical perspective on the time of year and time of day that tornadoes in the region have occurred.

## Figure 4-62 Region 1 Historical Tornadoes by Rating




Source: NOAA

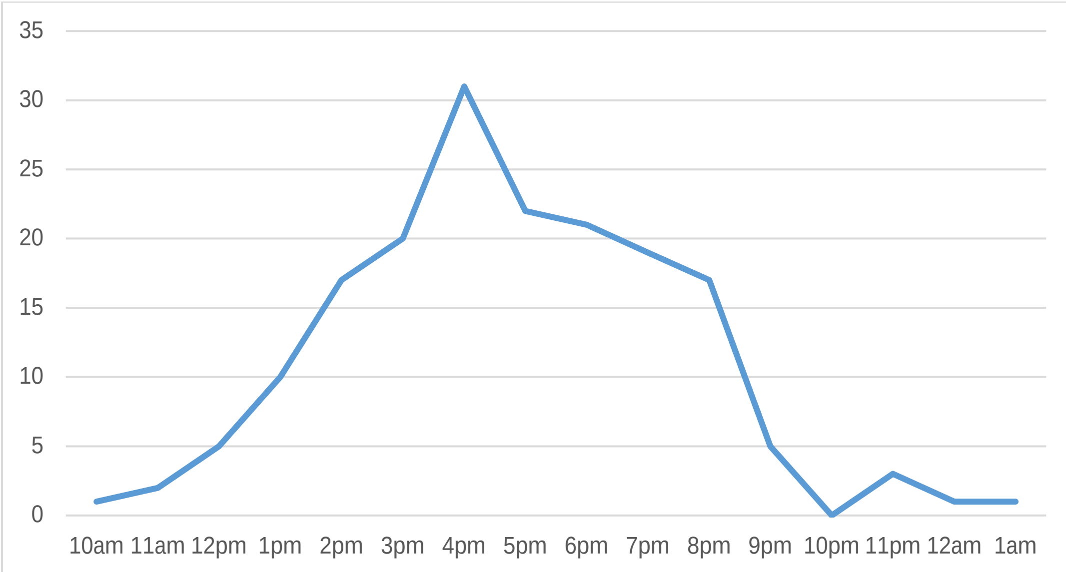
## Figure 4-63 Region 1 Historical Tornadoes by Month: 1950-2016




Source: NOAA

Historically, tornadoes occur in the spring/summer months between April and September, with the highest number of tornadoes occurring in June.

**Figure 4-64  Region 1 Historical Tornadoes by Time of Day: 1950-2016**




Source: NOAA

Historical tornadoes in Region 1 are most common during the months of May through August, and between the hours of noon and 10pm, with peak hours being from 2pm and 8pm.

Most tornadoes recorded in Region 1 cause no recorded injuries, no recorded fatalities, and little to no damage to property ($0 - $50,000 range). Of the 175 tornadoes that have been recorded by NOAA in Region 1 from 1950 to 2016, 71 (41%) have caused recorded property damage or injuries, and none have caused recorded crop damage.

Johnson County HMPC reported an EF1 or EF2 tornado in 2017 southwest of Kaycee that damaged one roof, an unused mobile home, and downed a power line. A recent tornado event took place in Johnson County on June 1, 2018. A supercell storm produced two EF2 tornadoes that touched down in eastern Washakie and western Johnson counties and left thousands of trees destroyed in their wake. Further details on this event can be found in the Johnson County annex. Campbell County has had 2 tornado fatalities from the 2005 Wright tornado, an F2 that also injured 13 people and used $5 million in property damage, resulting in Presidential Disaster Declaration DR-1599. Sheridan County HMPC reported several barns had been impacted by tornadoes; they also noted a 2015 tornado that touched down in neighboring Big Horn County and traveled into Sheridan County near Highway 14. And on June 1$^{st}$, 2018, four tornadoes touched down near Gillette, including an EF3, two EF1s and an EF0; the tornadoes damaged or destroyed several homes and outbuildings, flipped several vehicles, and snapped several utility poles. In 33 minutes, the tornadoes covered over 15 miles, destroying eight homes and damaging another 20 homes and properties in subdivisions north and northwest of Gillette. Damages were also reported at the Eagle Butte Coal Mine and the Dry Fork Power Station north of Gillette.

### Frequency/Likelihood of Occurrence

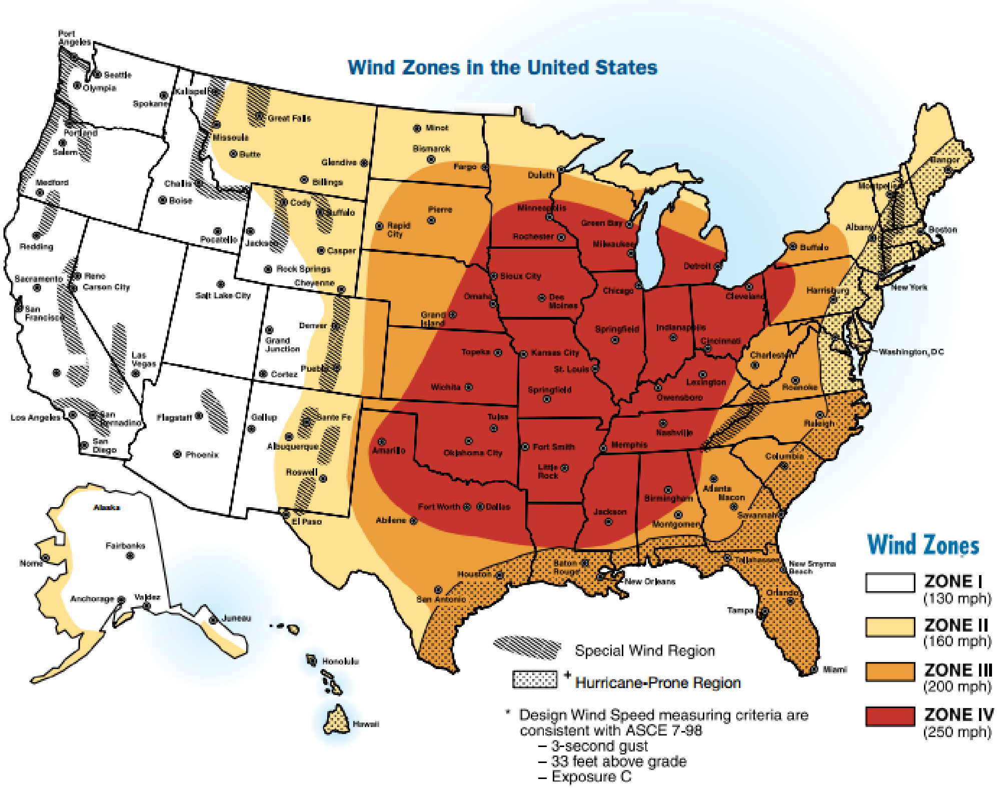
There were 175 tornadoes in the Region recorded between 1950 and 2016; of those, 71 resulted in damage or injuries. The likelihood of a tornado touching down in any given year varies from 20% in Sheridan County to 160% in Campbell County. However, the likelihood of a damaging tornado in any given year varies from 9% in Sheridan County to 54% in Campbell County.

On average, Region 1 experienced 2.6 tornadoes per year, and 1.1 damaging tornadoes per year; this trend will likely continue into the future.

### Potential Magnitude

The National Weather Service considers tornadoes to be among nature's most violent storms. The most violent tornadoes are capable of tremendous destruction with wind speeds of 250 mph or more. Tornadic winds can cause people and autos to become airborne, rip ordinary homes to shreds, and turn broken glass and other debris into lethal missiles. Even weaker tornados can cause large economic damages. The wind zone map shown below indicates the potential magnitude of wind speeds. All of Region 1 is located in Zone II, which can expect winds up to 160 mph.

**Figure 4-65 Wind Zones in the United States**




Source: FEMA

According to NCEI records, the storm of record for Region 1 occurred in Campbell County on August 12, 2005, when an F2 tornado touched down just north of Wright and traveled southeast into the town, striking a mobile home park and an elementary school. The tornado killed 2 people and injured 13 – all in the mobile home park – and caused $5,000,000 in property damage.

Though the strength of the tornado often dictates the impacts, it is important to remember that the location (rural or urban) of the tornado is just as important when assessing these risks, and location is a random factor. Impacts can vary depending on multiple factors, including the size and strength of a tornado, and its path.

### Vulnerability Assessment

Because of its rural composition, people or property within the county have not had a history of being severely impacted during past tornado incidents. While the F-Scale ratings of historical tornadoes in the counties in the Region are low, those ratings are partially based on recorded damage. Recorded damage may have been much more substantial if these tornadic events had impacted one of the many communities in the Region, rather than timber, outlying range, and farm acreage.

Tornadoes occur at random locations throughout the Region; for that reason, all structures, critical facilities, essential services, and populations are considered vulnerable.

### Future Development

Any future development that is exposed and above ground will be vulnerable to a direct or indirect hit by a tornado. Generally, most areas in the Region lack building codes. In areas where building codes are not in place and enforced, buildings may not be built to withstand tornado-force winds.

### Summary

Tornadoes are a credible threat, and will continue to occur in the counties of Region 1. Historically, the impacts to the county from tornadoes has been low; however, depending on a tornado's size, intensity and path, it can cause severe impacts to people, property and infrastructure. The likelihood of a tornado generally increases from west to east in the Region.

**Table 4-72 Tornado Hazard Risk Summary**

| County | Geographic Extent | Probability of Future Occurrence | Potential Magnitude/ Severity | Overall Significance |
|---|---|---|---|---|
| Campbell | Significant | Likely | Limited | High |
| Crook | Significant | Likely | Limited | Medium |
| Johnson | Significant | Occasional | Limited | Medium |
| Sheridan | Significant | Occasional | Limited | Medium |
| Weston | Significant | Likely | Limited | Medium |

## 4.2.15 Wildfire

### Hazard/Problem Description

Wildfire is defined as a highly destructive fire or any instance of uncontrolled burning in grasslands, brush, or woodlands. Wildfire increasingly encroaches into urban interface areas, as more people move closer to forest settings. As defined by the National Interagency Fire Center (NIFC), a “wildland fire” is any non-structure fire, other than prescribed fire, that occurs in the wildland. The term “wildland/urban interface” or WUI is widely used within the wildland fire management community to describe any area where man-made buildings are constructed close to or within a boundary of natural terrain and fuel, where high potential for wildland fires exists. “Aspect” refers to the cardinal direction a slope faces. “Fuel” consists of combustible material, including vegetation such as grass, leaves, ground litter, plants, shrubs, and trees that feed a fire.

Wildfires can occur at any time of the year, but are most likely to occur during the spring, summer or fall. Thunderstorms that contain lightning frequently start wildfires, but they can also be caused by humans. Wyoming’s semi-arid climate and rural character make the state vulnerable to catastrophic wildland fires, which comprise more than 50% of all fires in Wyoming.

As the population and the wildland/urban interface in Wyoming increases, the risk of wildland fire becomes more significant. The past 100 years of wildland fire suppression has led to heavy vegetation growth and thus has greatly increased the potential fuel-load for a wildfire to burn. As the wildland/urban interface has grown into densely packed forests, the potential for catastrophic wildland fires has increased as well. Fires have historically played a natural role on western landscapes. For example, some species of trees occupy sites following fire until replaced by more shade-tolerant species. In some cases, regeneration of vegetation can be enhanced by fire. Fires may have positive or negative effects, or both, depending upon the resources at risk in the fire area.

### Geographical Area Affected

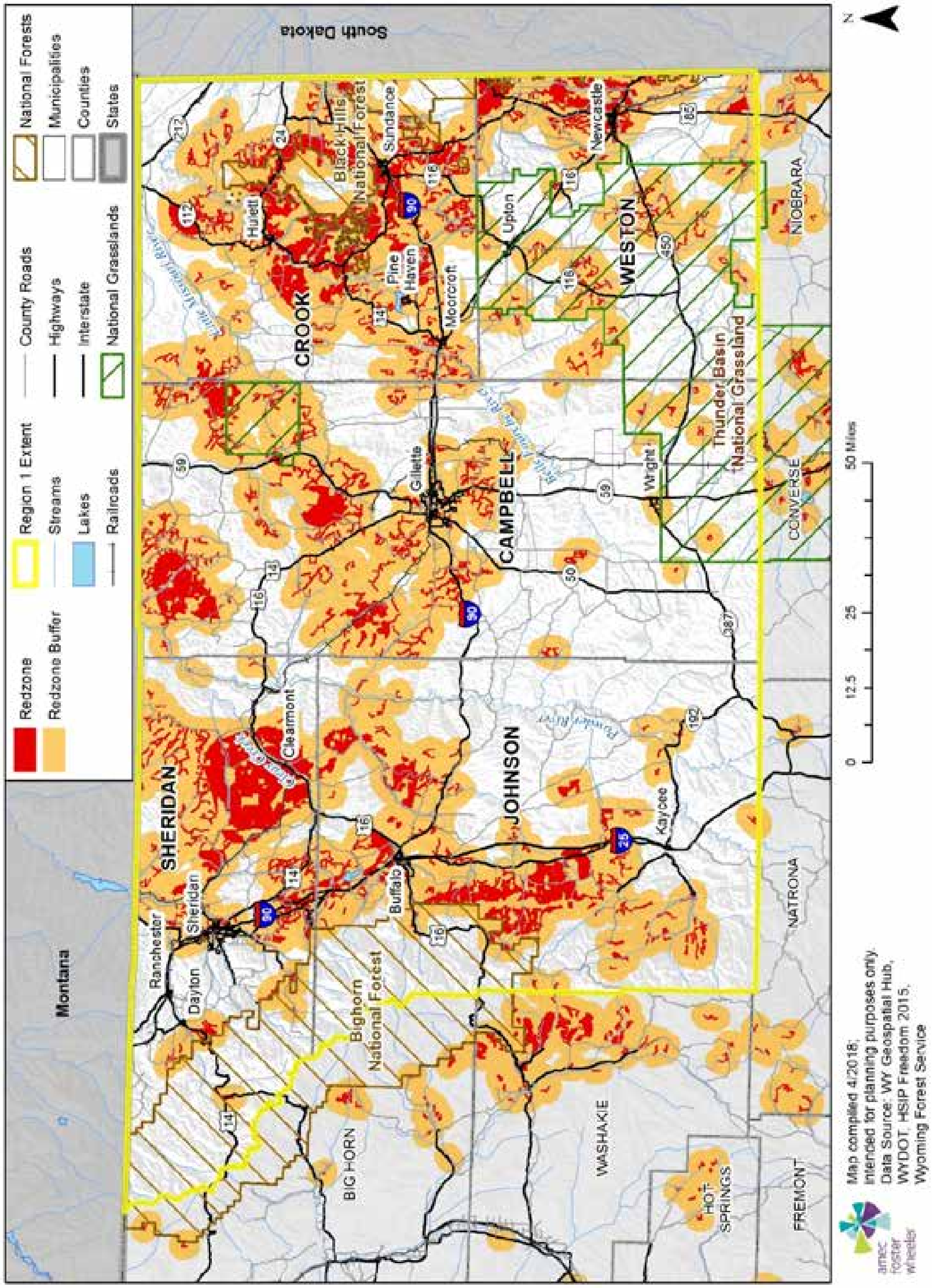
Certain areas within Region 1, because of their semi-arid climate and availability of fuel, are vulnerable to catastrophic wildland fires. Historically, over 50% of all wildfires in Wyoming involve wildland areas. A major portion of the Region is susceptible to wildfires, with the exception of areas above the tree line. According to the methodology for characterizing spatial extent, a **significant** portion of the planning area is affected by wildfires.

The wildland and wildland-urban interface areas are of most concern and are shown in Figure 4-66, based on the Wildland Urban Interface Hazard Assessment. This assessment was produced by a joint venture of the Wyoming State Forestry Division, USFS, BLM, NPS, and other interested parties. This Geographic Information System (GIS)-based mapping effort builds on the Front Range Redzone Project in Colorado. The Assessment seeks to map fire hazard incorporating population density against slope, aspect, and fuel conditions. With the mapping analysis evaluating areas of varying wildfire vulnerability, the final output results in a Risk, Hazard, and Value (RHV) map displaying areas of concern (called Redzones) for catastrophic wildland fires.

According to the Redzones analysis, the following areas seem to be at highest risk, based on wildfire-prone vulnerable characteristics:

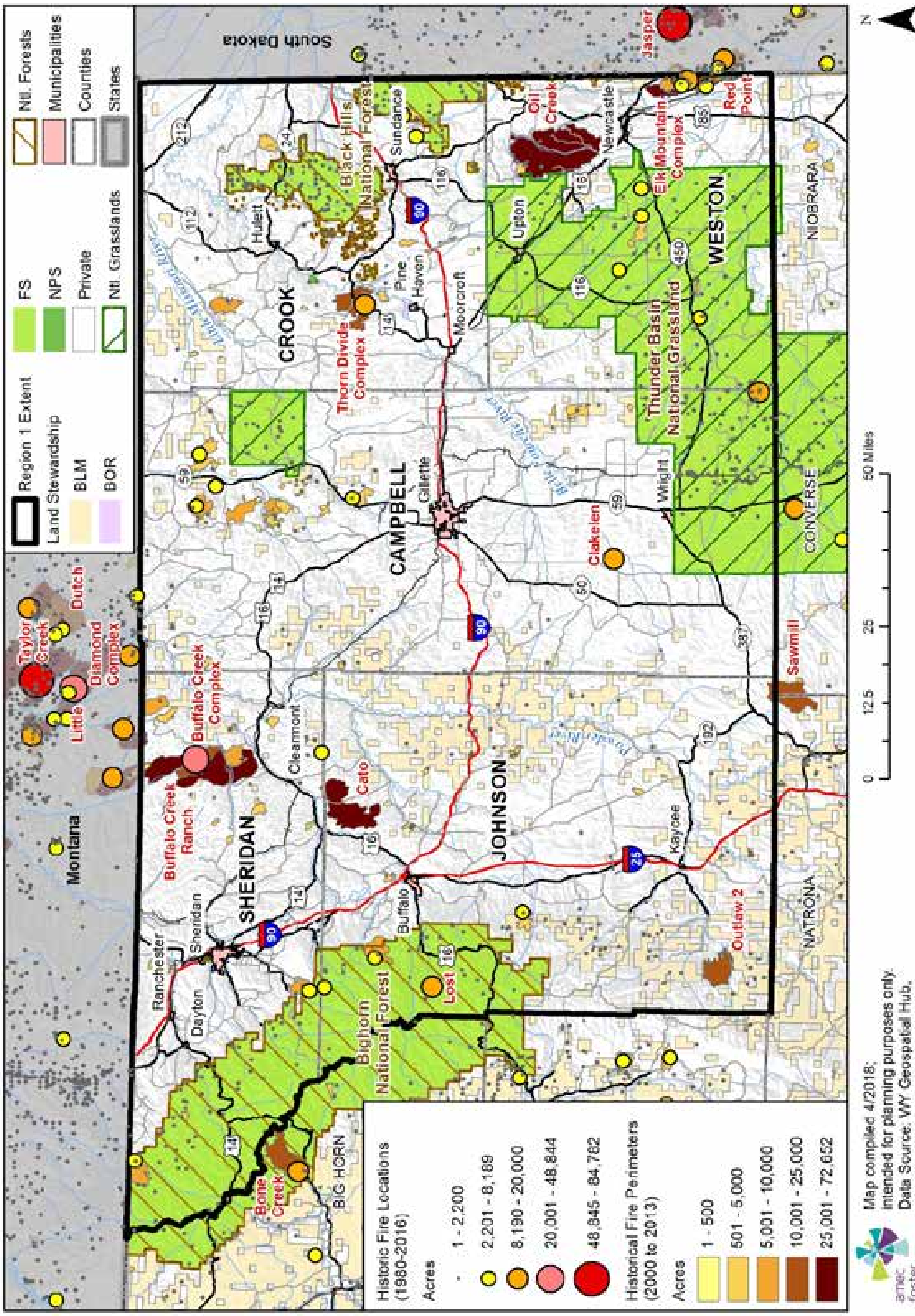
- Sheridan County has characteristics that indicate that a Catastrophic Fire is possible (especially near Clearmont)
- Most of Crook County
- North and eastern Weston County, especially near Newcastle
- Rural subdivisions surrounding the City of Gillette, and northern Campbell County
- All areas in or near forest lands, such as near the Bighorn Mountains and Black Hills National Forest

## Figure 4-66 Region 1 Wildland Fire Redzones



## Past Occurrences

**Figure 4-67 Region 1 Wildland Fire Occurrences from 1980 to 2016**



The Federal Wildland Fire Occurrence Database was used to analyze fire history in Region 1. The database, maintained by the USGS and other agencies, includes perimeter and point GIS layers for fires on public lands throughout the United States. The data includes fires dating back to 1980. The National Park Service, Bureau of Land Management, and U.S. Forest Service reports include fires of 10 acres and greater. The database is limited to fires on federal lands, though. Some fires may be missing altogether or have missing or incorrect attribute data. Some fire information may be lacking in the database because historical records were lost or damaged, fires were too small for the minimum cutoffs, documentation was inadequate, or fire perimeters had not yet been incorporated into the database. Also, agencies are at different stages of participation. For these reasons, the data should be used cautiously for statistical or analytical purposes.

Figure 4-67 shows wildfires that have affected the area based on the Federal Wildland Fire Occurrence Database. Some of the largest recorded fires occurred in the north and eastern parts of Sheridan County (near the boundary with Montana), as well as in the eastern-southern parts of Weston County (along the boundary with South Dakota). Some of the more significant fires are discussed by county in the following section.

### *Campbell County*

Campbell County has a history of wildfire. The Federal Wildland Fire Occurrence Data records 209 total fire events from 1980-2016. However, 92,512 acres burned in Campbell County just from fires of 1,000 acres or more in size (though many more occurred throughout those years). The largest fire in Campbell County occurred in 1999. It was the Clarkelen Fire, which burned 20,000 acres about 11 miles northwest of Wright. Table 4-73 below describes those Campbell County wildfires that burned 1,000 or more acres between 1980 and 2016, sorted by year.

**Table 4-73 Wildfires over 1,000 acres in Campbell County: 1980-2016**

| Name | Year | Acres Burned |
|---|---|---|
| Rochelle Hills #2 | 1988 | 9,216 |
| Edwards | 1992 | 1,477 |
| Logan Cr. | 1996 | 1,075 |
| Bear Gulch | 1998 | 1,300 |
| Clarkelen | 1999 | 20,000 |
| Turner | 1999 | 2,000 |
| Ponderosa | 2000 | 2,925 |
| Daley Complex | 2002 | 6,687 |
| Hairy | 2002 | 1,371 |
| Pownell Fire | 2002 | 6,949 |
| Daley | 2002 | 5,321 |
| Watt Draw | 2002 | 1,525 |
| Bacon Creek | 2006 | 2,076 |
| Little Powder Fire | 2006 | 4,728 |

| Name | Year | Acres Burned |
|---|---|---|
| Duck Creek | 2007 | 4,343 |
| Horse Creek 2 | 2007 | 8,349 |
| South Edwards | 2010 | 1,245 |
| Collins 1 | 2011 | 1,908 |
| Rourke | 2011 | 4,215 |
| Collins | 2012 | 2,444 |
| Wildcat Creek | 2012 | 1,322 |
| Cedar Draw 2 | 2016 | 2,035 |
| **TOTAL** | | **92,512** |

Source: Federal Wildland Fire Occurrence Data

It is important to note, however, that many other fires which burned thousands of additional acres took place in Campbell County throughout the years. About 31% of those were estimated to be human-caused, with another 1% with an unknown cause, and all others being natural-caused. Over 282 total fires have taken place in the county since 1980. (Source: Campbell County's WRDS, HSIP Freedom.)

### *Crook County*

Historically, most significant fires in Crook County have occurred north of Pine Haven and southeast of Sundance, in and around the Black Hills National Forest. The fires affecting over 1,000 acres of land in the county are summarized on Table 4-74.

According to the Federal Wildland Fire Occurrence Data, a total of 159 fires burned from 1980 to 2016, and 43,094 acres burned just in fires of 1,000 acres and above. The largest fire in Crook County occurred in 2006, when the Thorn Divide Complex burned, causing damage to 14,973 acres. The table below describes only the Crook County wildfires that burned 1,000 or more acres between 1980 and 2016, though many more have taken place over the years.

**Table 4-74 Wildfires over 1,000 acres in Crook County: 1980-2016**

| Name | Year | Acres Burned |
|---|---|---|
| Lantz | 1985 | 6,880 |
| Unknown | 2000 | 1,480 |
| Woods | 2000 | 6,089 |
| Mcfarland Divide | 2001 | 1,480 |
| Basin Draw | 2004 | 4,718 |
| Cement | 2005 | 3,025 |
| South Sundance Complex | 2005 | 2,933 |
| Thorn Divide Complex | 2006 | 14,973 |
| Ghost | 2012 | 1,516 |
| **TOTAL** | | **43,094** |

Source: Federal Wildland Fire Occurrence Data

### *Johnson County*

Johnson County has had 70,494 acres burned just in fires over 1,000 acres in size, and a total of 126 wildfire events (of all acreage) from 1980 to 2016. The Lost fire in 1988 was the most destructive, affecting 13,100 acres southwest of Buffalo, in the Bighorn National Forest. Outlaw #2 was the second largest fire event, taking place in 2006 and burning 12,411 acres of Johnson County lands, southwest of Kaycee. The fires affecting over 1,000 acres of land in the county are summarized on Table 4-75 below.

**Table 4-75 Wildfires over 1,000 acres in Johnson County: 1980-2016**

| Name | Year | Acres Burned |
|---|---|---|
| Lost | 1988 | 13,100 |
| Stockwell | 1996 | 3,400 |
| Big Spring | 2003 | 3,345 |
| Outlaw 2 | 2006 | 12,411 |
| Albright | 2010 | 1,199 |
| Cat Creek | 2011 | 1,173 |
| Gilead | 2012 | 8,189 |
| Cato | 2012 | 27,677 |
| **TOTAL** | | **70,494** |

Source: Federal Wildland Fire Occurrence Data

### *Sheridan County*

This county has had 55,062 acres burned just in fires over 1,000 acres in size, and a total of 84 wildfire events (of all acreage) from 1980 to 2016. The Buffalo Creek Complex Fire was by far the most destructive in Sheridan County, burning almost 30,000 near the central-east part, in 2006. The fires affecting over 1,000 acres of land in the county are summarized on Table 4-76 below.

**Table 4-76 Wildfires over 1,000 acres in Sheridan County: 1980-2016**

| Name | Year | Acres Burned |
|---|---|---|
| Hepp | 1996 | 3,068 |
| Thunderchild Cx | 2001 | 4,800 |
| Cabin Creek Fire | 2002 | 2,588 |
| Little Horn 2 | 2003 | 7,400 |
| Buffalo Creek Complex Fire | 2006 | 29,966 |
| Little Goose | 2007 | 5,202 |
| Whitmeyer Creek | 2012 | 2,039 |
| **TOTAL** | | **55,062** |

Source: Federal Wildland Fire Occurrence Data

***Weston County***

Weston has experienced 124 fires from 1980 to 2016. Around 111,154 acres were burned just in fires of 1,000 acres and above (not taking into account the acreage burned in smaller fires). The most significant wildfire event (the Oil Creek fire) took place in 2012, affecting 62,318 acres of land in the northeastern part of the county. A list of fires burning over 1,000 acres of land in the county are summarized on Table 4-77 below.

**Table 4-77 Wildfires over 1,000 acres in Weston County: 1980-2016**

| Name | Year | Acres Burned |
|---|---|---|
| 35 Mile Marker | 2010 | 4,896 |
| Elk Mountain | 1983 | 1,392 |
| Mush Creek | 1991 | 1,066 |
| Peterson-Elliott | 1994 | 7,150 |
| Elk Mtn 2 | 2001 | 12,136 |
| Red Point | 2003 | 2,724 |
| Cummings | 2006 | 4,266 |
| Wade Hill | 2007 | 2,445 |
| Whoop Up Fire | 2011 | 7,462 |
| Butterfield | 2012 | 2,225 |
| Oil Creek | 2012 | 62,318 |
| Skull Creek Complex | 2012 | 1,733 |
| Buck Draw Fire | 2016 | 1,341 |
| **TOTAL** | | **111,154** |

Source: Federal Wildland Fire Occurrence Data

## Frequency/Likelihood of Occurrence

Wildfires are **Highly Likely** to occur in the Region each year. It is important to note that the risk of wildfires occurring may increase during times of drought, especially in prolonged droughts such as 2000 – 2004; 2012 was also a drought year and a bad year for fires in the region.

## Potential Magnitude

Most of the counties' individual risk to wildfire is limited, given only around 10% to 25% of property is severely damaged, and facilities and services likely to become unavailable between 1 and 7 days. However, wildfire can have significant economic impacts as they often coincide with the busy tourist season in the summer months. These natural hazards coupled with the predictions by the Redzone fire assessments discussed previously (including a careful study of the historical prevalence of wildfires throughout the five counties), makes the overall potential for magnitude of wildfires rather **critical**. More specific consequences are discussed by county in the next section. It is important to note that, while only a small amount of built environments (e.g., infrastructure in the towns and cities) might be affected from wildfires, agricultural lands and other amenities valuable to the Region can still be greatly damaged, in turn affecting other aspects and sectors of the economy in the Region.

## Vulnerability Assessment

GIS tools are designed to collect, store, analyze, manipulate, and display spatial data. In the case of the Wildland Urban Interface Hazard Assessment, wildfire hazard vulnerability is determined by comparing values such as slope, vegetation, housing density, and aspect. The following is from the *Wyoming Wildland Urban Interface Hazard Assessment Methodology*—a report written by the Wyoming State Forestry Division:

"The Wildland Urban Interface Hazard Assessment uses three main layers to determine fire danger—Risk, Hazard, and Values. The following lists include the data used to create each of the three layers.

1) Risk – Probability of Ignition
   a. Lightning Strike density
   b. Road density
   c. Historic fire density
2) Hazard – Vegetative and topological features affecting intensity and rate of spread
   a. Slope
   b. Aspect
   c. Fuels – Interpreted from GAP Vegetation information.
3) Values – Natural or man-made components of the ecosystem on which a value can be placed
   a. Housing Density – Life and property
4) Non-flammable areas Mask – a mask was created to aid in the analysis for areas that will not carry fire such as water and rock areas. These areas show in the final assessment as a zero value for hazard."

The statewide Wildland Urban Interface Hazard Assessment and its resultant outputs serve two primary purposes: assisting in prioritizing and planning mitigation projects, and creating a communications tool to which agencies can relate to common information and data. With the mapping analysis evaluating areas of varying wildfire vulnerability, the final output will result in a Risk, Hazard, and Value (RHV) map displaying areas of concern (Redzones) for catastrophic wildland fires.

Another method of estimating vulnerability is to determine the value of structures that are located within Redzones, or wildland fire building exposure values. Wildland fire building exposure values are the values of buildings that can be potentially damaged by wildland fire in an area. For this plan, a vulnerability assessment based on the Redzone fire hazard zones and parcel data was conducted, to determine potential losses to property and assets in each community (broken up by property type, estimated content values, and total exposure to wildfire hazards).

## General Property Exposure

The building exposure value for the entire Region totals $1,280,616,321 according to the Redzone analysis. The tables below summarize counties' wildfire exposure by jurisdiction, while the county annexes contain jurisdictional maps to supplement the information contained herein.

### *Campbell County*

According to the Redzone and parcel data analysis, Campbell County's losses were determined to total the following:

**Table 4-78 Campbell County General Building and Population Exposure within the Redzone**

| Jurisdiction | Property Type | Parcel Count | Improved Value | Est. Content Value | Total Exposure | Population |
|---|---|---|---|---|---|---|
| Gillette | Agricultural | 1 | $281,436 | $281,436 | $562,872 | -- |
| | Commercial | 23 | $17,898,305 | $17,898,305 | $35,796,610 | -- |
| | Residential | 724 | $127,237,861 | $63,618,931 | $190,856,792 | 1,984 |
| | **Total** | **748** | **$145,417,602** | **$81,798,672** | **$227,216,274** | **1,984** |
| Wright | Residential | 108 | $12,529,077 | $6,264,539 | $18,793,616 | 296 |
| | **Total** | **108** | **$12,529,077** | **$6,264,539** | **$18,793,616** | **296** |
| Unincorporated | Agricultural | 40 | $6,474,894 | $6,474,894 | $12,949,788 | -- |
| | Commercial | 18 | $4,096,404 | $4,096,404 | $8,192,808 | -- |
| | Residential | 625 | $82,045,946 | $41,022,973 | $123,068,919 | 1,713 |
| | **Total** | **683** | **$92,617,244** | **$51,594,271** | **$144,211,515** | **1,713** |
| | **GRAND TOTAL** | **1,539** | **$250,563,923** | **$139,657,481** | **$390,221,404** | **3,992** |

Source: Amec Foster Wheeler analysis of Wyoming Forestry, USGS, HSIP Freedom, and parcel data.

### *Crook County*

Crook County's losses were calculated to amount to the following:

**Table 4-79 Crook County General Building and Population Exposure within the Redzone**

| Jurisdiction | Property Type | Parcel Count | Improved Value | Est. Content Value | Total Exposure | Population |
|---|---|---|---|---|---|---|
| Moorcroft | Residential | 5 | $748,045 | $374,023 | $1,122,068 | 12 |
| | **Total** | **5** | **$748,045** | **$374,023** | **$1,122,068** | **12** |
| Pine Haven | Commercial | 8 | $1,996,798 | $1,996,798 | $3,993,596 | -- |
| | Duplex | 2 | $318,153 | $159,077 | $477,230 | 5 |
| | Residential | 230 | $40,238,920 | $20,119,460 | $60,358,380 | 559 |
| | **Total** | **240** | **$42,553,871** | **$22,275,335** | **$64,829,206** | **564** |
| Sundance | Commercial | 12 | $4,560,410 | $4,560,410 | $9,120,820 | -- |
| | Residential | 66 | $10,263,416 | $5,131,708 | $15,395,124 | 160 |
| | **Total** | **78** | **$14,823,826** | **$9,692,118** | **$24,515,944** | **160** |
| Unincorporated | Agricultural | 239 | $15,610,560 | $15,610,560 | $31,221,120 | -- |
| | Commercial | 29 | $7,030,543 | $7,030,543 | $14,061,086 | -- |
| | Duplex | 1 | $92,722 | $46,361 | $139,083 | 2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Exempt | 1 | $28,587 | $28,587 | $57,174 | -- |
| | Residential | 666 | $127,006,640 | $63,503,320 | $190,509,960 | 1,618 |
| | **Total** | **936** | **$149,769,052** | **$86,219,371** | **$235,988,423** | **1,621** |
| | **GRAND TOTAL** | **1,259** | **$207,894,794** | **$118,560,846** | **$326,455,640** | **2,357** |

### *Johnson County*

According to the Redzone and parcel data analysis, Johnson County's losses were determined to amount to the values specified in Table 4-80 below:

**Table 4-80 Johnson County General Building and Population Exposure within the Redzone**

| Jurisdiction | Property Type | Parcel Count | Improved Value | Est. Content Value | Total Exposure | Population |
|---|---|---|---|---|---|---|
| Buffalo | Com Vacant Land | 1 | $19,406 | $19,406 | $38,812 | -- |
| | Res Vacant Land | 20 | $1,075,566 | $537,783 | $1,613,349 | -- |
| | Residential | 92 | $25,413,603 | $12,706,802 | $38,120,405 | 213 |
| | **Total** | **113** | **$26,508,575** | **$13,263,991** | **$39,772,566** | **213** |
| Unincorporated | Agricultural | 159 | $13,103,332 | $13,103,332 | $26,206,664 | -- |
| | Commercial | 18 | $4,667,460 | $4,667,460 | $9,334,920 | -- |
| | Industrial | 1 | $2,529 | $2,529 | $5,058 | -- |
| | Mobile Home | 3 | $310,794 | $155,397 | $466,191 | 7 |
| | Res Vacant Land | 178 | $15,401,942 | $7,700,971 | $23,102,913 | -- |
| | Residential | 404 | $90,948,543 | $45,474,272 | $136,422,815 | 937 |
| | **Total** | **763** | **$124,434,600** | **$71,103,961** | **$195,538,561** | **944** |
| | **GRAND TOTAL** | **876** | **$150,943,175** | **$84,367,951** | **$235,311,126** | **1,158** |

### *Sheridan County*

According to the Redzone and parcel data analysis, Sheridan County's losses were determined to amount to the values specified in Table 4-81 below:

**Table 4-81 Sheridan County General Building and Population Exposure within the Redzone**

| Jurisdiction | Property Type | Parcel Count | Improved Value | Est. Content Value | Total Exposure | Population |
|---|---|---|---|---|---|---|
| Sheridan | Commercial | 7 | $7,269,885 | $7,269,885 | $14,539,770 | -- |
| | Residential | 44 | $8,363,145 | $4,181,573 | $12,544,718 | 100 |
| | **Total** | **51** | **$15,633,030** | **$11,451,458** | **$27,084,488** | **100** |
| Unincorporated | Agricultural | 114 | $25,115,092 | $25,115,092 | $50,230,184 | -- |
| | Commercial | 19 | $3,263,577 | $3,263,577 | $6,527,154 | -- |
| | Exempt | 1 | $121,115 | $121,115 | $242,230 | -- |
| | Res Vacant Land | 1 | $4,553 | $2,277 | $6,830 | -- |
| | Residential | 646 | $129,902,103 | $64,951,052 | $194,853,155 | 1,473 |
| | **Total** | **781** | **$158,406,440** | **$93,453,112** | **$251,859,552** | **1,473** |

| | | | | | |
|---|---|---|---|---|---|
| **GRAND TOTAL** | **832** | **$174,039,470** | **$104,904,570** | **$278,944,040** | **1,573** |

***Weston County***

Weston County's losses were calculated to amount to the following:

**Table 4-82 Weston County General Building and Population Exposure within the Redzone**

| Jurisdiction | Property Type | Parcel Count | Improved Value | Est. Content Value | Total Exposure | Population |
|---|---|---|---|---|---|---|
| Newcastle | Com Vacant Land | 2 | $55,000 | $55,000 | $110,000 | -- |
| | Commercial | 11 | $440,716 | $440,716 | $881,432 | -- |
| | Multiple Unit | 1 | $13,743 | $13,743 | $27,486 | -- |
| | Res Vacant Land | 16 | $357,333 | $178,667 | $536,000 | -- |
| | Residential | 96 | $3,109,156 | $1,554,578 | $4,663,734 | 209 |
| | **Total** | **126** | **$3,975,948** | **$2,242,704** | **$6,218,652** | **209** |
| Unincorporated | Agricultural | 155 | $3,323,722 | $3,323,722 | $6,647,444 | -- |
| | Com Vacant Land | 14 | $229,275 | $229,275 | $458,550 | -- |
| | Commercial | 22 | $689,594 | $689,594 | $1,379,188 | -- |
| | Industrial | 3 | $248,940 | $248,940 | $497,880 | -- |
| | Multiple Unit | 1 | $1,698 | $1,698 | $3,396 | -- |
| | Res Vacant Land | 242 | $7,513,367 | $3,756,684 | $11,270,051 | -- |
| | Residential | 355 | $15,472,634 | $7,736,317 | $23,208,951 | 774 |
| | **Total** | **792** | **$27,479,230** | **$15,986,230** | **$43,465,460** | **774** |
| **GRAND TOTAL** | | **918** | **$31,455,178** | **$18,228,933** | **$49,684,111** | **983** |

Any flammable materials are vulnerable during a wildfire, including structures and personal property. The vulnerability of general property increases as the distance of the property to wildfire-prone areas decreases, and is particularly high for structures located in the WUI. These structures receive an even higher level of vulnerability if the properties surrounding them are not properly mitigated for fire. Appropriate mitigation techniques include using non-flammable materials such as concrete for construction, leaving appropriate spaces between buildings and vegetation areas filled with non-flammable materials (such as decorative rock or stone), and clearing of underbrush and trees.

## Population Exposure

The most exposed populations, as summarized in the tables above, are those living in the wildland-urban interface (WUI) zones, where residential properties are directly intruding into traditional wildland areas. The exposure of the population in these zones increases with the exposure of the corresponding general property. Other exposed (at-risk) population groups include children, the elderly, or those with breathing conditions who may be particularly affected by high levels of smoke.

Population at-risk estimates displayed in the tabulation summaries under the General Property Exposure subsection herein were developed by multiplying the average household size reported in the U.S. Census records in the region (per county) by the number of residential structures within the Redzone. It is important to note that many of these structures may include seasonal homes that could be vacant, although the likelihood of them being occupied during fire season is higher.

### Essential Infrastructure, Facilities, and Other Important Community Assets

To assess critical facilities at risk in the planning area, the inventory of critical and essential facilities and infrastructure was analyzed. Spatial analysis was carried out to determine which facilities would be damaged from wildfires, based on the Redzone hazard layer. Table 4-83 through Table 4-87 provide a summary of the critical facilities within the Redzone hazard zones, by county and jurisdiction.

**Table 4-83 Campbell County Critical Facility Exposure within the Redzone**

| Jurisdiction | Facility Type | Facility Count |
|---|---|---|
| Gillette | FM Transmission Towers | 3 |
| | Microwave Service Towers | 10 |
| Wright | Microwave Service Towers | 2 |
| Campbell County (Unincorporated) | Electric Substations | 4 |
| | EMS Stations | 1 |
| | Fire Stations | 2 |
| | FM Transmission Towers | 6 |
| | Microwave Service Towers | 21 |
| | Paging Transmission Towers | 2 |
| | TV Analog Station Transmitters | 1 |
| | Wastewater Treatment | 1 |
| **TOTAL** | | **53** |

**Table 4-84 Crook County Critical Facility Exposure within the Redzone**

| Jurisdiction | Facility Type | Facility Count |
|---|---|---|
| Pine Haven | EMS Stations | 1 |
| | Fire Stations | 1 |
| | Microwave Service Towers | 2 |
| Sundance | Hospitals | 1 |
| | Nursing Homes | 1 |
| Crook County (Unincorporated) | Cellular Towers | 3 |
| | Electric Substations | 1 |
| | Microwave Service Towers | 14 |
| | TV Analog Station Transmitters | 1 |
| **TOTAL** | | **25** |

**Table 4-85 Johnson County Critical Facility Exposure within the Redzone**

| Jurisdiction | Facility Type | Facility Count |
|---|---|---|
| Johnson County (Unincorporated) | Electric Substations | 2 |
| | Microwave Service Towers | 2 |
| **TOTAL** | | **4** |

**Table 4-86 Sheridan County Critical Facility Exposure within the Redzone**

| Jurisdiction | Facility Type | Facility Count |
|---|---|---|
| City of Sheridan | EMS Stations | 1 |
| Sheridan County (Unincorporated) | Cellular Towers | 1 |
| | Electric Substations | 1 |
| | FM Transmission Towers | 3 |
| | Microwave Service Towers | 16 |
| **TOTAL** | | **22** |

**Table 4-87 Weston County Critical Facility Exposure within the Redzone**

| Jurisdiction | Facility Type | Facility Count |
|---|---|---|
| Newcastle | EMS Stations | 2 |
| | Fire Stations | 2 |
| Weston County (Unincorporated) | FM Transmission Towers | 1 |
| | Microwave Service Towers | 2 |
| **TOTAL** | | **7** |

Facilities in the region such as those summarized in the tables above may be exposed directly or indirectly to wildfire. Direct exposures are similar to those of General Property and increase as the infrastructure or facilities and capabilities move into the WUI zones. Communication infrastructure and lines passing through susceptible areas such as forests are more exposed than those located in cities and more urbanized areas. The indirect vulnerability of response capabilities increases seasonally and with the number of occurrences. Though the populations making up the response capability systems are not directly exposed to all fire events, the response of some of the personnel to an event lessens the capabilities overall for responses to other emergency situations. If there is a large increase in the number of simultaneous wildland fires, even small ones, the response capability of the Region could easily be compromised.

Table 4-88 Summary of Region 1 Critical Facilities within the Redzone, by County

| County | Facility Type | Facility Count |
|---|---|---|
| Campbell | Communications | 45 |
| | EMS Station | 1 |
| | Fire Station | 2 |
| | Power | 4 |
| | Wastewater Treatment | 1 |
| | **TOTAL** | **53** |
| Crook | Communications | 20 |
| | EMS Station | 1 |
| | Fire Station | 1 |
| | Hospitals | 1 |
| | Nursing Homes | 1 |
| | Power | 1 |
| | **TOTAL** | **25** |
| Johnson | Communications | 4 |
| | **TOTAL** | **4** |
| Sheridan | Communications | 20 |
| | EMS Station | 1 |
| | Power | 1 |
| | **TOTAL** | **22** |
| Weston | Communications | 3 |
| | EMS Station | 2 |
| | Fire Station | 2 |
| | **TOTAL** | **7** |
| **GRAND TOTAL** | | **111** |

### *Natural, Historic and Cultural Resources*

A percentage of the Region includes National Forest, which contains many natural and cultural resources potentially at risk. Wildfires can often lead to contamination of drinking water, both at the surface level and in wells. Wildfires in the national forests may also have a regional impact on summer tourism and other economic sectors.

Wildfire can have negative impacts where significant areas of sagebrush are burned within crucial mule deer winter range and sage-grouse breeding and winter habitats, for example. Nevertheless, natural resources and spaces can actually benefit from wildland fire, to encourage a healthy ecological redevelopment of areas impacted by pests or other such deterrents to the environment's native species growth.

Historic and cultural resources exhibit a vulnerability rating similar to those in general property, however, where vulnerability ratings increase the closer into the WUI the property is, and the less mitigated the landscaping surrounding the property is. In addition, older buildings may be exempt from internal fire mitigation such as sprinklers and fire suppression technology, which may increase the vulnerability of the resource. Examples of buildings of this exempt nature may include historic buildings in downtown and tourist areas, such as museums or restaurants.

### Future Development

The wildland/urban interface (WUI) is a very popular building location, as shown by national and statewide trends. More and more homes are being built in the interface. Overall, Wyoming has less developed WUI than most western states. Throughout Wyoming there remains potential for future home construction in undeveloped, forested private lands adjacent to fire-prone public lands. Building homes in these high-risk areas would put lives and property in the path of wildfires. Regulating growth in these areas will be a delicate balance between protecting private property rights and promoting public safety. Should the region begin to experience this type of WUI growth, local government may wish to consider: regulation of subdivision entrance/exit roads and bridges for the safety of property owners and fire personnel; building considerations pertaining to land on slopes greater than 25% (in consideration of access for fire protection of structures); and water supply requirements set forth to include ponds, access by fire apparatus, pumps, and backup generators. Such standards serve to protect residents and property, as well as emergency services personnel and government/public resources.

### Summary

Wildfires occur within the region on an annual basis. Based on GIS analysis of the Redzone and property values, the Region has over $1 billion in building value potentially at risk to wildland fires. Though it is not likely that the areas at risk will simultaneously face a completely destructive event, this figure provides the upper end of what could be affected. Overall, wildfire is a **high** significance hazard to the Region. Overall county ratings are noted in the table below.

**Table 4-89 Wildfire Hazard Risk Summary**

| County | Geographic Extent | Probability of Future Occurrence | Potential Magnitude/ Severity | Overall Significance |
|---|---|---|---|---|
| Campbell | Significant | Highly Likely | Critical | High |
| Crook | Significant | Highly Likely | Critical | High |
| Johnson | Significant | Highly Likely | Critical | High |
| Sheridan | Significant | Highly Likely | Critical | High |
| Weston | Significant | Highly Likely | Critical | High |

# CHAPTER 5 MITIGATION STRATEGY

**Requirement §201.6(c)(3): [The plan shall include] a mitigation strategy that provides the jurisdiction's blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs and resources, and its ability to expand on and improve these existing tools.**

## 5.1 Mitigation Strategy: Overview

This section describes the mitigation strategy and mitigation action plan for the Region 1 Hazard Mitigation Plan. It describes how the participating jurisdictions in the Region met the following requirements from the 10-step planning process:

- Planning Step 6: Set Goals
- Planning Step 7: Review Possible Activities
- Planning Step 8: Draft an Action Plan

The results of the planning process, the risk assessment, the goal setting, the identification of mitigation actions, and the work of each county's HMPC led to this mitigation strategy and action plan. Section 5.2 below identifies the goals of this plan, Section 5.3 describes how action items were identified and prioritized, and Section 5.4 describes the mitigation action plan.

## 5.2 Goals and Objectives

**Requirement §201.6(c)(3)(i): [The hazard mitigation strategy shall include a] description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.**

Up to this point in the planning process, each county's HMPC had organized resources, assessed hazards and risks, and documented mitigation capabilities. The resulting goals and mitigation actions were developed and updated based on these tasks. During the 2018 development of this plan, each county HMPC held a series of meetings designed to achieve a collaborative mitigation strategy as described further throughout this section.

During the first set of planning workshops held in 2018, the counties reviewed the results of the hazard identification and vulnerability assessment, capability assessment and goals from previous county-level hazard mitigation plans as well as the State of Wyoming Multi-Hazard Mitigation Plan (2016). This analysis of the risk assessment identified areas where improvements could be made, and provided the framework for the counties to update (or formulate, in the case of Weston County) planning goals, and develop new or updated mitigation strategies.

Goals were defined for the purpose of this mitigation plan as broad-based public policy statements that:

- Represent basic desires of the community;
- Encompass all aspects of community, public and private;
- Are nonspecific, in that they refer to the quality (not the quantity) of the outcome;
- Are future-oriented, in that they are achievable in the future; and
- Are time-independent, in that they are not scheduled events.

Goals are stated without regard to implementation. The cost of implementation, schedule, and means are not considered. Goals are defined before considering how to accomplish them so that they are not dependent on the means of achievement. Goal statements form the basis for objectives and actions that will be used to achieve the goals. Objectives are more specific and measurable than goals, and are used to define strategies to attain those goals. Objectives are sometimes developed in mitigation planning as an intermediate step between goals and mitigation actions or projects.

The update or development of goals for the counties in the region was initiated through a facilitated discussion at the first planning workshops held in 2018 (Hazard Risk Assessment and Goals Workshop). The HMPC members were provided a PowerPoint presentation that explained goals, objectives and actions, and provided examples of each. Existing plan goals (including sharing the goals from the previous hazard mitigation plans for Campbell, Crook, Johnson and Sheridan counties) and related plan goals were noted in the PowerPoint, including the State of Wyoming Multi-Hazard Mitigation Plan (2016). This review ensured that the Regional Plan's mitigation goals were aligned and integrated with existing plans and policies.

Based on the risk assessment update and the goals development or update process, each county identified, updated or developed specific goals which provide the direction for reducing future hazard-related losses within each county and the regional planning area. During the 2018 Regional Plan development process, Crook, Johnson, and Sheridan counties made minor language modifications to their goals. Weston County developed new goals since this was the first official plan of its nature for the county. Campbell County's six goals and multiple objectives did not change during the planning process. Several of the counties in the region incorporated Campbell County's Goal 2, *Increase the resilience of citizens by embracing their personal responsibility to be prepared and involved through education and volunteering.* Weston County developed goals similar to Campbell County's goals and objectives with the exception of Goal 5, which was incorporated into Goal 2 as an objective.

The Crook County HMPC determined only minor language modifications were necessary to update their goals. It was decided the word "natural" should be removed from their goals to be more inclusive of manmade hazards. The Sheridan County HMPC made similar minor language changes to their goals, while keeping the intent of each goal.

The Johnson County HMPC reviewed the existing goals of the County Hazard Mitigation plan; they determined the number of goals and objectives should remain the same, and the intent of Goal

1 and Goal 2 should not change. The committee determined Goal 3 should be expanded to include both public and private owned facilities as well private infrastructure.

The updated goals and objectives for each county in the Region are noted below and in each county annex.

**<u>Campbell County Goals and Objectives</u>**

**Goal 1: Reduce the impact of severe weather on people, property, or natural resources.**

Objective 1.1: Improve severe weather detection and tracking capabilities.

Objective 1.2: Improve warning and communication capabilities.

Objective 1.3: Provide public education on personal preparation and appropriate response to severe weather events.

Objective 1.4: Promote appropriate shelter during severe weather.

Objective 1.5: Increase the local capacity to deal with psychological effects of emergency and disaster events.

Objective 1.6: Reduce Flood Damage.

**Goal 2: Increase the resilience of citizens by embracing their personal responsibility to be prepared and involved through education and volunteering.**

Objective 2.1: Determine the need for volunteers and training.

Objective 2.2: Provide training and public education opportunities.

**Goal 3: Maintain the reliability and resilience of critical infrastructure.**

Objective 3.1: Work to harden critical public infrastructure.

Objective 3.2: Provide for continuity of both governmental and private sector functions.

Objective 3.3: Provide for continuity of public sector GIS data/information function.

**Goal 4: Reduce the impact of human-caused incidents, emergencies or disasters.**

Objective 4.1: Prepare the public to minimize the impact of hazardous material incidents.

Objective 4.2: Reduce the impact of terrorism within the jurisdictions.

Objective 4.3: Reduce the impact of incidents, emergencies and disasters on our Special Needs populations.

**Goal 5: Reduce loss of life and property from fire.**

Objective 5.1: Reduce the potential for fire in future developments.

**Goal 6: Increase resilience through coordination of governmental policies, procedures, codes and regulations.**

Objective 6.1: Review current planning documents and their ability to protect the public from natural and human-caused incidents, emergencies and disasters.

Objective 6.2: Educate the public and contractors about the relationship between construction techniques and potential for disasters.

**Crook County Goals**

**Goal 1: Mitigate hazards to reduce the potential for property loss or damage, injury and loss of life in the Town of Hulett.**

**Goal 2: Mitigate hazards to reduce the potential for property loss or damage, injury and loss of life in the Town of Moorcroft.**

**Goal 3: Mitigate hazards to reduce the potential for property loss or damage, injury and loss of life in the Town of Pine Haven.**

**Goal 4: Mitigate hazards to reduce the potential for property loss or damage, injury and loss of life in the City of Sundance.**

**Goal 5: Mitigate hazards to reduce the potential for property loss or damage, injury and loss of life in Crook County.**

**Goal 6: Increase the resilience of citizens by embracing their personal responsibility to be prepared and involved through education and volunteering**

**Johnson County Goals and Objectives**

**Goal 1: To protect life and property from hazards**

Objective 1.1: To minimize loss of life and damage to property due to flooding in the Middle Fork of Powder River through the Town of Kaycee.

Objective 1.2: To minimize loss of life and damage to property due to wildland fire throughout the county.

Objective 1.3: To minimize the potential for loss of life and damage to property by reducing the potential for accidental or intentional release of hazardous materials.

Objective 1.4: To minimize the potential for loss of life and damage to property by being prepared to shelter travelers and residents during and after severe weather events.

Objective 1.5: To minimize the potential for loss of life and damage to property through an early warning system.

Objective 1.6: To minimize the potential for loss of life and damage to property by facilitating training of the Incident Command System (ICS) including and Emergency Operations Center.

Objective 1.7: To minimize the potential for loss of life and damage to property due to flooding of Clear Creek through the City of Buffalo.

Objective 1.8: To minimize the potential for loss of life and damage to property due to landslides.

**Goal 2: To increase public awareness and education about hazards.**

Objective 2.1: Provide resources for outreach and education programs to increase public and governmental awareness of risks associated with the identified hazards.

Objective 2.2: Provide information and education to the local city and county planning departments regarding the identified hazards, risks, and vulnerabilities within the county.

Objective 2.3: Provide education and assistance to rural areas about fire protection and fire safety.

**Goal 3: The strengthen and improve disaster resistance of publicly and privately owned facilities and infrastructure.**

Objective 3.1: To update facilities' capability to withstand identified hazards and risks.

Objective 3.2: To improve mapping of publicly-owned facilities.

Objective 3.3: To enhance mitigation project management.

## Sheridan County Goals and Objectives

**Goal 1: Mitigate the effect of hazards through education, ordinances, resolutions, and clear definition, and implementation of mitigation projects to reduce the loss of property and enhance life-safety.**

**Goal 2: Coordinate mitigation activities with all entities and stakeholders of Sheridan County to assess the hazards and take various actions to reduce or eliminate the risk factors of those hazards.**

**Goal 3: Reduce the economic impact on the local economy caused by the effects of hazards in the communities.**

**Goal 4: Increase the resilience of citizens by embracing their personal responsibility to be prepared and involved through education and volunteering.**

**Weston County Goals and Objectives**

**Goal 1: Reduce the impact of severe weather on people, property, or natural resources.**

Objective 1.1: Improve severe weather detection and tracking capabilities.

Objective 1.2: Improve warning and communication capabilities.

Objective 1.3: Provide public education on personal preparation and appropriate response to severe weather events.

Objective 1.4: Promote appropriate shelter during severe weather.

Objective 1.5: Increase the local capacity to deal with psychological effects of emergency and disaster events.

Objective 1.6: Reduce Flood Damage.

**Goal 2: Increase the resilience of citizens by embracing their personal responsibility to be prepared and involved through education and volunteering.**

Objective 2.1: Determine the need for volunteers and training.

Objective 2.2: Provide training and public education opportunities.

Objective 2.3: Reduce the potential for fire in future developments.

**Goal 3: Maintain the reliability and resilience of critical infrastructure.**

Objective 3.1: Work to harden critical public infrastructure.

Objective 3.2: Provide for continuity of both governmental and private sector functions.

Objective 3.3: Provide for continuity of public sector GIS data/information function.

**Goal 4: Reduce the impact of human-caused incidents, emergencies or disasters.**

Objective 4.1: Prepare the public to minimize the impact of hazardous material incidents.

Objective 4.2: Reduce the impact of terrorism within the jurisdictions.

Objective 4.3: Reduce the impact of incidents, emergencies and disasters on our Special Needs populations.

**Goal 5: Increase resilience through coordination of governmental policies, procedures, codes and regulations.**

Objective 5.1: Review current planning documents and their ability to protect the public from natural and human-caused incidents, emergencies and disasters.

Objective 5.2: Educate the public and contractors about the relationship between construction techniques and potential for disasters

# 5.3 Identification and Analysis of Mitigation Actions

**Requirement §201.6(c)(3)(ii): [The mitigation strategy shall include a] section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure.**

The next step in the mitigation strategy is to identify and analyze a comprehensive range of specific mitigation actions and projects to reduce the effects of each hazard on new and existing buildings and infrastructure. During the 2018 Regional Plan development, each county HMPC analyzed viable mitigation options by hazard that supported the identified goals. The HMPCs were provided with the following list of categories of mitigation actions, which come from the Community Rating System:

- **Plans and regulations (prevention)**: Administrative or regulatory actions or processes that influence the way land and buildings are developed and built.
- **Property protection**: Actions that involve the modification of existing buildings or structures to protect them from a hazard or remove them from the hazard area.
- **Structural and infrastructure projects**: Actions that involve the construction of structures to reduce the impact of a hazard.
- **Natural resource protection**: Actions that, in addition to minimizing hazard losses, also preserve or restore the functions of natural systems.
- **Public information/education and awareness:** Actions to inform and educate citizens, elected officials, and property owners about the hazards and potential ways to mitigate them.
- **Emergency services**: Actions that protect people and property during and immediately after a disaster or hazard event.

In order to identify and select mitigation actions to support the mitigation goals, each hazard identified and profiled in Chapter 4 was evaluated. At the mitigation strategy workshops the counties were also provided a matrix showing examples of potential mitigation action alternatives from each of the above categories for each of the identified hazards. The counties were also provided a handout that explains the categories and provided further examples. Finally, another reference document titled "Mitigation Ideas" developed by FEMA was made available. This document lists several common alternatives or best practices for mitigation by hazard. The counties were asked to consider both future and existing buildings in considering possible mitigation actions. A facilitated discussion then took place to examine and analyze the options. Appendix A provides the matrix of alternatives considered. Each proposed action was written on a large sticky note and posted on flip charts in the meeting rooms underneath the hazard it addressed. The result was several new project ideas intended to reduce the impacts of the identified hazards.

The mitigation strategy is based on existing local authorities, policies, programs, and resources, as well as the ability to expand on and improve these existing tools. As part of the Regional Plan development, the county planning teams reviewed existing capabilities for reducing long-term vulnerability to hazards. Those capabilities are noted by jurisdiction in the county annexes, and can be assessed to identify gaps to be addressed and strengths to enhance through new mitigation actions. For instance, gaps in design or enforcement of existing regulations can be addressed through additional personnel or a change in procedure or policy.

Based upon the capability assessment and key issues identified in the risk assessment, the counties came to consensus on proposed mitigation actions for each hazard for their jurisdictions. Certain hazards' impacts were best reduced through multi-hazard actions. A lead for each new action was identified to provide additional details on the project in order to be captured in the plan. Final action strategies are discussed in Section 5.4 and detailed within the respective annexes.

## 5.3.1 Prioritization Process

Once the mitigation actions were identified, the county planning teams were provided FEMA's recommended prioritization criteria, STAPLEE, to assist in deciding why one recommended action might be more important, more effective, or more likely to be implemented than another. STAPLEE is an acronym for the following:

- Social: Does the measure treat people fairly (e.g., different groups, different generations)?
- Technical: Is the action technically feasible? Does it solve the problem?
- Administrative: Are there adequate staffing, funding, and other capabilities to implement the project?
- Political: Who are the stakeholders? Will there be adequate political and public support for the project?
- Legal: Does the jurisdiction have the legal authority to implement the action? Is it legal?

- Economic: Is the action cost-beneficial? Is there funding available? Will the action contribute to the local economy?
- Environmental: Does the action comply with environmental regulations? Will there be negative environmental consequences from the action?

Other criteria used to evaluate the priority of a mitigation action included:

- Does the action address hazards or areas with the highest risk?
- Does the action protect lives?
- Does the action protect infrastructure, community assets or critical facilities?
- Does the action meet multiple objectives (Multiple Objective Management)?

At the mitigation strategy workshops, the counties used STAPLEE to determine which of the new identified actions were most likely to be implemented and effective. Keeping the STAPLEE criteria in mind, each member voted for the new mitigation actions by sticking a colored dot on the sticky note on which the action was written. The number of dots next to each action was totaled as an indication of relative priority and translated into either high, medium, or low priority. The results of the STAPLEE evaluation process produced prioritized mitigation actions for implementation within the planning area.

The process of identification and analysis of mitigation alternatives allowed the county planning teams to come to a consensus and to prioritize recommended mitigation actions for their jurisdictions. During the voting process, emphasis was placed on the importance of a benefit-cost review in determining project priority, as this is a requirement of the Disaster Mitigation Act regulations. However, this was a planning level analysis as opposed to a quantitative analysis. A quantitative cost-benefit analysis will be considered in additional detail when seeking FEMA mitigation grant funding for eligible projects identified in this plan.

Each mitigation action developed for this plan contains a brief description of the problem and proposed project, the entity with primary responsibility for implementation, a cost estimate, and a schedule for implementation; see the County Annexes for details. Development of these project details further informed the determination of a high, medium, or low priority for each.

For the mitigation actions carried forward from the existing Campbell, Sheridan, Johnson and Crook County hazard mitigation plans, priority levels were revisited and in some cases modified to reflect current priorities based on the STAPLEE principles.

## 5.4 Mitigation Action Plan

**Requirement §201.6(c)(3)(iii): [The mitigation strategy section shall include] an action plan describing how the actions identified in section (c)(3)(ii) will be prioritized, implemented, and administered by the local jurisdiction. Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.**

This section outlines the development of the mitigation action plan. The action plan consists of the specific projects, or actions, designed to meet the identified goals within the plan. Over time the implementation of these projects will be tracked as a measure of demonstrated progress on meeting the plan's goals.

### 5.4.1 Progress on Previous Mitigation Actions

This Regional Plan represents a plan update for Campbell, Johnson, Crook and Sheridan counties. The mitigation actions in these counties' plans provided the basis for the updates of mitigation action strategies. As part of the update process, the four counties with existing plans reviewed the previously identified actions to assess progress on implementation. These reviews were completed using worksheets to capture information on each action, including if the action had been completed or was to be deferred for future implementation. Actions that had not been completed were discussed for continued relevance, and were either continued in the Plan or in some cases recommended for deletion.

The counties and their participating jurisdictions have been successful in implementing actions identified in their respective plans' Mitigation Strategies, to work steadily towards meeting each plan's goals. Progress on mitigation actions previously identified in these planning mechanisms are detailed in the mitigation action strategy in the county annexes. These action plans were also shared among the regional plan participants to showcase progress and stimulate ideas among the respective county planning committees. Both Sheridan and Johnson counties have received mitigation grant funding from FEMA to implement projects identified in their mitigation plans. Reasons that some actions have not been completed include low priority, lack of funding, or lack of administrative resources. Refer to the county annexes for more details on progress on implementation.

This Regional Plan represents the first mitigation plan for Weston County. As such, this planning process was an opportunity for the HMPC, the public and other stakeholders to identify and discuss potential mitigation actions that will benefit both the incorporated and unincorporated jurisdictions through the reduction of potential risks and vulnerabilities. The discussion on potential mitigation actions began with the HMPC reviewing the results from the public survey, and actions from existing hazard mitigation plans of other counties in the Region. In total 12 mitigation actions related to various hazards were developed. Refer to the Weston County Annex for more details on the County's mitigation action plan.

## 5.4.2 Continued Compliance with NFIP

Given the significance of the flood hazard in the planning area and the importance of floodplain management and insurance as loss reduction measures, an emphasis will be placed on continued compliance with the National Flood Insurance Program (NFIP). Continued compliance with the NFIP is also required by the DMA. Counties and jurisdictions that participate in the NFIP will continue to make every effort to remain in good standing with the program. The table below summarizes the NFIP mapping and participation status for applicable jurisdictions in the Region.

**Table 5-1 NFIP Participation Status Summary**

| Jurisdiction | Effective Map Status | Date Joined | Comments |
|---|---|---|---|
| **Campbell County** | 01/02/08 | 05/15/84 | |
| City of Gillette | 01/02/08 | 05/15/78 | |
| Town of Wright | 01/2/08 | 01/2/08 | Participation optional due to No Special Flood Hazard Area (NSFHA) |
| **Crook County** | Not mapped | | Participation optional due to no mapping |
| Town of Hulett | 09/28/07 | 04/01/99 | |
| Town of Moorcroft | 02/02/07 | 03/01/86 | |
| Town of Pine Haven | Not mapped | Not mapped | Participation optional due to no mapping |
| Town of Sundance | 02/02/07 | 08/19/86 | |
| **Johnson County** | NSFHA | 07/21/98 | |
| City of Buffalo | 04/03/84 | 05/15/78 | |
| Town of Kaycee | 02/20/08 | 10/01/86 | |
| **Sheridan County** | 01/16/14 | 08/01/86 | |
| Town of Clearmont | 01/16/14 | 02/10/14 | |
| Town of Dayton | 01/16/14 | 08/1/08 | No elevation determined – all zone A, C, X |
| Town of Ranchester | 01/16/14 | 04/15/88 | |
| City of Sheridan | 01/16/14 | 09/01/78 | |
| **Weston County** | Not mapped | | Participation optional due to no mapping |
| City of Newcastle | 04/2/02 | 05/01/86 | |
| Town of Upton | 06/25/76 | | Sanctioned since 06/25/77 |

Source: NFIP Community Status Book

Weston County and Crook County are not mapped, and are therefore not required to participate in the NFIP, but they are exploring possible participation in the future. The Town of Upton in Weston County is mapped, but was sanctioned from the program in 1977 and does not currently participate NFIP; as a result, residents are unable to receive federal flood insurance. See the Weston County Annex for further discussion.

Continued compliance with the NFIP includes continuing to adopt floodplain maps when updated, and implementing, maintaining, and updating floodplain ordinances. Actions related to continued compliance include:

- Continued designation of a local floodplain manager, whose responsibilities include reviewing floodplain development permits to ensure compliance with local floodplain management ordinances and rules;
- Suggest changes to improve enforcement of and compliance with regulations and programs;
- Participate in Flood Insurance Rate Map updates by adopting new maps or amendments to maps;
- Utilize Digital Flood Insurance Rate maps in conjunction with GIS to improve floodplain management, such as improved risk assessment and tracking of floodplain permits;
- Promote and disperse information on the benefits of flood insurance.

Also to be considered are the flood mitigation actions contained in this Regional Plan that support the ongoing efforts by participating counties to minimize the risk and vulnerability of the community to the flood hazard, and to enhance their overall floodplain management program.

### 5.4.3 Mitigation Action Plan

The action plan presents the recommendations developed by the county planning teams, outlining how each county and the Region can reduce the risk and vulnerability of people, property, infrastructure, and natural and cultural resources to future disaster losses. The mitigation actions developed by the counties are detailed in the county annexes. These details include the action description, hazard(s) mitigated, lead and partner agencies responsible for initiating implementation, costs, and timeline. Many of the action items included in this plan are a collaborative effort among local, state, and federal agencies and stakeholders in the planning area.

The actions included in this mitigation strategy are subject to further review and refinement, alternatives analyses, and reprioritization due to changes in funding availability and/or other criteria. The counties are not obligated by this document to implement any or all of these projects. Rather, this mitigation strategy represents the desires of the community to mitigate the risks and vulnerabilities from identified hazards. The counties also realize that new needs and priorities may arise because of a disaster or other circumstances, and reserve the right to support new actions, as necessary, as long as they conform to their overall goals as listed in this plan.

Where feasible it is recommended that mitigation be integrated and implemented through existing planning mechanisms. Specific related mechanisms such as Community Wildfire Protection Plans, are discussed in the county annexes.  Chapter 6 also discusses incorporating the plan into existing planning mechanisms and how to ensure continued public involvement.

# CHAPTER 6 PLAN ADOPTION, IMPLEMENTATION AND MAINTENANCE

**Requirement §201.6(c)(4): [The plan maintenance process shall include a] section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.**

**Requirement §201.6(c)(5): [The local hazard mitigation plan shall include] documentation that the plan has been formally approved by the governing body of the jurisdiction requesting approval of the plan (e.g., City Council, county commissioner, Tribal Council).**

Implementation and maintenance of the plan is critical to the overall success of hazard mitigation planning. This is Planning Step 10 of the 10-step planning process. This chapter provides an overview of the overall strategy for plan implementation and maintenance and outlines the method and schedule for monitoring, updating, and evaluating the regional plan. The chapter also discusses incorporating the plan into existing planning mechanisms and how to address continued public involvement.

## 6.1 Formal Adoption

The purpose of formally adopting this plan is to secure buy-in from participating jurisdictions, raise awareness of the plan, and formalize the plan's implementation. The adoption of this plan completes Planning Step 9 of the 10-step planning process: Adopt the Plan. The governing board for each participating jurisdiction has adopted this local hazard mitigation plan by passing a resolution. A copy of the generic resolution and the executed copies are included in Appendix B, Plan Adoption. This plan will be updated and re-adopted every five years in concurrence with the required DMA local plan update requirements.

## 6.2 Implementation

Once adopted, the plan faces the truest test of its worth: continued implementation. While this plan contains many worthwhile actions, each county and jurisdiction will need to decide which action(s) to undertake or continue. Two factors will help with making that decision: the priority assigned the actions in the planning process and funding availability. Low or no-cost actions most easily demonstrate progress toward successful plan implementation.

Mitigation is most successful when it is incorporated into the day-to-day functions and priorities of government and development. Implementation will be accomplished by adhering to the schedules identified for each action and through constant, pervasive, and energetic efforts to network and highlight the benefits to the counties, communities and stakeholders. This effort is achieved through the routine actions of monitoring meeting agendas for hazard mitigation related initiatives, coordinating on the topic at meetings, and promoting a safe, sustainable community. Additional mitigation strategies could include consistent and ongoing enforcement of existing policies and vigilant review of programs for coordination and multi-objective opportunities.

Simultaneous to these efforts, it is important to maintain a constant monitoring of funding opportunities that can be leveraged to implement some of the more costly recommended actions. This will include creating and maintaining a bank of ideas on how to meet local match or participation requirements. When funding does become available, the Region and its counties will be in a position to capitalize on the opportunity. Funding opportunities to be monitored include special pre- and post-disaster funds, state and federal earmarked funds, benefit assessments, and other grant programs, including those that can serve or support multi-objective applications.

### 6.2.1 Role of Hazard Mitigation Planning Committee in Implementation and Maintenance

With adoption of this plan, the Region, its counties, and participating municipalities will be responsible for the plan implementation and maintenance. Each county, led by their Emergency Management Coordinators, will reconvene their HMPC for plan implementation and maintenance. These HMPCs will be the same committees (in form and function, if not actual individuals) that developed this plan, and will also be responsible for the next formal update to the plan in five years.

The county-level HMPCs will:

- Act as a forum for hazard mitigation issues;
- Disseminate hazard mitigation ideas and activities to all participants;
- Pursue the implementation of high-priority, low/no-cost recommended actions;
- Ensure hazard mitigation remains a consideration for community decision makers;
- Maintain a vigilant monitoring of multi-objective cost-share opportunities to help the community implement the plan’s recommended actions for which no current funding exists;
- Monitor and assist in implementation and update of this plan;
- Report on plan progress and recommended changes to county and municipal officials; and
- Inform and solicit input from the public.

Each HMPC will not have any powers over respective county staff; it will be purely an advisory body. The primary duty is to see the plan successfully carried out and to report to the county commissioners, municipal boards, and the public on the status of plan implementation and mitigation opportunities. Other duties include reviewing and promoting mitigation proposals, considering stakeholder concerns about hazard mitigation, passing concerns on to appropriate entities, and posting relevant information on county websites (and others as appropriate).

# 6.3 Plan Maintenance

The Plan maintenance process lays out a framework to monitor and evaluate plan implementation and to update the plan as progress, roadblocks, or changing circumstances are recognized. The regulation at 44 CFR§201.6(d)(3) requires that a local jurisdiction must review and revise its plan to reflect changes in development, progress in local mitigation efforts, and changes in priorities, and resubmit it for approval within five (5) years in order to continue to be eligible for mitigation project grant funding.

## 6.3.1 Maintenance Schedule

The Emergency Management Coordinators are responsible for initiating plan reviews and consulting with the heads of participating departments in their own counties. In order to monitor progress and update the mitigation strategies identified in the action plan, each county and their standing HMPC will conduct an annual review of this plan and/or following a hazard event. An annual mitigation action progress report will be prepared by the Emergency Management Coordinators based on the HMPC input and kept on file to assist with for future updates. The annual review will be conducted by re-convening each HMPC in November of each year.

This plan will be updated, approved and adopted within a five-year cycle as per Requirement §201.6(c)(4)(i) of the Disaster Mitigation Act of 2000 unless disaster or other circumstances (e.g., changing regulations) require a change to this schedule. The Region and its counties will inquire with WOHS and FEMA for funds to assist with the update. It is recommended to begin seeking funds in 2020 as most applicable grants have multiple years to expend the funds. Funding sources may include the Emergency Management Performance Grants, Pre- Disaster Mitigation, Hazard Mitigation Grant Program (if a presidential disaster has been declared), and Flood Mitigation Assistance grant funds. The next plan update should be completed and reapproved by WOHS and FEMA Region VIII within five years of the FEMA final approval date. The planning process to prepare the update should begin no later than 12 months prior to that date.

## 6.3.2 Maintenance Evaluation Process

Evaluation of progress can be achieved by monitoring changes in vulnerabilities identified in the plan. Changes in vulnerability can be identified by noting:

- Decreased vulnerability as a result of implementing recommended actions;
- Increased vulnerability as a result of new or altered hazards
- Increased vulnerability as a result of new development.

Updates to this plan will:

- Consider changes in vulnerability due to action implementation;
- Document success stories where mitigation efforts have proven effective;

- Document areas where mitigation actions were not effective;
- Document any new hazards that may arise or were previously overlooked;
- Incorporate new data or studies on hazards and risks;
- Incorporate new capabilities or changes in capabilities;
- Incorporate growth and development-related changes to infrastructure inventories; and
- Incorporate new action recommendations or changes in action prioritization.

In order to best evaluate any changes in vulnerability as a result of plan implementation, each county will adhere to the following process:

- A representative from the responsible office identified in each mitigation measure will be responsible for tracking and reporting on an annual basis to the department lead on action status and provide input on whether the action, as implemented, meets the defined objectives and is likely to be successful in reducing vulnerabilities.
- If the action does not meet identified objectives, the lead will determine what additional measures may be implemented, and an assigned individual will be responsible for defining action scope, implementing the action, monitoring success of the action, and making any required modifications to the plan.

Changes will be made to the plan to accommodate for actions that were not successful or were not considered feasible after a review of their consistency with established criteria, time frame, community priorities, and/or funding resources. Actions that were not ranked high but were identified as potential mitigation activities will be reviewed as well during the monitoring and update of this plan to determine feasibility of future implementation. Updating of the plan will be by written changes and submissions, as each HMPC deems appropriate and necessary, and as approved by the respective participating agencies. In keeping with the five-year update process, the HMPC will convene public meetings to solicit public input on the plan and its routine maintenance and the final product will be adopted by the governing council of each participating jurisdiction.

### 6.3.3 Incorporation into Existing Planning Mechanisms

Another important implementation mechanism that is highly effective and low-cost is incorporation of the hazard mitigation plan recommendations and their underlying principles into other county plans and mechanisms. Where possible, plan participants will use existing plans and/or programs to implement hazard mitigation actions. As described in each county annex capability assessment, the counties already implement policies and programs to reduce losses to life and property from hazards. This plan builds upon the momentum developed through previous and related planning efforts and mitigation programs and recommends implementing actions, where possible, through these other program mechanisms. Where applicable, these existing mechanisms could include:

- County or community comprehensive plans

- County or community land development codes
- County or community emergency operations plans
- Threat and Hazard Identification and Risk Assessments (THIRA)
- Community Wildfire Protection Plans (CWPP)
- Transportation plans
- Capital improvement plans and budgets
- Recovery planning efforts
- Watershed planning efforts
- Wildfire planning efforts on adjacent public lands
- Master planning efforts
- River corridor or greeenway planning efforts
- Other plans, regulations, and practices with a mitigation aspect

The county annexes note, where applicable, how the previous versions of the hazard mitigation plan have been incorporated into existing planning mechanisms in the past 5 years. Each annex notes specific opportunities to integrate the mitigation plan into other mechanisms in the future.

HMPC members involved in these other planning mechanisms will be responsible for integrating the findings and recommendations of this plan with these other plans, programs, etc., as appropriate. As described in Section 6.2 Implementation, incorporation into existing planning mechanisms will be done through the process of:

- Monitoring other planning/program agendas;
- Attending other planning/program meetings;
- Participating in other planning processes;
- Ensuring that the related planning process cross-references the hazard mitigation plan, where appropriate, and
- Monitoring community budget meetings for other community program opportunities.

The successful implementation of this mitigation strategy will require constant and vigilant review of existing plans and programs for coordination and multi-objective opportunities that promote a safe, sustainable community.

Efforts should continuously be made to monitor the progress of mitigation actions implemented through these other planning mechanisms and, where appropriate, their priority actions should be incorporated into updates of this hazard mitigation plan.

## 6.3.4 Continued Public Involvement

Continued public involvement is imperative to the overall success of the plan's implementation. The update process provides an opportunity to solicit participation from new and existing stakeholders and to publicize success stories from the plan implementation and seek additional public comment. The plan maintenance and update process will include continued public and stakeholder involvement and input through attendance at designated committee meetings, web postings, press releases to local media, and through public hearings.

When each HMPC reconvenes for the update, they will coordinate with all stakeholders participating in the planning process—including those that joined the committee since the planning process began—to update and revise the plan. Public notice will be posted and public participation will be invited, at a minimum, through available website postings and press releases to the local media outlets, primarily newspapers, or through public surveys. As part of this effort, at least one public meeting or public survey will be held and public comments will be solicited on the plan update draft.