Wyoming Region 6

Park County

Washakie County

Hot Springs County

Big Horn County

Regional
Hazard Mitigation Plan
DRAFT August 2016

Developed by Washakie, Hot Springs, Park and Big Horn Counties

With professional planning assistance from

Amec Foster Wheeler Environment & Infrastructure, Inc.
Hazard Mitigation and Emergency Management Program

Table of Contents

Chapters

Chapter 1 – Introduction **1.1**
1.1 Purpose 1.1
1.2 Background and Scope 1.1
1.3 Plan Organization 1.2
1.4 Multi-Jurisdtional Planning 1.3

Chapter 2 – Community Profile **2.1**
2.1 Geography and Climate 2.1
2.2 Population 2.3
2.3 Economy 2.3

Chapter 3 – Planning Process **3.1**
3.1 Background on Mitigation Planning in the Region 3.1
3.2 Local Government Participation 3.3
3.3 The 10-Step Planning Process 3.3
3.3.1 Phase 1: Organize Resources 3.5
3.3.2 Phase 2: Assess Risks 3.15
3.3.3 Phase 3: Develop the Mitigation Plan 3.15
3.3.4 Phase 4: Implement the Plan and Monitor Progress 3.16

Chapter 4 –Hazard Analysis and Risk Assessment **4.1**
4.1 Hazard Identification 4.2
4.1.1. Results and Methodology 4.2
4.1.2 Disaster Declaration History 4.4
4.2 Hazard Profiles 4.7
4.2.1 Profile Methodology 4.7
4.2.2 Avalanche 4.9
4.2.3 Dam Failure 4.15
4.2.4 Drought 4.23
4.2.5 Earthquake 4.43
4.2.6 Expansive Soils 4.63
4.2.7 Extreme Cold 4.69
4.2.8 Flood 4.74
4.2.9 Hailstorm 4.90
4.2.10 Hazardous Materials 4.95

4.2.11 High Winds and Downbursts 4.100
4.2.12 Landslide/Rockfall/Debris Flow 4.106
4.2.13 Lightning 4.116
4.2.14 Mine Subsidence 4.121
4.2.15 Tornado 4.125
4.2.16 Severe Winter Weather 4.135
4.2.17 Wildfire 4.140

Chapter 5 – Mitigation Strategy 5.1
5.1 Mitigation Strategy: Overview 5.1
5.2 Goals and Objectives 5.1
5.3 Identification and Analysis of Mitigation Actions 5.4
5.3.1 Prioritization Process 5.5
5.4 Mitigation Action Plan 5.7
5.4.1 Progress on Previous Mitigation Actions 5.7
5.4.2 Continued Compliance with NFIP 5.7
5.4.3 Mitigation Action Plan 5.8

Chapter 6 – Plan Adoption, Implementation, and Maintenance 6.1
6.1 Formal Plan Adoption 6.1
6.2 Implementation 6.1
6.2.1 Role of the Hazard Mitigation Planning Committee in Implementation and Maintenance 6.2
6.3 Maintenance 6.3
6.3.1 Maintenance Schedule 6.3
6.3.2 Maintenance Evaluation Process 6.3
6.3.3 Incorporation into Existing Planning Mechanisms 6.4
6.3.4 Continued Public Involvement 6.5

County Planning Annexes

Washakie County Planning Annex

Hot Springs County Planning Annex

Park County Planning Annex

Big Horn County Planning Annex - 2015 Hazard Mitigation Plan

Appendixes

Appendix A – County Hazard Mitigation Planning Committee Members

Appendix B – Region 6 Landslide Attachment

Appendix C - Planning Process Documentation

Appendix D – Washakie County Flood Chapter Update 2013

Appendix E – Records of Adoption (electronic)

Appendix F – Critical Facility Details (electronic)

EXECUTIVE SUMMARY

This plan is the product of a 2016 planning process undertaken by the four counties in the Big Horn Basin in Wyoming Office of Homeland Security Region 6 – Big Horn, Park, Hot Springs and Washakie. 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 Washakie and Park counties, and serves as a new hazard mitigation plan for Hot Springs County. Big Horn County had updated its hazard mitigation plan in late 2015 and adopted it in 2016, thus it is included in its entirety as an annex to this plan.

The process followed a methodology that adheres to FEMA guidance. It consisted of two levels of planning teams; a coordinating planning team comprised of the County Emergency Management Coordinators, and four local government teams – one in 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: avalanche, dam failure, drought, earthquake, expansive soils, extreme cold, 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 plans for Park, Big Horn and Washakie Counties. 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 ultimately, in the Region.

CHAPTER 1 INTRODUCTION

1.1 Purpose

The counties of Wyoming Region 6 including Big Horn, Hot Springs, Park, and Washakie 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 planning area’s eligibility 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).

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 determined, 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 County and 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 the community and its property owners by protecting critical community facilities, reducing liability exposure, and minimizing overall community impacts and disruption. The planning area has been affected by hazards in the past and is thus committed to reducing future disaster impacts and maintaining eligibility for federal funding.

1.3 Plan Organization

The Wyoming Region 6 Regional Hazard Mitigation Plan is organized in alignment with the DMA planning requirements and the FEMA plan review crosswalk as follows:

- 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 county participating in this plan developed its own annex, which provides a more detailed assessment of the county and respective jurisdiction's unique risks as well as their mitigation strategy to reduce long-term losses. Each county 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 four counties in Wyoming Region 6 (Region), established by the Wyoming Office of Homeland Security (WYOHS); the region includes Big Horn, Hot Springs, Park and Washakie 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 options 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. All of the counties in the Region with the exception of Hot Springs County had county-wide multi-jurisdictional hazard mitigation plans prior to the development of this Regional Plan. These plans were last updated in 2010-2011 with the exception of Big Horn County which updated its plan in 2015 and re-adopted it in 2016. Since this occurred during the same timing of the regional plan development their FEMA approved plan has been included as an annex in its entirety to this regional 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 2016 version of this plan. Changes in participation since the 2010-2011 planning updates are noted. Additional details about participation can be referenced in Chapter 3 and the county annexes.

Table 1.1 Multi-Jurisdictional Participation 2016

Jurisdiction	Participation Status
Big Horn County	Participated in 2015 plan update approved in 2016
Town of Basin	Participated in 2015 plan update approved in 2016
Town of Burlington	Participated in 2015 plan update approved in 2016
Town of Byron	Participated in 2015 plan update approved in 2016
Town of Cowley	Participated in 2015 plan update approved in 2016
Town of Deaver	Participated in 2015 plan update approved in 2016
Town of Frannie	Participated in 2015 plan update approved in 2016
Town of Greybull	Participated in 2015 plan update approved in 2016
Town of Lovell	Participated in 2015 plan update approved in 2016
Town of Manderson	Participated in 2015 plan update approved in 2016
Hot Springs County	**New in 2016**
Town of East Thermopolis	New in 2016
Town of Kirby	New in 2016
Town of Thermopolis	New in 2016
Park County	**Continuing from 2011**
City of Cody	Continuing from 2011
City of Powell	Continuing from 2011
Town of Meeteetse	Continuing from 2011
Washakie County	**Continuing from 2011**
City of Worland	Continuing from 2011
Town of Ten Sleep	Continuing from 2011

CHAPTER 2 COMMUNITY PROFILE

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

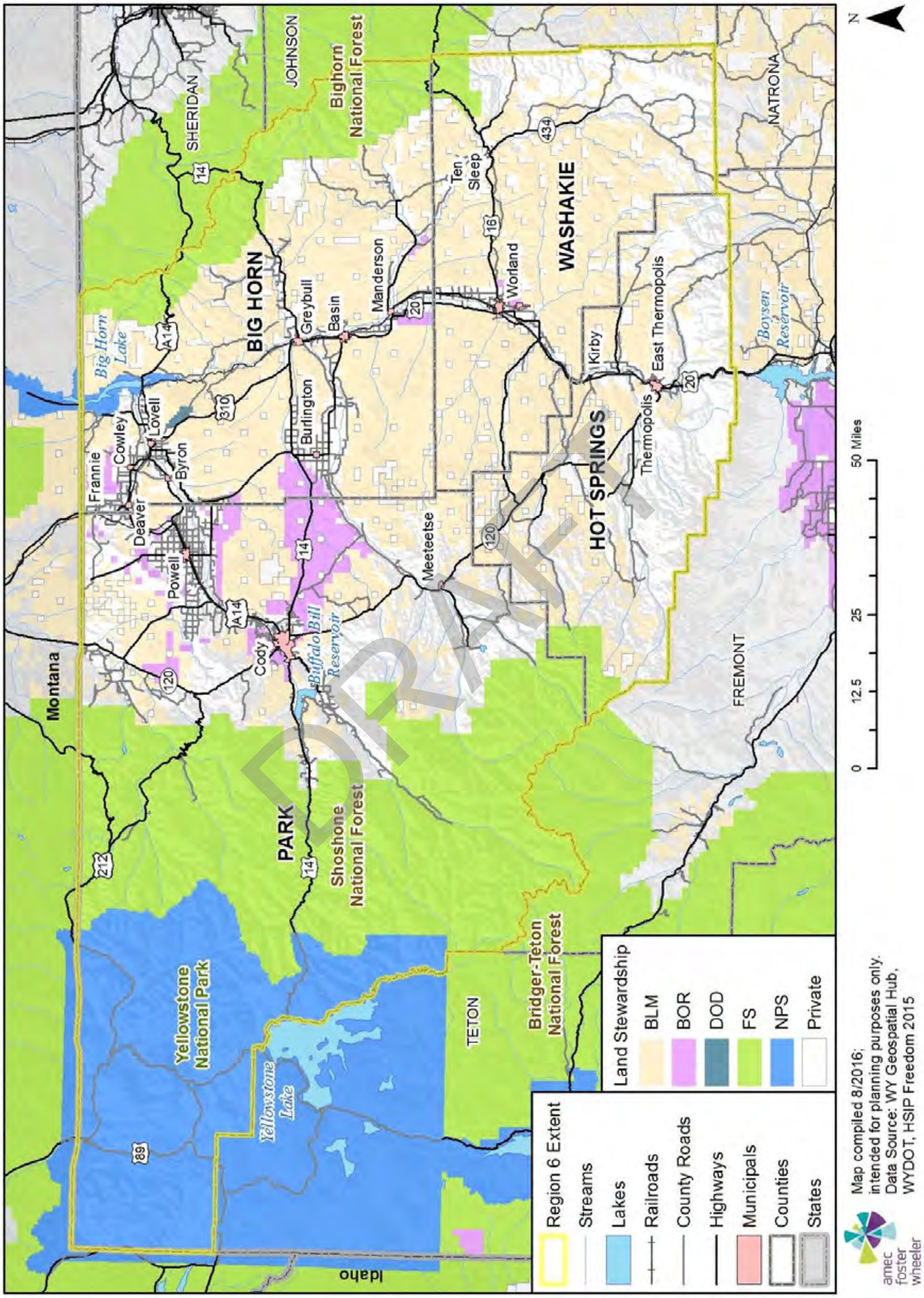
2.1 Geography and Climate

Wyoming Region 6 is comprised of four counties in northern Wyoming in the Bighorn River Basin. Member counties include Big Horn, Hot Springs, Park and Washakie. It is bounded by the Absaroka Range on the west, the Bighorn Mountains on the east, and the Owl Creek Mountains and Bridger Mountains on the south. It is drained to the north by tributaries of the Bighorn River.

The region covers some 14,375 square miles and elevations range between 3,000 and 11,372 feet. Eagle Peak is the highest point in Region 6, located in Yellowstone National Park in Park County. The major rivers in the region include the Bighorn River, the Shoshone River, the Greybull River, the Yellowstone River, and the Nowood River. Major roadways include Highway 14, Highway 20, Highway 16, and Highway 310. A base map of the planning region is illustrated in Figure 2.1. A large percentage of the Region's land is public or federally managed as shown in the land stewardship designations on the base map.

The climate of the Bighorn Basin region varies depending on location and time of year. The region is semi-arid, receiving only 6-10 inches of rain annually. The Bighorn Basin can experience both some of the warmest and coldest temperatures within the state of Wyoming. The highest recorded temperature in the state was 114 ° F on July 12, 1900, at Basin in Big Horn County. Protecting mountain ranges prevents the wind from stirring the air, and the colder heavier air settles into the valleys often sending readings well below zeros. Mean January temperatures in the Bighorn Basin show the variation between temperatures in the lower part of the valley and those higher up. In the lower portion of the basin, the mean minimum temperature for January is zero, while Cody has a mean January minimum of 11 ° F. Winters are usually long and cold. Precipitation is also dependent on location in the basin. Mountain ranges block the flow of moisture laden air from the east as well as the west. The lower portion of the basin receives 5 to 8 inches of precipitation a year, while areas like Cody and Thermopolis receive 10 to 12 inches annually. Total annual snowfall also varies considerably. In areas of the Basin where elevations range from 5,000 to 6,000 feet, annual averages can be 20 to 40 inches. In the higher regions, snowfall averages often reach 200 inches.

Figure 2.1. Wyoming Region 6



2.2 Population

Table 2.1 describes the population and estimated population change for the planning region as a whole and each individual county. Estimates beyond 2010 are based on the American Community Survey data from the US Census Bureau. As a whole, the Region is increasing slightly in population, but percent increase varies by county within the region.

Table 2.1. Region 6 Population Estimates

	2010 Census	2011 Estimate	2012 Estimate	2013 Estimate	2014 Estimate	2015 Estimate	Change 2010 to 2015	% Change 2010 to 2015
Region 6	53,218	53,505	53,937	54,528	54,154	54,319	1,101	2
Big Horn	11,668	11,745	11,785	12,002	11,919	12,022	354	3.0
Hot Springs	4,812	4,818	4,846	4,846	4,793	4,741	-71	-1.5
Park	28,205	28,473	28,863	29,237	29,126	29,228	1,023	3.6
Washakie	8,533	8,469	8,443	8,443	8,316	8,328	-205	-2.4

Source: US Census Bureau

2.3 Economy

Historically, the primary industry in Region 6 was oil and gas. The Bighorn Basin forms a geologic structural basin filled with more than 20,000 feet of sedimentary rocks. Since the early 20th century, the basin has been a significant source of petroleum and has produced more than 1,400,000,000 barrels of oil. Some uranium has been mined in the northern part of the basin. Region 6 is losing ground in the oil and gas and mining industries for a variety of reasons. Big Horn County created an Economic Development Plan that explains that many of the reasons for loss can be corrected with targeted support (which may include workforce training, marketing, recruitment, research and education). Yet, some of these industries have struggled due to commodity prices and other market conditions. Wyoming's second highest earning industry is tourism. Park County is home to Yellowstone National Park, the world's first national park and the fourth most visited park. In addition to tourism and energy extraction agriculture is a major industry in the Region including row crops, farming and ranching. Soft drinks and the bottled water industry are other important parts of the economy particularly in Washakie County due to the presences of high-quality aquifers.

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 6

While Region 6 has never had a regional hazard mitigation plan prior to 2016, multiple counties in the region have adopted county-specific hazard mitigation plans over the years. Big Horn, Park and Washakie each had county-specific plans and this Regional Plan builds upon and updates those efforts. The following is a short description of those efforts by county.

Washakie County. Washakie County has been a leader statewide in mitigation planning and had one of the first approved local mitigation plans in the State. The Washakie County components of this Regional Plan have their roots in meetings and activities that began in August of 2002 and continued through June 2005. Washakie's plan underwent a major update in 2010-2011 under the coordination of the Washakie County Homeland Security Coordinator, as part of the required 5 year update cycle. The municipalities of Worland and Ten Sleep have been participants since the inception of these mitigation planning efforts.

Park County. Park County has had a county hazard mitigation plan in place for 10 years, including the initial plan developed in 2006 and a comprehensive update in 2011. The planning process and development of this Regional Plan builds on these previous efforts. The municipalities of Cody, Meeteetse, and Powell have been participants since the inception of these mitigation planning efforts.

Big Horn County. Big Horn County and the incorporated communities of Basin, Burlington, Byron, Cowley, Deaver, Frannie, Greybull, Lovell, and Manderson prepared and adopted a Pre-Disaster Mitigation Plan (PDM Plan) in 2010. In 2015 this plan underwent a comprehensive update with consultant assistance. The plan was approved pending adoption in February of 2016 and was undergoing local adoptions during the development of this Regional Plan. The county's plan was adopted and received final approval from FEMA on May 24, 2016. Due to the coinciding of adoption of an updated plan during the Regional Plan development the Big Horn County annex includes this recently updated plan in its entirety.

Hot Springs County. Hot Springs County did not have an adopted local hazard mitigation plan prior to the development of this Regional Plan. Some components existed however, including a Hazard Identification and Risk Assessment developed with assistance by the Wyoming Office of Homeland Security (WYOHS) in 2005 and a Public Health Risk Assessment completed in 2016.

Regional Planning. In Wyoming, the WYOHS utilizes a regional support structure to assist the counties with all aspects of emergency management, including planning. Each county has an emergency management coordinator. The counties in the Bighorn River basin, Park, Hot Springs, Washakie and Big Horn, comprise Region 6. In 2016 the WYOHS 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 DMA 2000 is often beyond local capabilities and expertise. Instead of each county hiring consultants the WYOHS took the lead in procuring and funding a professional hazard mitigation planning consultant through a competitive bid process. Due to the timing of plan updates Regions 6 and 4 were chosen as the first regions in the state to develop regional plans. Amec Foster Wheeler of Boulder, Colorado was selected in March of 2016 to provide assistance to both regions.

Prior to initiating the development of this regional multi-jurisdictional Hazard Mitigation Plan in 2016 a substantial coordination effort took place to ensure the participation of all four counties within Region 6. The WYOHS received letters of commitment from each county (copies included in Appendix C) indicating their interest in and willingness to participate in the regional planning process. Each county designated the Emergency Management Coordinator as the primary point of contact. Each Coordinator was required to undertake a coordination role within their respective counties to help fulfill 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 6 Hazard Mitigation Plan. Every incorporated community within the four counties chose to participate in the development of the initial Regional Plan.

Each Emergency Management Coordinator led county-level Hazard Mitigation Planning Committees (HMPCs) working in concert with the hazard mitigation planning consultant. As the planning consultant Amec Foster Wheeler's role was to:

- Provide guidance on a planning organization for the entire planning area representative of the participants;

- Meet all of 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 WYOHS and FEMA Region VIII

3.2 Local Government Participation

The Disaster Mitigation Act (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 6 Multi-Hazard Mitigation Plan's HMPC, "participation" meant:

- Attending and participating in HMPC meetings;
- Establishing/reconvening a local steering committee;
- Providing available data requested by the HMPC coordinator/Amec Foster Wheeler;
- Providing/updating the hazard profile and vulnerability details specific to jurisdictions;
- Developing/updating 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 the municipalities in Region 6 as noted in Chapter 1 and detailed further in Section 3.3.1. Documentation of participation is included in Appendix C in the form of meeting sign in sheets, meeting summaries, and more.

3.3 The 10-Step Planning Process

Amec Foster Wheeler established the planning process for the Region 6 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, Amec Foster Wheeler 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 (CRS), 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 step process within the four phase process. Table 3.1 summarizes the four-phase DMA process, the detailed CRS planning steps and workplan 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 Amec Foster Wheeler Workplan 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 y 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 county 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 county annexes
	Step 5. Assess the problem		Chapter 4 and county annexes
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 county 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 county's commitment to develop a Regional Plan, Amec Foster Wheeler worked with WYOHS 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 and need for the regional hazard mitigation plan. During the development of this Regional Plan, the planning process was directed through a regional planning committee comprised of Big Horn County Emergency Management, Hot Springs County Emergency Management, Park County Emergency Management, Washakie County Emergency Management, and participating jurisdictions. The planning consultant held an initial conference call/WebEx to discuss the organizational aspects of the planning process with the county coordinators. Using FEMA planning guidance, representative participants for each county's HMPC base membership were established, with additional invitations extended as appropriate to other federal, state, tribal, and local stakeholders and the public throughout the planning process. The list of agencies and individuals invited to participate is listed in the following table. More details are included in Appendix A with documentation of participation included in Appendix C.

Table 3.2. HMPC Members and Stakeholders by County

Hot Springs County	
Jurisdictions and Stakeholders	**Representatives**
Hot Springs County	HSC Emergency Management
	HSC Commission Chairman
	HSC Attorney
	HSC Sheriff
	HSC Sheriff Dept., Lieutenant
	HSC Clerk
	HSC Assessor
	HSC Treasurer
	HSC Planner
	HSC Road & Bridge
	HSC Public Health - Nurse Manager
	HSC Public Health - PH Response Coordinator
	HSC Memorial Hospital - CEO
	HSC Memorial Hospital - Emergency Planner
	HSC Museum
	HSC LEPC - Chairman
	HSC Fire District #1
	HSC Senior Citizens Center
	HSC Counseling Services
	HSC Weed & Pest
Town of East Thermopolis	East Thermopolis Mayor
	Council
Town of Kirby	Kirby Mayor

Town of Thermopolis	Thermopolis Mayor
	Assistant to Mayor, Codes Administrator
	Thermopolis Police Chief
	Thermopolis Police Dept., Sergeant
	Thermopolis Vol. Fire Department - Chief
	Thermopolis Public Works
	Public Citizen - Member at Large
Stakeholders	HSC School District Superintendent
School District	HSC School District Administrative Assistant to Superintendent
	HSC High School - Principal
	Thermopolis Middle School - Principal
	Ralph Witters Elementary - Principal
	Transportation Department (Bus Barn)
State Agencies	Wyoming Department of Transportation
	Wyoming State Geological Survey
	Wyoming Highway Patrol
	Wyoming Office of Homeland Security
	Wyoming Game and Fish
	Wyoming Pioneer Home
Federal Agencies	National Weather Service - Riverton
Business and Industry	High Plains Power
	Wyoming Gas
	RT Communications
	TCT Telephone
	Springcity.com/pitchengine Communities (Digital News)
	Thermopolis Independent Record Publisher/Editor and Reporter
	HOPE Agency
	Burlington Northern Santa Fe Railroad
	Big Horn Enterprises
	Thermopolis Rehab and Care Center
	Mortimore Ambulance Service
	Risen Son Christian School - Principal
	Northwest Boces School
	Community Home Health
	American Red Cross of Wyoming

Park County	
Jurisdictions and Stakeholders	**Representatives**
Park County	Park County Homeland Security
	Park County Commissioners
	Park County Dispatch
	Park County Public Works
	Park County Fire District #2
	Park County Planning and Zoning
City of Cody	Cody Police Department
	Cody Parks & Recreation
City of Powell	Powell Emergency Management
	Powell Public Works
	Powell Police Department
Town of Meeteetse	Meeteetse Emergency Management
Stakeholders	Northwest Rural Water
	Rocky Mountain Power
Washakie County	
Jurisdictions and Stakeholders	**Representatives**
Washakie County	Washakie County Clerk
	Washakie County Attorney
	Washakie County Treasurer
	Washakie County Commissioners
	Washakie County Conservation District
	Washakie County Homeland Security
	Washakie County LEPC
	Washakie County Planning Office
	Washakie County GIS Office
	Washakie County Road and Bridge
	Washakie County Extension Office
	Washakie County Sheriff
	Washakie County Coroner's Office
	Washakie County Fire Protection District
	Washakie County Public Health Department
	Washakie County Weed and Pest
	Washakie County Ambulance - Director
	Washakie County
	Washakie County Public Health Department

City of Worland	City of Worland Mayor and Council
	City of Worland Police Department
	City of Worland Police Department
	City of Worland GIS/Planning Department
	City of Worland Public Works Department
	City of Worland City Engineer
	City of Worland City Council
Town of Ten Sleep	Town of Ten Sleep Administration
	Town of Ten Sleep Ambulance
Stakeholders	Ten Sleep Rural Fire District
	Washakie County School District #1
	Washakie County School District #2
	Chamber of Commerce
	Admiral Beverage
	Red Cross
	Washakie Development Association
	Wyoming Sugar Company
	WMC
	Crown Cork and Seal Co Inc
	Washakie Development Association
	KWOR AM/FM Local radio
	Devon Energies
	High Plains Power
	Big Horn Rural Electric Company
	Williston Basin Pipeline
Federal Agencies	National Oceanic and Atmospheric Administration
	Bureau of Land Management
	Federal Aviation Administration
	US Forest Service
State Agencies	Wyoming State Forestry Division
	Wyoming State Geological Survey
	Wyoming Highway Patrol
	Wyoming Office of Homeland Security

Private Industry	Wyoming Daily news
	KWOR AM/FM Local radio
	Devon Gas
	Kinder Morgan, Inc.
	Williston Basin Pipeline
	Pepsi Cola Bottling
	Wyoming Sugar Corp.
	KCS Gas
	Worland Community Care
Big Horn County	
Jurisdictions and Stakeholders	**Representatives**
County	County Emergency Management See Big Horn County Annex

Amec Foster Wheeler and each county's Emergency Management Coordinator 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, conference calls, a WebEx meeting, phone interviews, and mail and email correspondence. Following the initial kickoff WebEx/conference call on April 12, 2016 two planning workshops with each county's HMPC were held during the plan's development between May 2016 and July 2016. The meeting schedule and topics are listed below. In addition, monthly conference calls were held with the County Coordinators and Amec Foster Wheeler to discuss the process including upcoming milestones and information needs. The sign-in sheets and agendas for each of the meetings are documented in Appendix B.

The County HMPC meetings were scheduled as follows. Each meeting was 3-4 hours:

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

May 23, 2016 – Washakie County
May 24, 2016 – Big Horn County
May 25, 2016 – Park County
May 26, 2016 – Hot Springs County

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

Workshop #2: Mitigation Strategy update

June 13, 2016 – Washakie County, PM; public meeting in late afternoon/eve
June 14, 2016 – Hot Springs County, PM; public meeting in late afternoon/eve
June 15, 2016 – Park County, PM; public meeting in late afternoon/eve
June 16, 2016 – Big Horn County; as needed in AM

This workshop was aimed to update the mitigation strategy and brainstorm new mitigation actions to include in the HMP. These meetings were all followed by a public meeting.

During the kickoff WebEx/conference call, Amec Foster Wheeler presented information on the scope and purpose of the plan update, participation requirements of HMPC members, and the proposed project work plan and schedule. A plan 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 worksheets to facilitate the collection of information needed to support the plan update, such as data on historic hazard events, values at risk, and current capabilities.

Planning Step 2: Involve the Public

The 2016 planning process was an open one, with the public informed and involved early in the process. In some cases the HMPC meetings included members of the public and/or local media. A local newspaper reporter from the Northern Wyoming Daily News attended the June 13th HMPC and public meeting in Washakie County.

Public outreach included press releases, radio spots, a survey and newspaper articles. A radio interview with KWOR AM/FM local radio was held on June 7, 2016 with the Washakie County Emergency Management Coordinator and the Project Manager from Amec Foster Wheeler to discuss the plan and advertise the upcoming public meeting. The Thermopolis Independent Record published an article on June 2, 2016 that discussed the development of the mitigation plan for Hot Springs County based on an interview with the County Emergency Management Coordinator.

Public meetings were held in each county as part of the 2016 plan update process. The first public meeting was held in Worland on June 13, 2016. The Amec Foster Wheeler Project Manager and Emergency Management Coordinator were present to facilitate the meeting. The only attendee was a reporter from the Northern Wyoming Daily News. A discussion took place with the reporter regarding the planning process and the progress on actions from the 2011 plan. This resulted in a front page news article on the June 15, 2016 edition of the Northern Wyoming Daily News.

Following the Hot Springs County HMPC meeting on June 14, a public meeting was held in the Big Horn Federal Savings Building. Five members of the public were present for the meeting and three were documented on a sign in sheet. A short PowerPoint slide deck was presented by Amec

Foster Wheeler that outlined the meeting agenda and topics. The members of the public noted concerns about hazardous materials spills, landslides, grass fires, and flooding.

The Park County HMPC meeting on June 15 was followed by a public meeting at the County EOC. The Amec Foster Wheeler Project Manager and County Homeland Security Coordinator were present to facilitate the meeting. The only other attendee was the County Planner/Floodplain Manager. While there were no members of the public present, the meeting time was used to further discuss and continue dialogue on the plan update, including items related to land use planning, emergency planning and floodplain management.

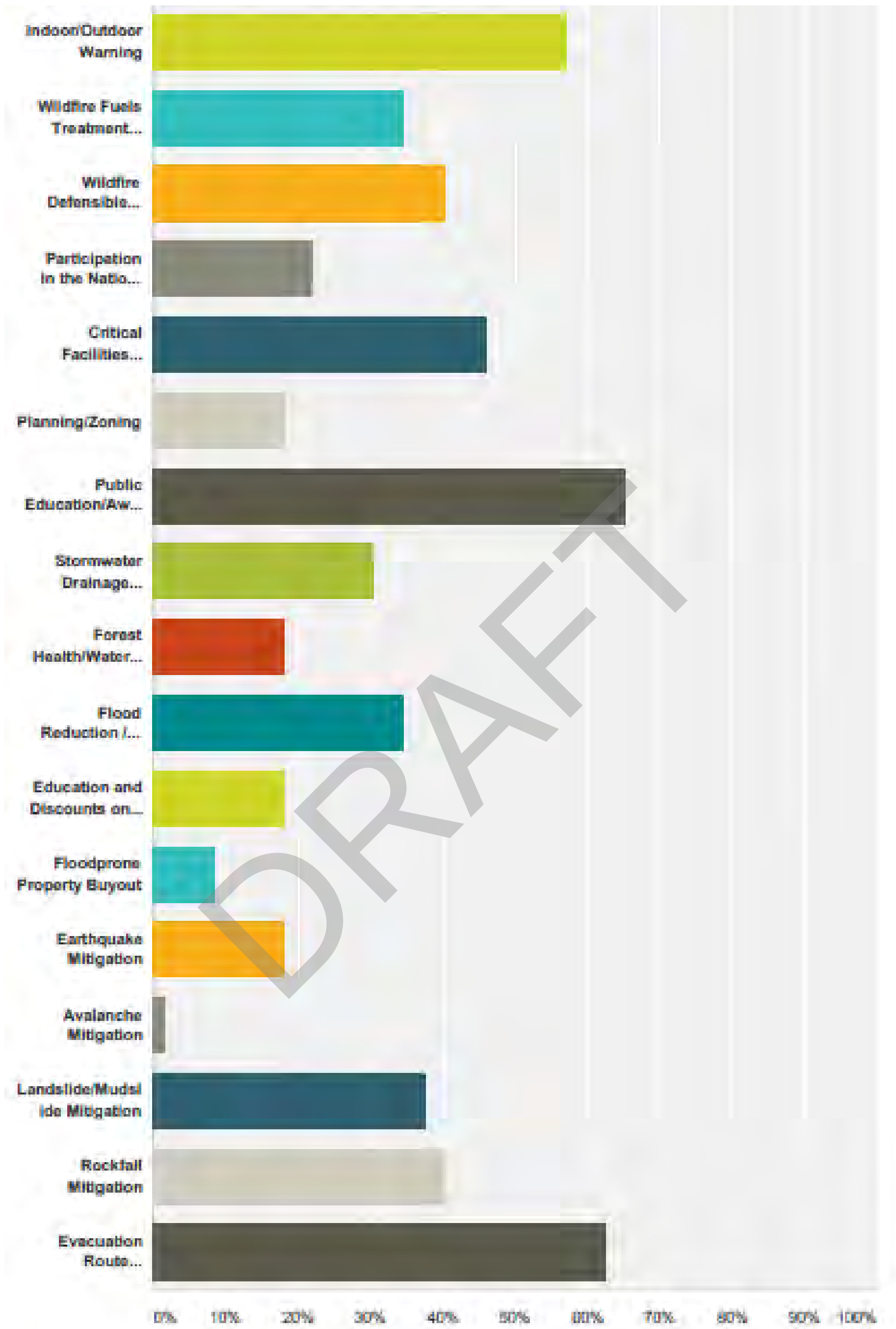
As the Big Horn County Hazard Mitigation Plan had recently been updated a public survey was distributed within the county instead of holding a public meeting. The survey is described further below.

2016 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 6 were drought and winter storms. The survey was released as both an online tool and a hardcopy form on or around May 6th in each county and closed on June 30th, 2016. The counties provided links to the public survey by distributing it using social media, email, and posting the link on websites. Eighty-eight responses were received and shared with the county planning committees to inform the process. Other survey outreach included:

- Park County posted a hard-copy version of the public input survey at the Cody Public Library including the Powell and Meeteetse branches.
- Big Horn County placed a hard copy of the survey in several locations. The county coordinator presented information on their newly updated plan and handed out the results from the survey at the quarterly Mayor's Meeting for Big Horn County on 7-14-2016.

The survey included a question on ranking hazard significance. The results generally track with the significance levels noted in Chapter 4 of this plan, with drought, winter storm, wildfire, landslides, and hazardous materials being considered the most significant. The following graph is a display of the results from Question 4. Question 4 read: *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 indicate that public education/awareness indoor/outdoor warning, and evacuation planning were popular with the public. Additional results of the survey are included in Appendix C, Planning Process Documentation.



Prior to finalizing, a draft of the regional plan was made available to the public for review and comment. The plan was placed on each county's web page and a press release and social media were used to announce the public comment period. A feedback form was provided to collect specific comments.

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. 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 invited to participate on the HMPC in 2016 and are noted in Table 3.2.

Many of these stakeholders participated in the process by attending HMPC meetings or providing data and information that was used to update hazard profiles in the plan. The Wyoming Department of Transportation (WYDOT) was an active participant in the planning meetings for Washakie and Hot Springs Counties. This has resulted in continued partnerships on landslide hazard mitigation along highways in these counties. Rocky Mountain Power participated with Park County's HMPCs and provided input regarding hazards and mitigation efforts related to power disruptions. Stakeholders were also given an opportunity to review and comment on the draft plan.

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 this plan establishes a credible and comprehensive plan 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. Examples of this include.

- 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

Amec Foster Wheeler led the HMPC in an exhaustive research effort to identify and document all the hazards that have, or could, impact the planning area. Data collection worksheets were used in this effort to aid in determining hazards and vulnerabilities and where risk varies across the planning area. The existing hazard mitigation plans and Wyoming Hazard Mitigation Plan provided a basis for many of the hazard profiles. The HMPC decided to focus on certain hazard chapters most relevant to the County instead of looking at all of the State of Wyoming Hazard Mitigation Plan hazard chapters. 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 Amec Foster Wheeler that included an analysis of flood risk based on the recent Digital Flood Insurance Rate Maps (DFIRMs).

Also included in the 2016 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 county annex. A more detailed description of the risk assessment process and the results are included in Chapter 4 Risk Assessment.

3.3.3 Phase 3: Develop the Mitigation Plan

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

Amec Foster Wheeler 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, Amec Foster Wheeler produced a complete first draft of the Regional Plan. This complete draft was posted for HMPC review and comment on the project ftp site. Other agencies were invited to comment on this draft as well. HMPC and agency comments were integrated into the second draft, which was advertised and distributed to collect public input and comments. Amec Foster Wheeler 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 re-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

In order 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 follows the FEMA plan review and approval, copies of the adoption resolution will be included electronically in Appendix E 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. Up to this point in the planning process, all of the HMPC's efforts have been directed at researching data, coordinating input from participating entities, and developing/updating appropriate mitigation actions. 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 a discussion and 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 6 planning area whose goals and interests interface with hazard mitigation. Coordination with these other planning efforts, as addressed in Planning Step 3, is paramount to the ongoing success of this plan and mitigation in Region 6 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.

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.

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 a summary 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 detailed maps.

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.

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 each county 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, the Spatial Hazard Events and Losses Database for the United States (SHELDUS), 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 2016 Region 6 Multi-Hazard Mitigation Plan includes:

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

Members of each county's 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 the expansive soils and mine subsidence hazards were added in 2016 for Washakie and Park. Other changes in the hazard identification list are noted with an asterisk in the table below. This plan represents the first hazard mitigation plan for Hot Springs County.

Table 4.1. Region 6 Hazard Significance Summary Table

Hazard	Big Horn	Park	Washakie	Hot Springs*
Avalanche		L	L	L
Dam Failure	H	L	M	H
Drought	M	H	H	H
Earthquake	L	M	M	M
Expansive Soils		L*	L	L
Extreme Cold		M*	H	M
Flood	M	M	H	M
Hail	M	H	M	L
Landslide		M	L	H
Lightning		M	L*	L
Mine Subsidence		L*	L*	L
Tornado	H	M	M	L
Wildfire	H	H	H	H
High Wind and Downbursts	H	M*	L	L
Severe Winter Weather	M	H	M	M
Human Caused Hazards				
Hazardous Materials		M	M	H

Significance based on a combination of Geographic Extent, Potential Magnitude/Severity and Probability as defined below.
An asterisk indicates hazard was not identified prior to 2016 in County.

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

Potential Magnitude/Severity
Negligible: Less than 10 percent 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 percent 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 percent 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 percent 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 percent probability of occurrence in the next year, or has a recurrence interval of greater than every 100 years.
Occasional: Between a 1 and 10 percent probability of occurrence in the next year, or has a recurrence interval of 11 to 100 years.
Likely: Between 10 and 90 percent probability of occurrence in the next year, or has a recurrence interval of 1 to 10 years
Highly Likely: Between 90 and 100 percent 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 volcanism. The region is significantly vulnerable to an eruption of the Yellowstone Caldera due to its proximity to 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 good response or mitigation plan is not possible for an event of this magnitude, it was not analyzed in this document.

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.

Table 4.2 provides information on federal emergencies and disasters declared in Wyoming between 1963 and 2016.

Table 4.2. Major Disaster Declarations in Wyoming: 1963 – July 2016

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	
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	
Winter storm	2000	Presidential – Major Disaster Declaration	
Hensel Fire	2002	Fire Mgmt Assistance Declaration	
Reese Mountain Fire	2002	Fire Mgmt Assistance Declaration	

Event/ Hazard	Year	Declaration Type	Remarks/Description
Commissary Ridge Fire	2002	Fire Mgmt Assistance Declaration	
Tongue River Fire	2003	Fire Mgmt Assistance Declaration	
Tornado	2005	Presidential – Major Disaster Declaration	
Drought	2006	USDA Declaration	Statewide drought affecting Washakie County
Thorn Divide Fire Complex	2006	Fire Mgmt Assistance Declaration	
Jackson Canyon Fire	2006	Fire Mgmt Assistance Declaration	
Drought	2007	USDA Declaration	Statewide drought affecting Washakie County
Little Goose Fire	2007	Fire Mgmt Assistance Declaration	
Drought	2009	USDA Declaration	Drought affecting Johnson, Big Horn, Campbell, Converse, Natrona, Sheridan, and Washakie Counties
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	Rain and snowmelt flooding in Fremont County
Severe Storms, Flooding, and Landslides	2011	Presidential-Major Disaster Declaration	
Arapahoe Fire	2012	Fire Mgmt Assistance Declaration	
Squirrel Creek Fire	2012	Fire Mgmt Assistance Declaration	
Oil Creek Fire	2012	Fire Mgmt Assistance Declaration	
Sheep Herder Hill Fire	2012	Fire Mgmt Assistance Declaration	
Severe Storms and Flooding	2015	Presidential-Major Disaster Declaration	
Station Fire	2015	Fire Mgmt Assistance Declaration	
Lava Mountain Fire	2016	Fire Mgmt Assistance Declaration	

Event/ Hazard	Year	Declaration Type	Remarks/Description
Tokawana Fire	2016	Fire Mgmt Assistance Declaration	

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.

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 percent of the planning area
Significant: 10 to 50 percent of the planning area
Extensive: 50 to 100 percent 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 Climatic Data Center (NCDC) and SHELDUS where available.

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 NCDC databases it was not used as a resource during the 2016 regional plan development except for when the data was already available.

When available, tables showing county-specific data from the NCDC 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 percent chance of occurrence in next year, or happens every year.
- **Likely**—Between 10 and 100 percent chance of occurrence in next year, or has a recurrence interval of 10 years or less.
- **Occasional**—Between 1 and 10 percent chance of occurrence in the next year, or has a recurrence interval of 11 to 100 years.
- **Unlikely**—Less than 1 percent 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 percent 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 percent of property severely damaged, and/or facilities are inoperable or closed for more than 30 days. More than 50 percent agricultural losses. Multiple fatalities and injuries. Critical indirect impacts.
- **Critical**—25 to 50 percent of property severely damaged, and/or facilities are inoperable or closed for at least 2 weeks. 10-50 percent agricultural losses. Injuries and/or illnesses result in permanent disability and some fatalities. Moderate indirect impacts.
- **Limited**—10 to 25 percent of area affected. Some injuries, complete shutdown of critical facilities for more than one week, more than 10 percent of property is severely damaged.

- **Negligible**—Less than 10 percent of area affected. Minor injuries, minimal quality-of-life impact, shutdown of critical facilities and services for 24 hours or less, less than 10 percent 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 resources. For the regional planning process two standard databases were utilized for the basis of building and critical facility data. The 2016 Parcel and Assessor Data was obtained through the Wyoming Cama website which is maintained by the Wyoming Department of Revenue. This information provided the basis for building exposure and property types. The available data is annually updated on the site and contains all counties within Wyoming. Data current as of 2015 was downloaded for all the counties within the Region and joined by Parcel Number in a separate database for analysis using GIS. 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 Homeland Security Infrastructure Program (HSIP) Freedom dataset. Where applicable, this information was used in an overlay analysis for hazards such as flood and landslide. More detail on assets potentially exposed to hazards can be found in the county annexes.

Future Development

This section describes how the hazard could impact future development.

Summary

This section summarizes risk by county 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 Avalanche

Hazard/Problem Description

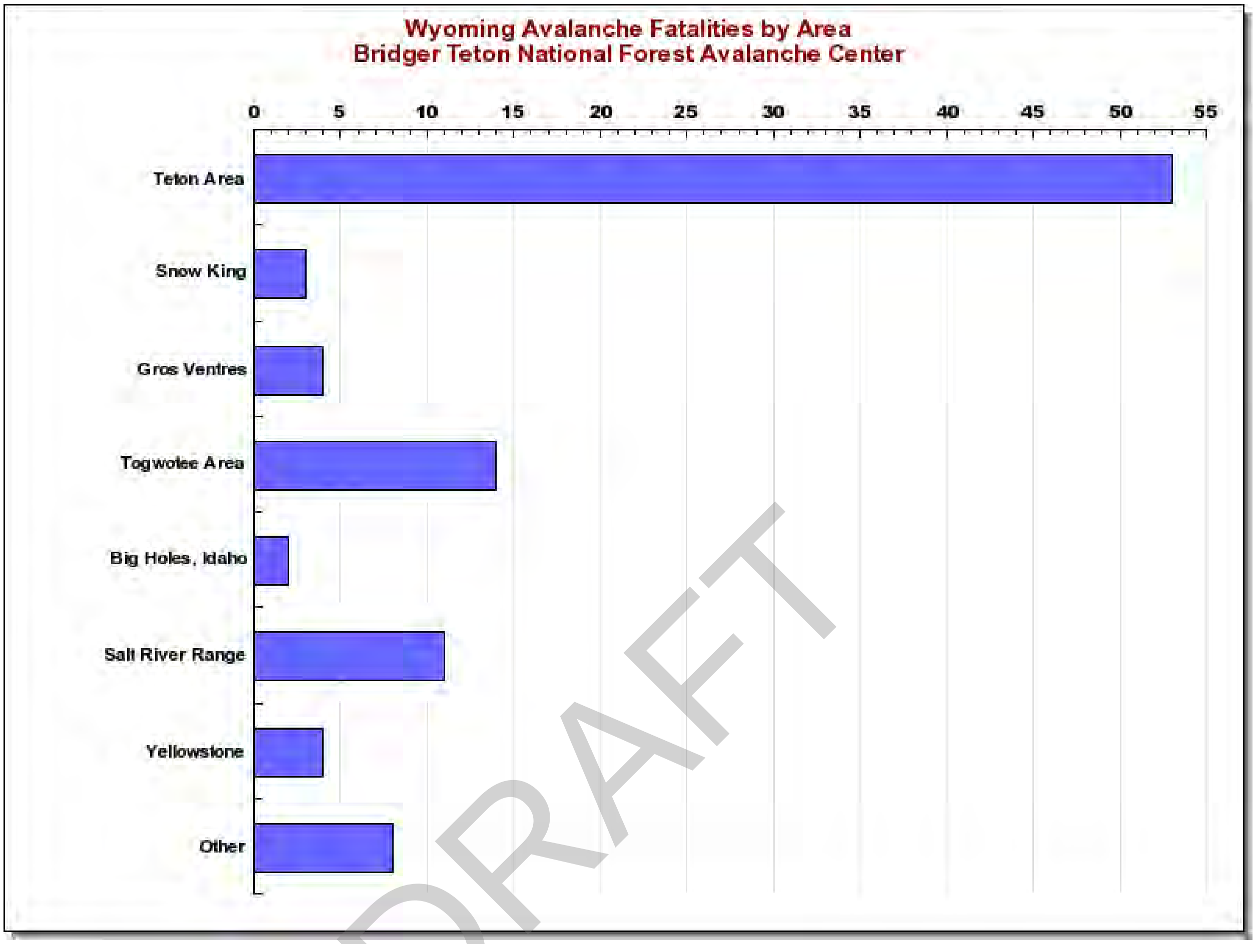
An avalanche is a mass of snow sliding down a mountainside. The vast majority of avalanches occur during and shortly after storms. Avalanches occur when loading of new snow on a slope increases stress at a rate faster than strength develops, and the slope fails. There are four factors that contribute to an avalanche: a steep slope, a snow cover, a weak layer in the snow cover, and a trigger. About 90 percent of all avalanches start on slopes of 30-45 degrees; about 98 percent of all avalanches occur on slopes of 25-50 degrees. Avalanches release most often on slopes above timberline that face away from prevailing winds (leeward slopes collect snow blowing from the windward sides of ridges). Nevertheless, avalanches can run on small slopes well below timberline, such as gullies, road cuts, and small openings in the trees. Very dense trees can anchor the snow to steep slopes and prevent avalanches from starting; however, avalanches can release and travel through a moderately dense forest.

This hazard generally affects a small number of people, such as snowboarders, skiers, and hikers, who venture into backcountry areas during or after winter storms. Roads and highway closures, damaged structures, and destruction of forests are also a direct result of avalanches. Areas prone to avalanche hazards include hard to access areas deep in the backcountry.

Geographical Area Affected

Avalanches affect a limited spatial area in the Region. Most avalanches occur in the western part of the state along the Teton Range. However, a few fatalities have occurred in the Big Horn Range over the past several decades. Figure 4.1 illustrates the geographic distribution of avalanche fatalities around Wyoming.

Figure 4.1. Wyoming Avalanche Fatalities by Area: 1913-2016



Source: www.jhavalanche.org

Past Occurrences

Historically, avalanches occur within the Region between the months of December and April, following snowstorms. According to the HMPCs, there has been some historical avalanche activity involving people, but specific details are unknown. According to the SHELDUS database, an avalanche occurred on February 6, 2001 in Washakie County and resulted in one fatality. Additional details were not available from SHELDUS. Washakie Homeland Security records indicate that avalanches also occurred on December 1, 2000; December 9, 2000; December 25, 2000; and February 23, 2001.

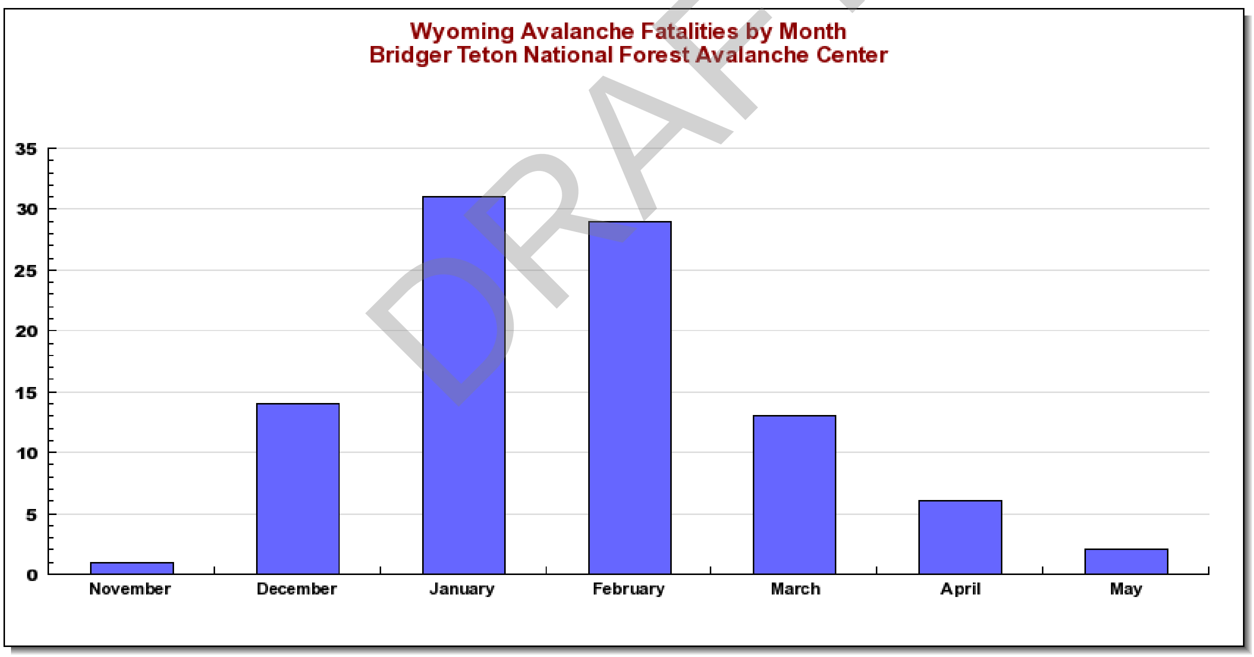
According to the Bridger-Teton Avalanche Center fatalities in the region include two in the Big Horn Range near the Big Horn-Sheridan County border:

- 02/19/2016 Hunt Mountain Road Area, Big Horn Range 39 year old male Snowmobiling
- 01/19/1975 Hunt Mountain Road Area, Big Horn Range, 24 year old male backcountry skiing

Frequency/Likelihood of Future Occurrences

The probability that an avalanche will occur in the Region in any given year can be determined by using the formula described in Section 4.2. According to local records, 7 events occurred between 2000 and February 2016. This yields a 43% occurrence probability. Therefore, the likelihood rating for avalanches in the Region is **likely.** Although few records exist of avalanches in the Region, it is important to remember that many avalanches go unreported or undocumented when no fatalities or injuries are involved. Given the terrain and weather conditions in the mountainous areas of the Region, avalanches are likely to occur, but the damages should continue to be limited. Injuries and loss of life from an avalanche are usually due to people recreating in remote areas at the wrong time. Many residents and visitors to the Region avidly enjoy outdoor recreation, so it is likely that people will continue to be exposed to avalanche hazards in the Big Horn Mountains and Absoraka Range. The figure below lists the distribution of avalanche fatalities by month based on statewide statistics, with January and February being the most likely time of year for avalanche accidents.

Figure 4.2. Wyoming Avalanche Fatalities by Month: 1913-2016



Source: www.jhavalanche.org

Potential Magnitude

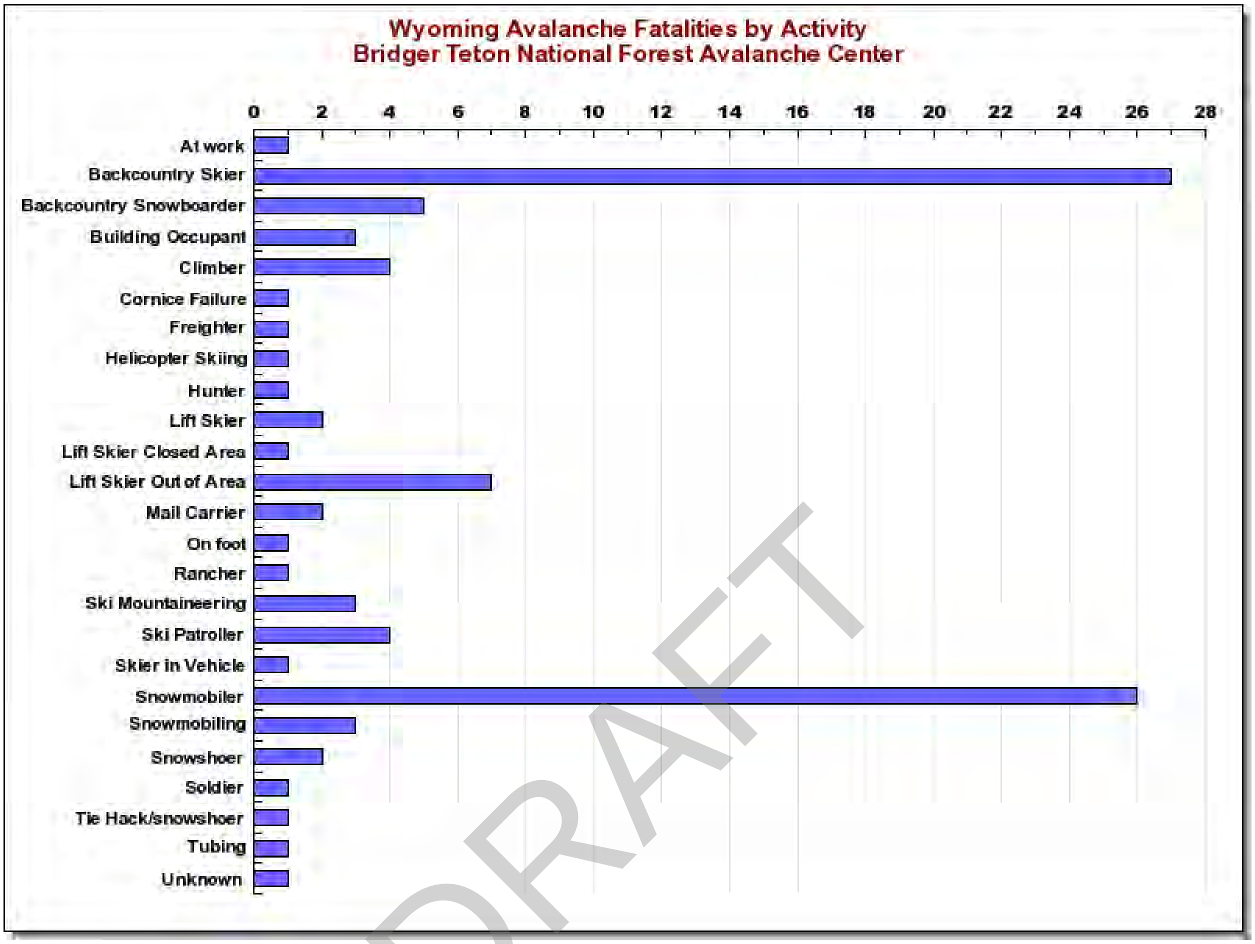
In order to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area, information from the event of record is used. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of a common occurrence. Only one recorded event, a fatality in 2001, exists in national storm and disaster databases such as SHELDUS and NCDC.

Overall, avalanche impacts would likely be **negligible** in all counties in the Region. However, a road closure due to avalanche activity could result in transportation disruptions due to the limited number of roads region wide. Apart from backcountry skiers, snowshoers, snowmobilers and snowboarders, the threat to life and safety is minimal.

Vulnerability Assessment

Although future avalanches are likely to occur, the spatial extent is limited and the magnitude is low. Therefore, avalanches are a low significance hazard in the Region. No known critical facilities or cultural resources were located in avalanche paths at the time this plan was written. It is public safety that is most threatened by this hazard. Outdoor recreationalists who travel into backcountry areas are most at risk. Additionally, while road closures help to mitigate impacts to travelers in avalanche-prone areas, snowplow drivers can still be exposed while clearing roads of snow or avalanche debris. The following is an analysis of fatalities by activity, based on statewide statistics through 2016.

Figure 4.3. Wyoming Avalanche Fatalities by Activity: 1913-2016



Source: www.jhavalanche.org

The keys to limiting impacts to individuals recreating in the area are knowledge and awareness of the hazard and being properly equipped for self-rescue, if necessary, with tools such as locator beacons, shovels, and probes.

Future Development

Avalanche vulnerability could increase with future development and population growth as there will be a higher number of people driving on roadways and taking part in backcountry recreation. It is unlikely that risk to structures will increase as long as future development is planned outside of mapped or suspected avalanche hazard zones.

Summary

Overall, avalanches are a **low** significance hazard to counties in the Region. Impacts are isolated to backcountry users and possibly first responders.

Table 4.3. Avalanche Hazard Risk Summary

County	Likelihood	Spatial Extent	Potential Magnitude	Significance
Big Horn	Likely	Limited	Negligible	Low
Hot Springs	Likely	Limited	Negligible	Low
Park	Likely	Limited	Negligible	Low
Washakie	Likely	Limited	Negligible	Low

4.2.3 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 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. Two factors that influence the potential severity of a full or partial dam failure are the amount of water impounded and the density, type, and value 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 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: US Army Corps of Engineers *Flood Emergency Plans: Guidelines for Corps Dams*. Hydrologic Engineering Center, (June 1980) p 4.)

Dam failures can be classified 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 due to a failure in some way of the dam. Dams 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 based on an expected loss of human life, should the dam fail, and 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 inhabitable or inoperable. 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 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. 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.

There were 1,458 dams in Wyoming that were reviewed by the Corps of Engineers. Of that number 38 were rated high hazard, 56 were rated significant hazard, and the remaining 1,364 were rated low hazard. 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 web site, the WSEO regulates 1,515 dams. As a part of the regulatory process the WSEO inspects these dams once every five years. Of these dams, 84 are rated high hazard, 106 are rated significant hazard, and 1,325 are rated low hazard. (Source: http://www.damsafety.org/map/state.aspx?s=51 (Accessed 7/12/2016))

Table 4.4 shows the dams affecting Region 6. Twenty six are classified as High Hazard (Class I) and 17 are classified as Significant Hazard (Class II). Many dams upstream of Big Horn, Hot Springs and Washakie counties are located in Fremont County. Table 4.4 below provides details of the High and Significant Hazard Dams sorted by the county where they are located.

Figure 4.4. Locations of High and Significant Hazard Dams Affecting Region 6

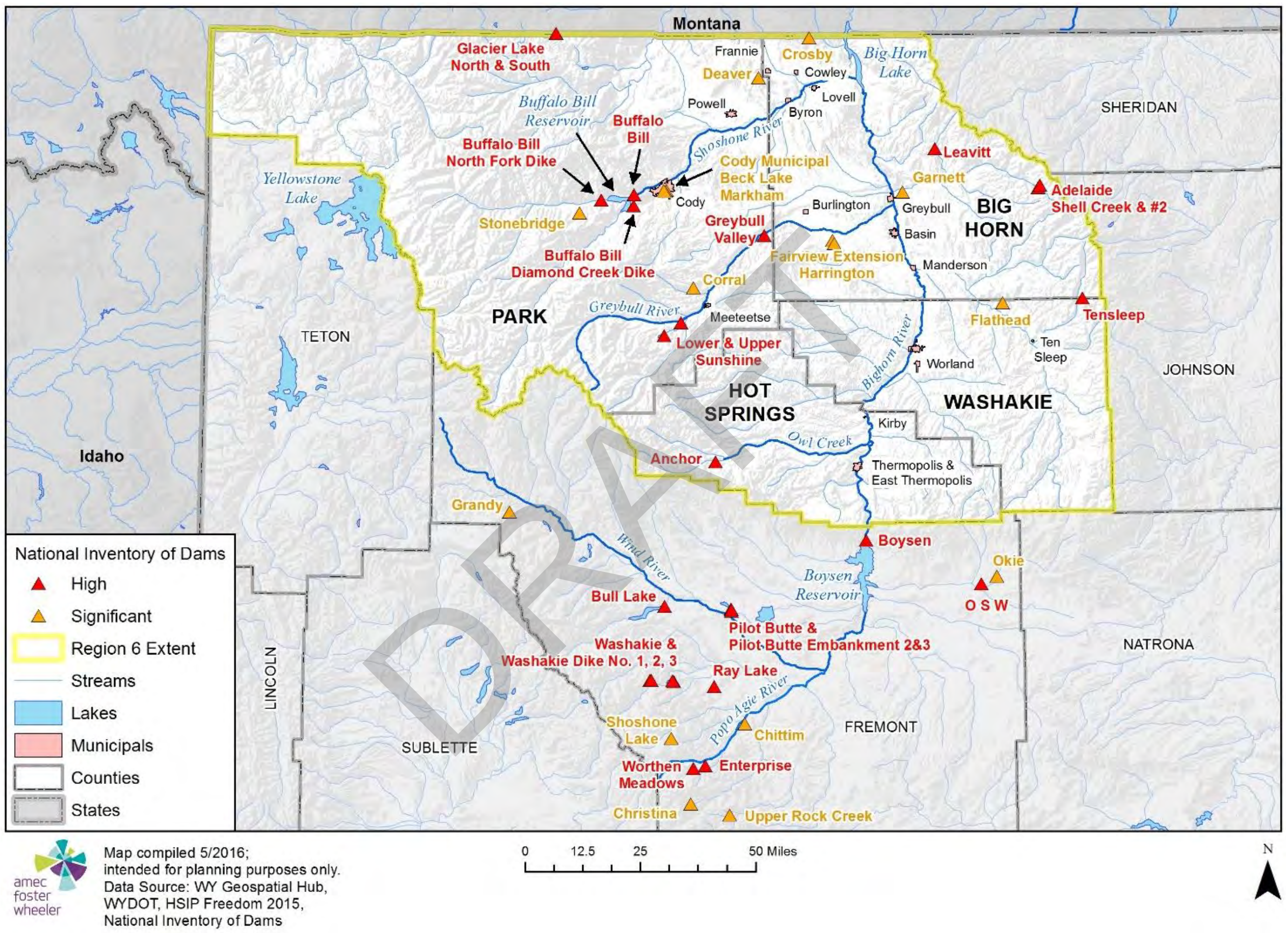


Table 4.4. High and Significant Hazard Dams in Region 6

Dam Name	Owner	River	Hazard Class	Nearest Downstream Community	Distance To Nearest Downstream Community (Miles)	EAP
Fremont County (Upstream Of Hot Springs, Washakie And Big Horn)						
Boysen	DOI Br	Wind River	H	Boysen	2.0	Y
O S W	Lysite Utilities Association	Badwater Creek	H	Lysite	1.0	Y
Enterprise	Enterprise Ditch Company (Jeff Hamilton)	Townsend Creek	H	Lander	14.0	Y
Pilot Butte	DOI Br	Wyoming Canal	H	Riverton	25.0	Y
Anchor	Doi Br	South Fork Owl Creek	H	Embar	8.0	Y
Pilot Butte Embankment 3	Doi Br	Wyoming Canal	H	Riverton	25.0	Y
Pilot Butte Embankment 2	Doi Br	Wyoming Canal	H	Riverton	25.0	Y
Ray Lake	Bia	Mill Creek Tr Os	H	Lander	15.0	Y
Washakie	Bia	S Fk Little Wind River	H	Ft. Washakie	11.0	Y
Washakie Dike No. 3	Usdi Bia	South Fork Little Wind River	H	Ft Washakie	11.0	Y
Bull Lake	Doi Br	Bull Lake Creek	H	Riverton	40.0	Y
Washakie Dike No. 2	Usdi Bia	South Fork Little Wind River	H	Ft Washakie	11.0	Y
Washakie Dike No. 1	Usdi Bia	South Fork Little Wind River	H	Ft Washakie	11.0	Y
Worthen Meadows	City Of Lander	Roaring Fork Creek	H	Lander	15.0	Y
Chittim	Wyo. State Training School	Chittim Gulch	S	Hwy. 789	0.5	N
Okie	Conoco Phillips Company (Zane Fross)	Badwater Creek	S	Lost Cabin	1.0	N
Upper Rock Creek	Neil Mcmurry (Va Resources, Llc)	Rock Creek	S	Atlantic City	4.0	N
Christina	Little Popo Agie Irrigation District	Little Popo Agie River	S	Lander	50.0	N
Grandy	Mike Houck, Todd Dewitt	Little Warm Springs Creek-Off	S	Dubois	5.0	N

Dam Name	Owner	River	Hazard Class	Nearest Downstream Community	Distance To Nearest Downstream Community (Miles)	EAP
Shoshone Lake	Shoshone Lake Reservoir Company	Shoshone Creek	S	Milford	16.0	N
Big Horn County						
Shell Creek	Shell Valley Watershed Imp. District	Shell Creek	H	Shell	6.0	Y
Adelaide	Shell Valley Watershed Improvement Dist.	Adelaide Creek	H	Shell	8.0	Y
Leavitt	Frank Schmidt	Davis Draw, Trib. Beaver Creek	H	Shell	15.0	N
Garnett	Gene And Louise Powers	Shell Creek Trib Bighorn River	S	Greybull	1.0	N
Fairview Extension	Fairview Extension Reservoir Co.	Wardell Draw	S	Greybull	16.0	N
Hot Springs County						
Anchor	Doi Br	South Fork Owl Creek	H	Embar	8.0	Y
Park County						
Greybull Valley	Greybull Valley Irrigation District	Red Clay Draw	H	Unnamed Ranch	0.3	Y
Buffalo Bill - Diamond Creek Dike	Doi Br	Shoshone River	H	Cody	0.0	Y
Buffalo Bill	Doi Br	Shoshone River	H	Cody	7.0	Y
Washakie Dike No. 2	Usdi Bia	South Fork Little Wind River	H	Ft Washakie	11.0	Y
Buffalo Bill - North Fork Dike	Doi Br	Shoshone River	H	Cody	0.0	Y
Upper Sunshine	Greybull Valley Irrigation District	Greybull	H	Meeteetse	11.0	Y
Lower Sunshine	Greybull Valley Irrigation District	Sunshine Creek Offstream	H	Meeteetse	6.0	Y
Deaver	Usbr	Shoshone River Offstream	S	Deaver	3.0	N
Beck Lake	Cody Canal Assn. (Aka Cody Canal, Inc.)	South Fork Of Shoshone	S	Cody	0.0	N

Dam Name	Owner	River	Hazard Class	Nearest Downstream Community	Distance To Nearest Downstream Community (Miles)	EAP
Cody Municipal	City Of Cody	S Fork Shoshone Offstream	S	Cody	36.0	N
Corral	Lds Church - Corp. Of Presiding Bishop	Corral Draw, Trib. Snyder Draw	S	Burlington	28.0	N
Stonebridge	Pierre Williams	Whit Creek Offstream	S	Wapati	2.0	N
Markham	City Of Cody	S Fork Shoshone Offstream	S	Cody	1.0	N
Washakie County						
Ten Sleep	Usda Forest Service	East Tensleep Creek	H	Ten Sleep	16.0	Y
Flathead	Ken Tanner, (Flathead Ranch)	Gomer Gulch	S	Manderson	25.0	N

Source: National Inventory of Dams

Buffalo Bill Dam is a concrete arch-gravity dam on the Shoshone River about 6 miles upstream of Cody in Park County. It is operated by the U.S. Federal Bureau of Reclamation and is designated a High Hazard Dam. The dam was last inspected on August 14, 2012. Impacts from a failure of this dam would be greatest outside of Park County as the canyon is deeply incised as it passes by Cody. Big Horn County could have substantial impacts, particularly areas along the Shoshone River including towns of Byron and Lovell.

A High Hazard Dam whose failure would have potentially the biggest impact on Hot Springs, Big Horn, and Washakie counties lies outside the Region's boundaries to the south. Boysen Dam and Reservoir is an earthen dam located on the Wind River, approximately 20 miles south of Thermopolis in Fremont County. The current dam is operated by the U.S. Federal Bureau of Reclamation, and is an earth-filled dam with a structural height of 220 feet. Total flood damages reduced by the reservoir since construction totaled about $75.0 million by the end of 1998. This dam was last inspected on June 22, 2010.

Downstream Emergency Action Plans (EAPs) for both Boysen and Buffalo Bill dams include inundation maps and downstream warning and notification plans, including local emergency services agencies and municipal contacts to be used in the event of a breach or imminent threat. Given the geographical extent and number of High and Significant dams in the Region the rating is **Significant** for the Region.

Past Occurrences

There have been no documented dam failures in Region 6, however, there have been a number of dam failures elsewhere in Wyoming, some of which resulted in loss of life and damage to property.

In 1906, snow melt flooding along the North Platte caused the failure of a diversion dam. The flooding destroyed a railroad embankment and resulted in a train wreck that claimed 12 lives. Snow melt flooding caused another dam to fail in 1984. Dozens of residences, businesses, and farms were impacted for a total of $5 million in damages to the area.

Frequency/Likelihood of Future Occurrences

It is estimated that it is **occasional** Region 6 will be affected by dam failure in the future. The structural integrity of dams depends on regular inspections and maintenance, which do not always happen. Additionally, 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 6 counties.

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 basis and case-by-case basis. This information is considered sensitive and is not detailed due to Homeland Security concerns. Emergency management coordinators have access to inundation maps contained in the emergency action plans for the High Hazard dams in the State. High Hazard (Class I) dams, by definition, would merit a magnitude/severity rating of **catastrophic**, whereas Significant Hazard (Class II) dams rate as **critical** and Low Hazard dams fall into the **limited** rating. The magnitude/severity rating for the hazard in Region 6 is considered mostly **critical**, mostly due to the number of Class I dams that could impact communities in the Region.

Vulnerability Assessment

The failure of Boysen Reservoir or Buffalo Bill Cody dam could result in hundreds of millions of dollars of damage in downstream communities, although the probability of such an event is low. Active faults lie very close to both Boysen and Buffalo Bill dams (see earthquake section). Each county has emergency action plans on file for Boysen and Buffalo Bill dams. These emergency action plans include specific information on flood damages if either of these dams failed. However, due to the sensitive nature of this information, it is not included in this plan. Specific details will not be given regarding the population, property, critical infrastructure or community resources that would be affected. However, if Boysen Dam failed, Thermopolis, East Thermopolis, Kirby, and Worland would be significantly impacted. The failure of Boysen dam could result in millions of dollars of damage in the Thermopolis area. Several lives could be lost as well. The probability of such an event is low.

If Buffalo Bill Dam failed, impacts could be significant—primarily downstream in Big Horn County. If Buffalo Bill dam failed, Cody would be relatively unaffected. The one area of potential inundation in Park County would be a mobile home park on the north side of the Shoshone River just east of the Highway 120 bridge. The probability of such an event is low. (Source: Park County HMP)

Upper and Lower Sunshine Dams are located above the Town of Meeteetse in Park County. Breach of either or both of these dams could quickly flood Meeteetse. Impacts could include property loss and damage, damage to municipal infrastructure, interruption of traffic and commerce, even loss of life.

Another concern is the aging of the dams. Of the 1,548 dams in the State inventory, 860 or 56% were constructed before 1965 and are over fifty years old. The SOD staff responds to reports of dam failures or near failures. All of the incidents in the past five years are attributable to the age of the dam and the appurtenant structures (Source: 2015 WY SOD report.)

Future Development

As communities or 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. Growth rates in the region do not indicate that risk is increasing substantially.

Summary

Overall, dam failure significance ranges from high to low dependent upon location in the Region. The probability of such an event is low, but impacts could be significant depending upon the dam involved and where it occurred in the region.

Table 4.5. Dam Failure Hazard Risk Summary

County	Geographic Extent	Probability of Future Occurrence	Potential Magnitude/ Severity	Overall Significance
Big Horn	Significant	Occasional	Critical	High
Hot Springs	Significant	Occasional	Critical	High
Park	Limited	Occasional	Limited	Low
Washakie	Limited	Occasional	Critical	Medium

Municipalities impacted:
Washakie County: Worland, Ten Sleep, Unincorporated County

Hot Springs County: Thermopolis, East Thermopolis, Kirby, Unincorporated County

Park County: Meeteetse, Unincorporated County

Big Horn County: Greybull, Manderson, Lovell, Unincorporated County

4.2.4 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 most costly to our society. It indirectly kills more people and animals 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 US 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 extent. 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 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 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. 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 6 Hazard Mitigation Plan Committee, the Region is at high risk to drought events over an **extensive** spatial area. Droughts are often regional events, impacting multiple counties and states simultaneously. Therefore, as the climate of the planning area is fairly contiguous, it is reasonable to assume that a drought will impact the entire planning region. According to the Wyoming State Climate Office, Wyoming is the 5th driest state in the U.S. Drought can be a normal occurrence in Wyoming due to the State's natural climate. Based on this information, the geographic extent rating for drought in Region 6 is **extensive**.

Past Occurrences

The planning area has experienced several multi-year droughts over the past several decades. The most recent statewide drought started in 1999, but began in earnest in the spring of 2000 and endured through 2004. 2005 was a wetter year, technically signifying the end of the drought period. Dry conditions returned in the following years and became especially severe between 2006 and 2007. According to the Wyoming State Climate Office, "conditions have 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). Another particularly dry year occurred in 2012.

The 1999-2004 drought is considered by many to be the most severe in collective memory. However, some old timers have indicated that they remember streams drying up in the 1930s and 1950s. According to instrument records, since 1895 there have been only seven 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.

Table 4.6. Significant Multi-Year Wyoming Droughts of the Modern Instrumented Era

Years	Average Annual Precipitation (inches)	Percent of 1985-2006 Average Annual Precipitation (13.04")
1952-1956	10.65	81.69%
1900-1903	10.76	82.52%
1999-2004	11.07	84.89%
1987-1990	11.12	85.28%
1958-1964	11.67	89.49%
1974-1977	11.77	90.26%
1931-1936	11.79	90.41%

Widespread droughts in Wyoming, as determined from stream flow records, were most notable during three periods: 1929-1942, 1948-1962, and 1976-1982.

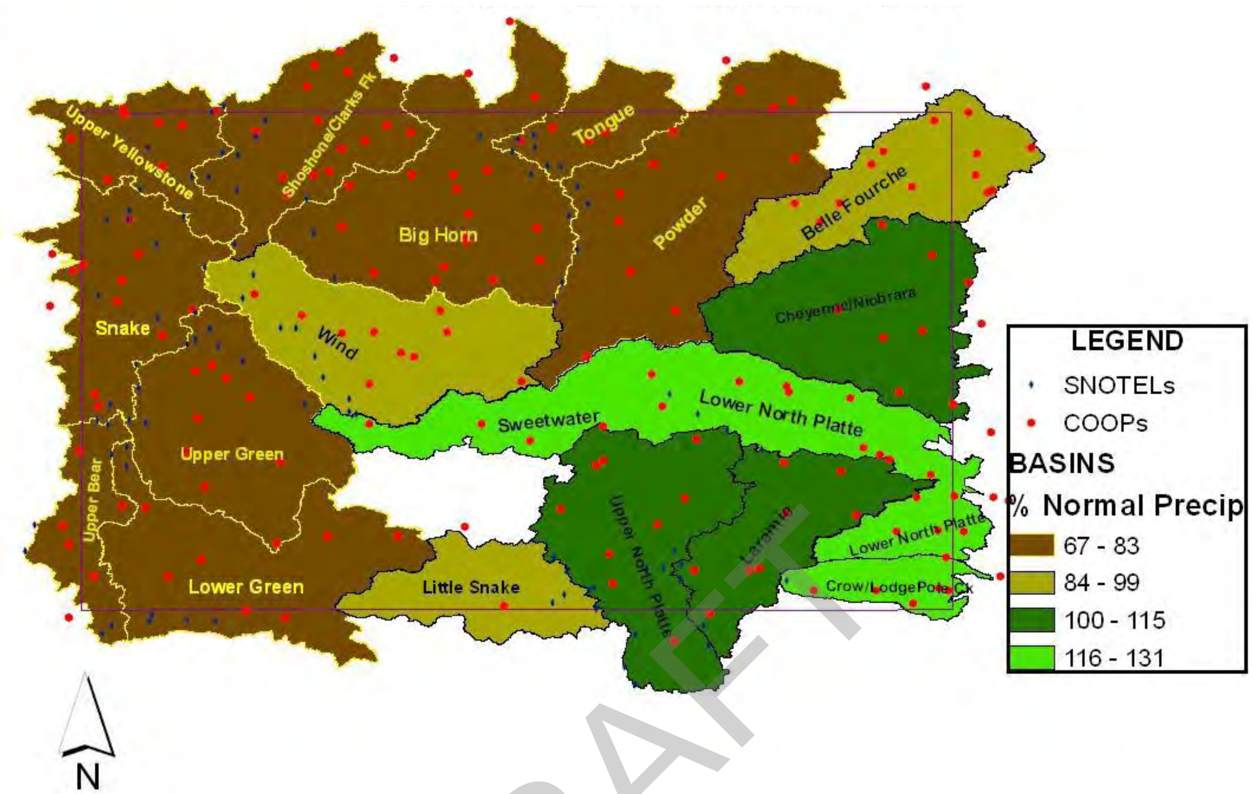
Drought Disaster Declarations

All counties in Region 6 have, at various times, been included in regional USDA disaster declarations for droughts. In November 2007, the USDA designated 11 counties as natural disaster areas for drought including Big Horn, Converse, Fremont, Hot Springs, Lincoln, Niobrara, Platte, Sublette, Sweetwater, Washakie and Weston. An ongoing drought declaration was made in December 2007 for Wyoming. Originally, this declaration was directed at Park County but was extended to the contiguous counties of Big Horn, Fremont, Hot Springs, Teton, and Washakie. In May 2009, Johnson County was designated as a natural disaster area for drought. Farm operators in Washakie, Big Horn, Campbell, Converse, Natrona, and Sheridan, the six counties contiguous with Johnson County, also qualified for disaster assistance. The six contiguous counties were designated as natural disaster areas in December 2009.

In June, 2012 the USDA declared farmers in Hot Springs, Fremont, Park and Washakie counties in Wyoming eligible for disaster assistance due to drought that started March 1, 2012. On September 12, 2012, the USDA designated 12 counties in Montana as primary natural disaster areas. Big Horn and Park Counties were designated as a contiguous county in the same designation. On April 10, 2013, the USDA designated 20 counties in Wyoming as primary natural disaster areas due to damages and losses caused by the recent drought. The counties included Hot Springs, Big Horn, Park, and Washakie. On June 3, 2016, Big Horn and Washakie counties were designated as primary natural disaster areas due to damage and losses caused by a recent drought. The counties of Park and Hot Springs were designated as contiguous counties in the same designation.

Figure 4.5 illustrates the departure from normal precipitation levels in the Big Horn Basin during the winter of 2009-2010.

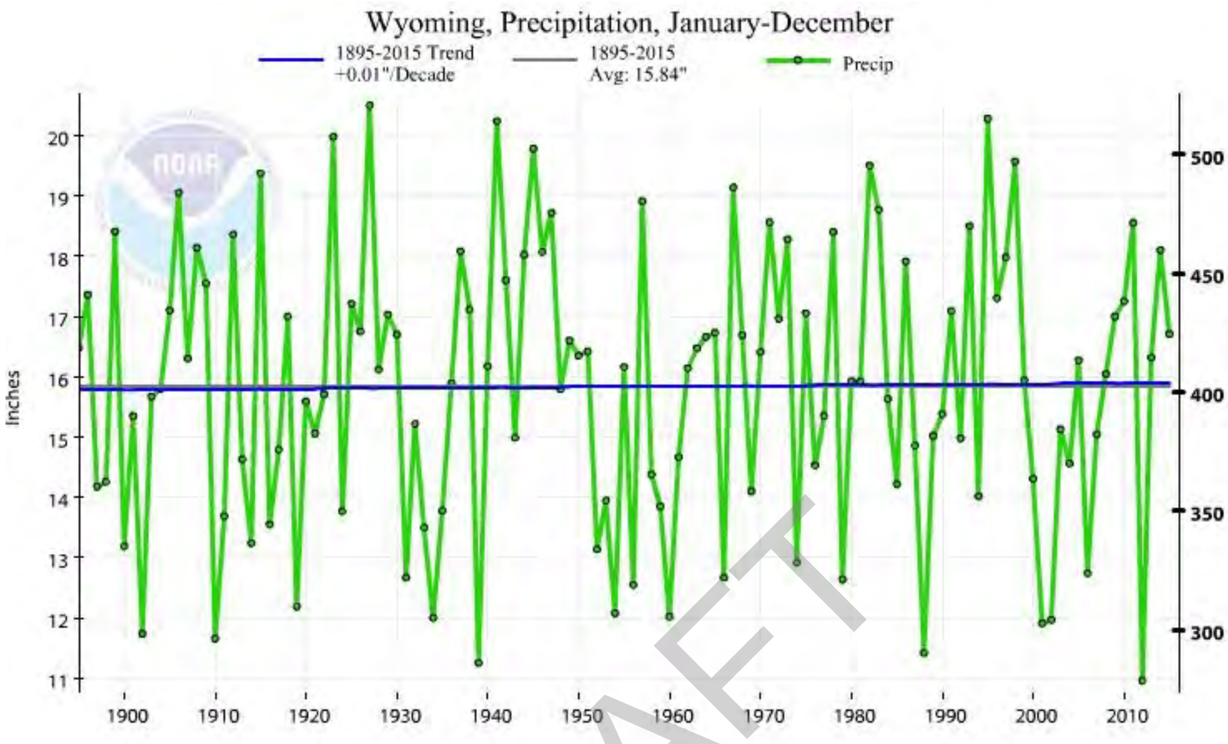
Figure 4.5. Percent of Normal Precipitation by Basin: October 2009-March 2010



Source: NOAA, *Wyoming Drought Information*, updated April 30, 2010, http://www.crh.noaa.gov/images/riw/hydro/drought_info.pdf

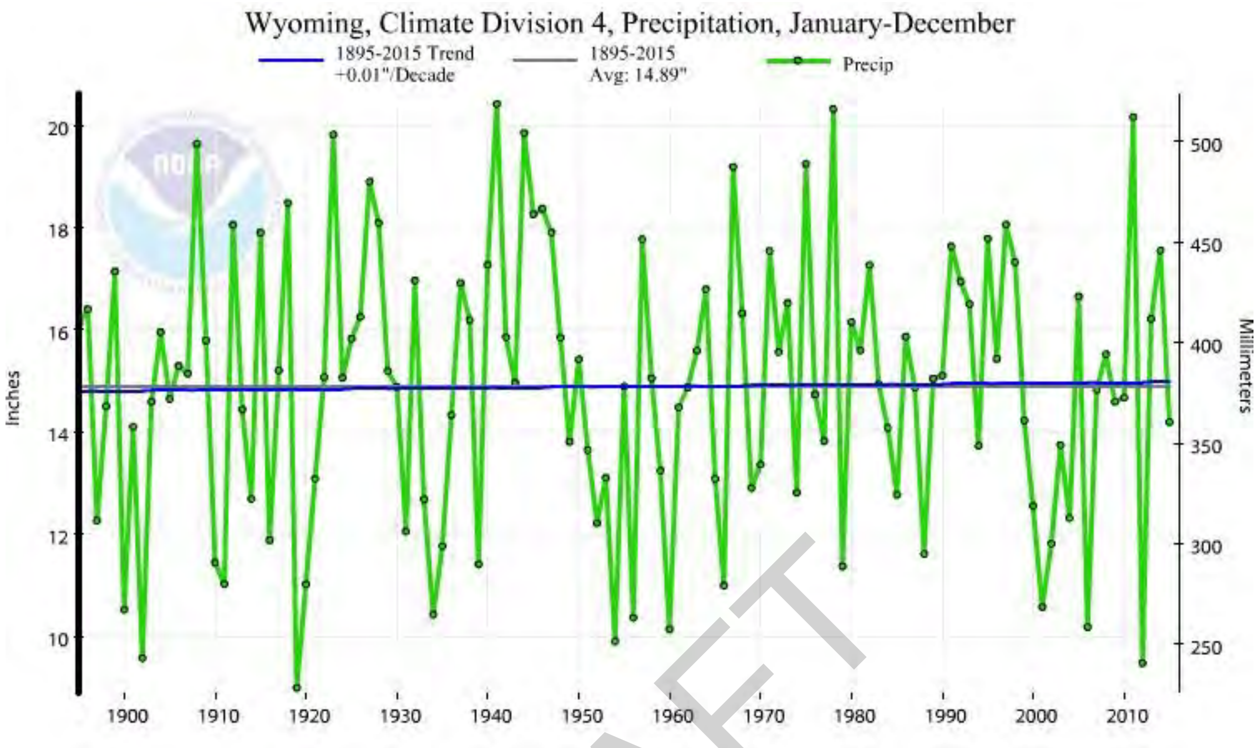
As a whole, Wyoming's precipitation record from 1895-2015 reveals that, for the first half of the 20th century (except for the Dust Bowl years of the 1930s), there was generally a surplus of moisture. During the second half of the 20th century and into the 21st century there was an increasing trend of increased periods of drought (Figure 4.6).

Figure 4.6. Wyoming Annual Precipitation: 1895-2015



Source: http://www.ncdc.noaa.gov/cag/time-series/

Figure 4.7. Big Horn River Basin Annual Precipitation: 1895-2015

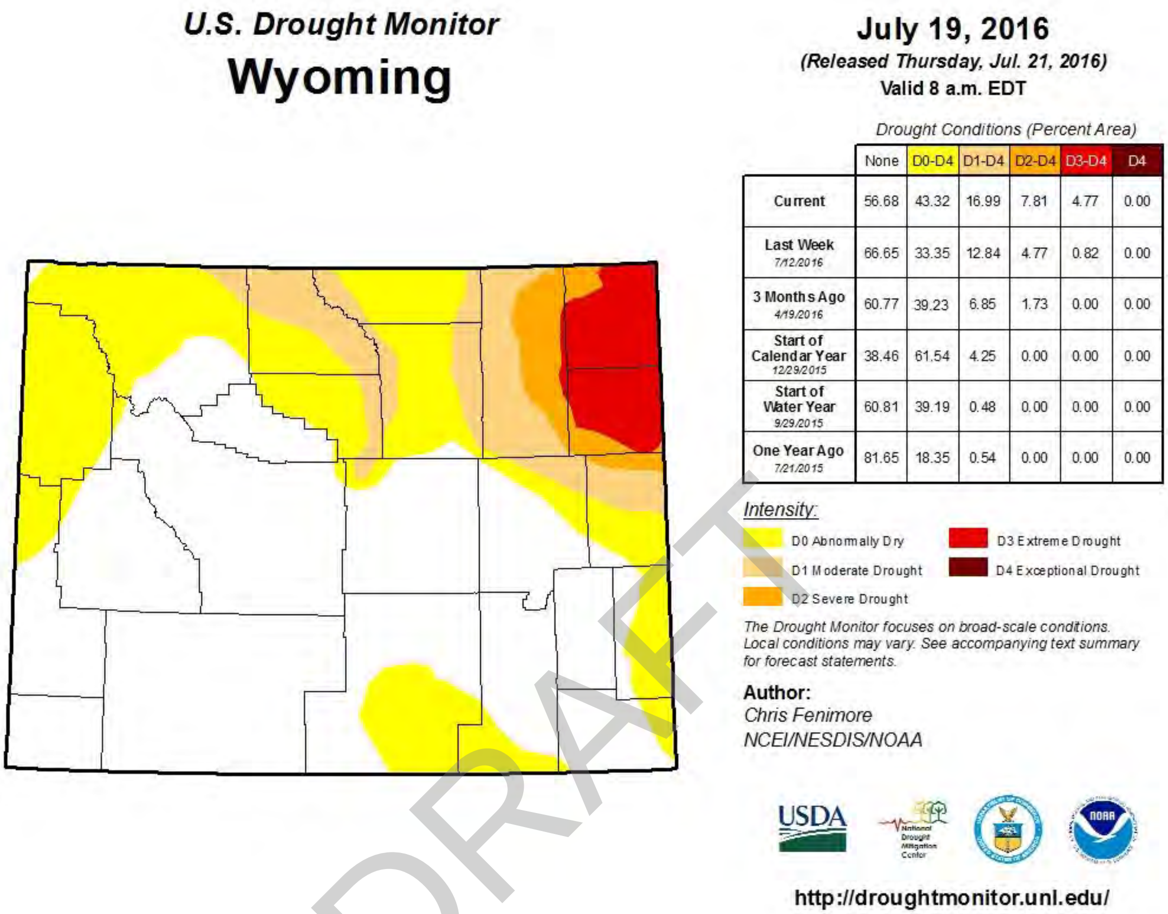


Source: National Oceanic and Atmospheric Administration

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 USDM map. The image is color-coded for four levels of drought intensity. An additional 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 dominant type of drought is also indicated (i.e. agricultural and/or hydrological). (Source: http://www.drought.unl.edu/dm/index.html)

As of July 19, 2016, no drought conditions are identified in Hot Springs County and portions of Park County, however, the majority of Big Horn, Park and Washakie counties in Region 6 are in Abnormally Dry to Moderate Drought conditions.

Figure 4.8. U.S. Drought Monitor



Another 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 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 from a variety of sources such as media, government agencies, and the public. Information within the Drought Impact Reporter 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 6 from 1999 to 2016 (which includes the most recent severe droughts) shows a total of 26 reported impacts. Figures 4.9 through 4.12 show the breakdown of reported impacts by county. The most reported impacts (19) are in the Agricultural and Relief, Response & Restriction categories. 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. The Relief, Response & Recovery category refers to drought effects associated with disaster declarations, aid programs, requests for disaster declaration or aid, water restrictions, or fire restrictions.

Figure 4.9. Number of Reported Drought Impacts 1999-2016 Big Horn County

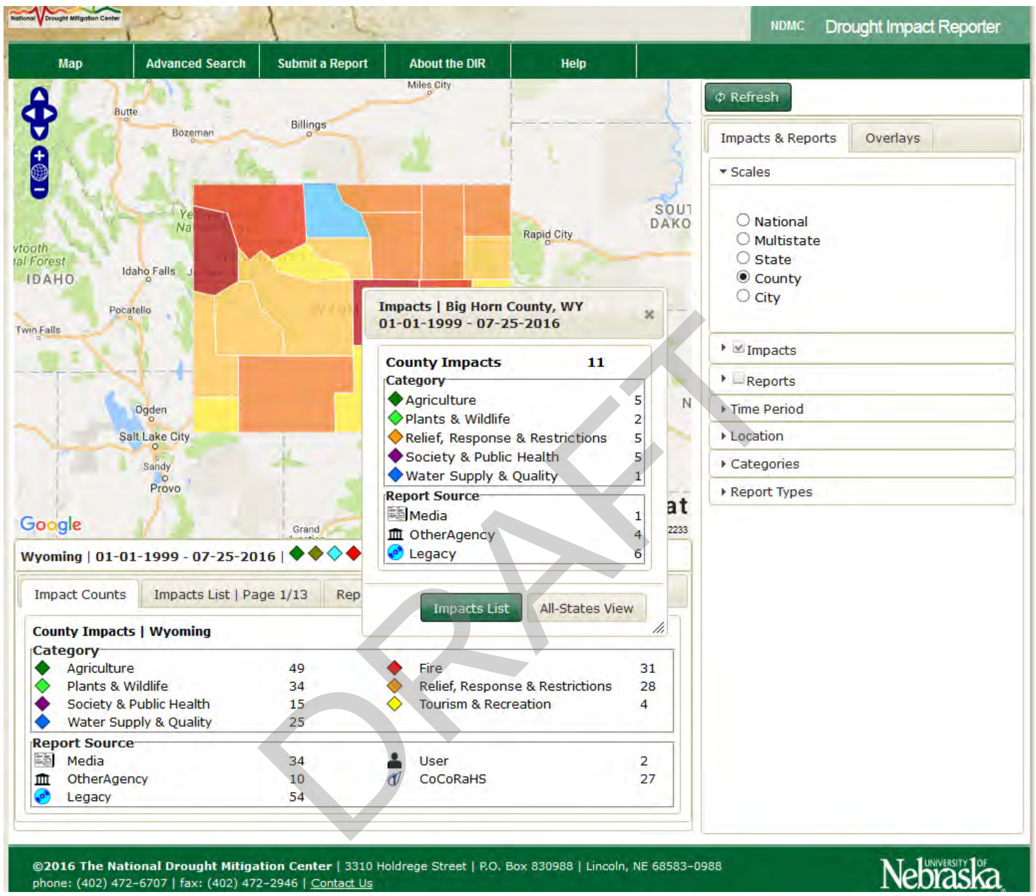


Figure 4.10. Number of Reported Drought Impacts 1999-2016 Hot Springs County

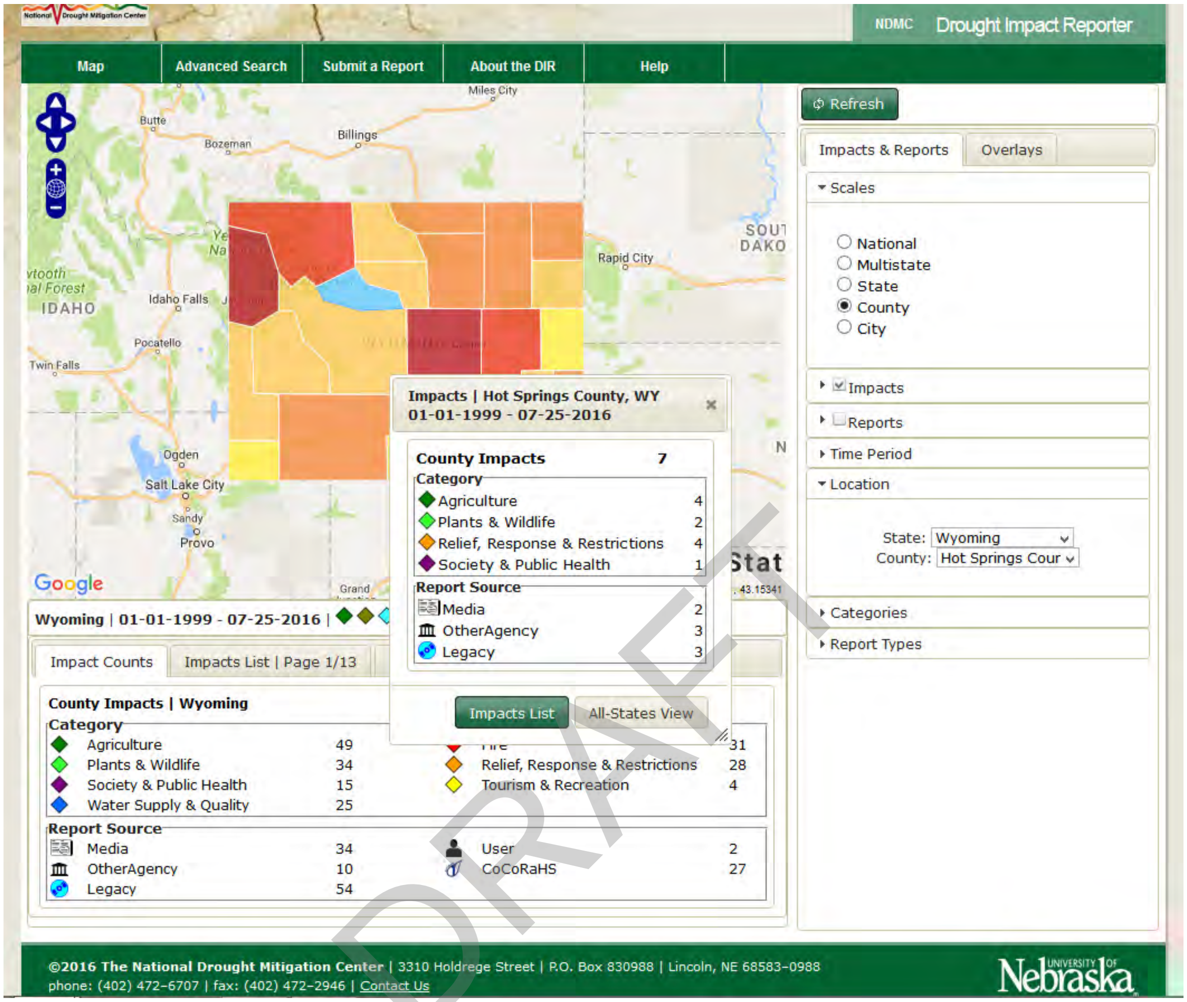


Figure 4.11. Number of Reported Drought Impacts 1999-2016 Park County

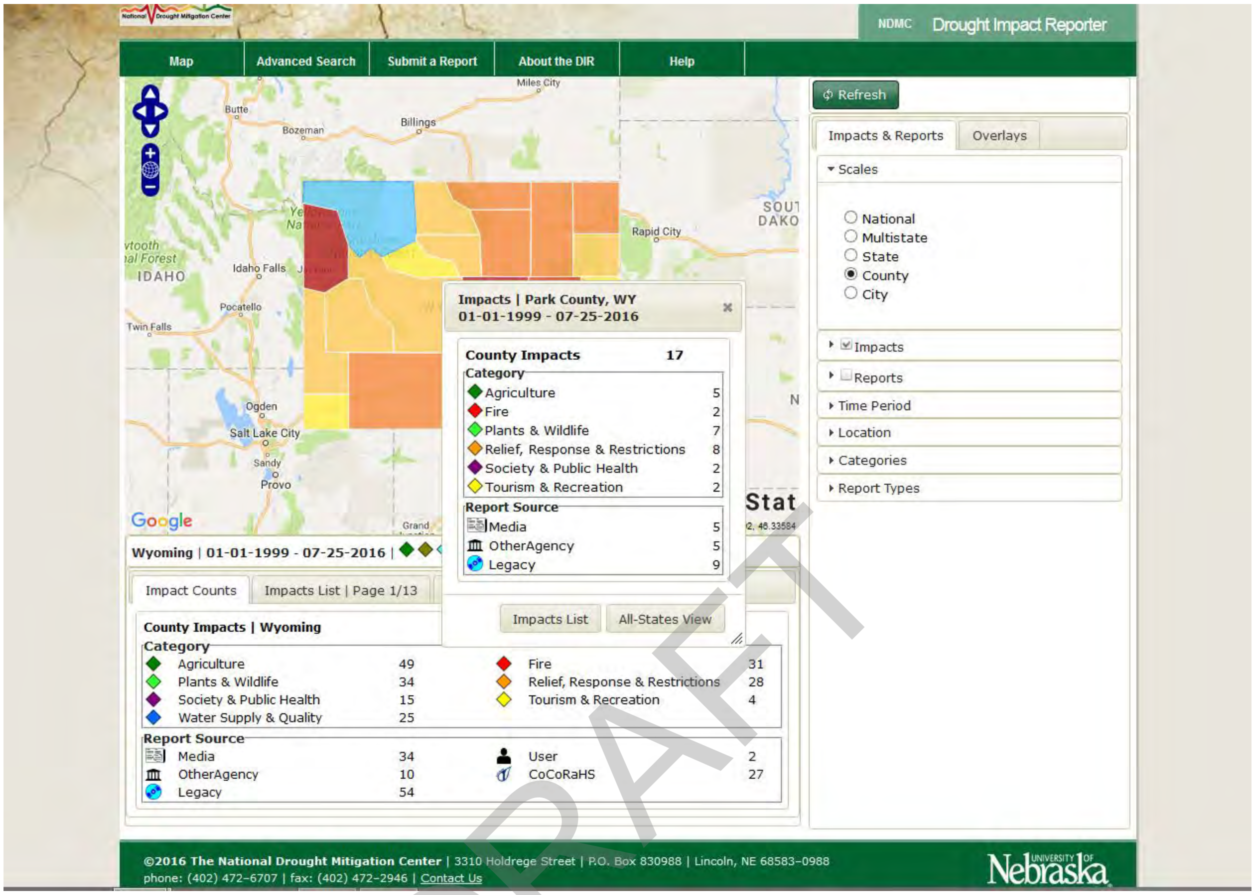
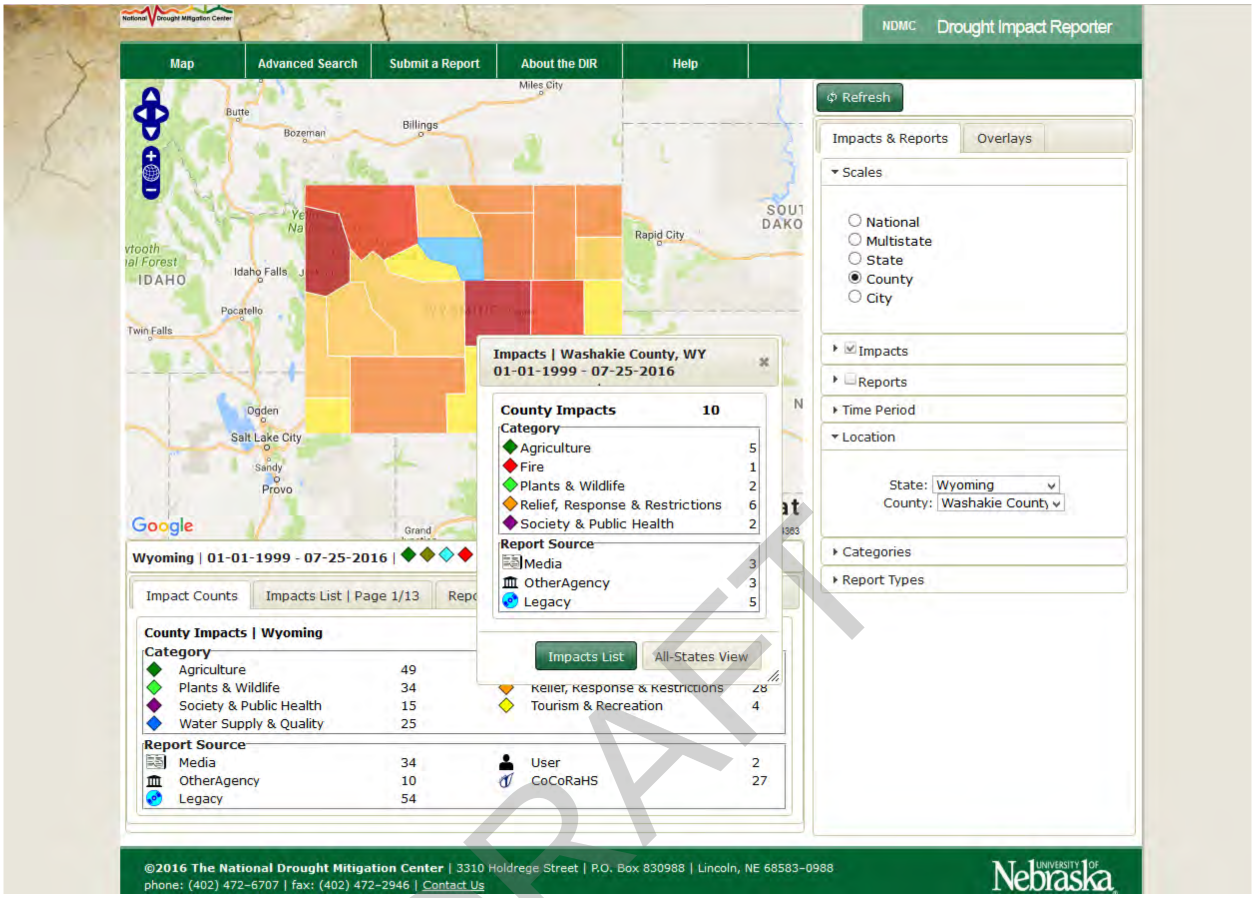


Figure 4.12. Number of Reported Drought Impacts 1999-2016 Washakie County



Some examples of losses during a drought include a July 2012, report regarding the selloff of cattle by Wyoming ranchers. "In the western part of the state, ranchers on Bureau of Land Management property are worried they will be forced to move their livestock earlier than normal because the riparian areas are in such poor shape due to the drought conditions," Magagna (vice president of the Wyoming Stock Grower's Association) said. Many of the people who lease grazing area from the BLM don't have anywhere else to go, Magagna said. (Source: http://trib.com/news/local/state-and-regional/wyoming-ranchers-sell-off-cattle-in-record-amounts-to-cope/article_14a4c30a-a0a1-575c-b1f4-74816a3a5d54.html)

An MSNBC report in February, 2007, stated, "Bighorn Lake in northern Wyoming has lost 30 miles in length over the last 8 years due to drought. Lower lake levels have hurt tourism in the area, although the lake used to draw nearly half a million visitors per year. Less water in the lake means fewer fishermen on the Montana side of Bighorn. Those anglers used to contribute $30 million to the local economy yearly. In Wyoming, the lower water level translates to the Kane boat launch near Lovell remaining closed and no water at the Horseshoe Bend campground and boat ramp." (Source: http://www.msnbc.msn.com/id/16986059)

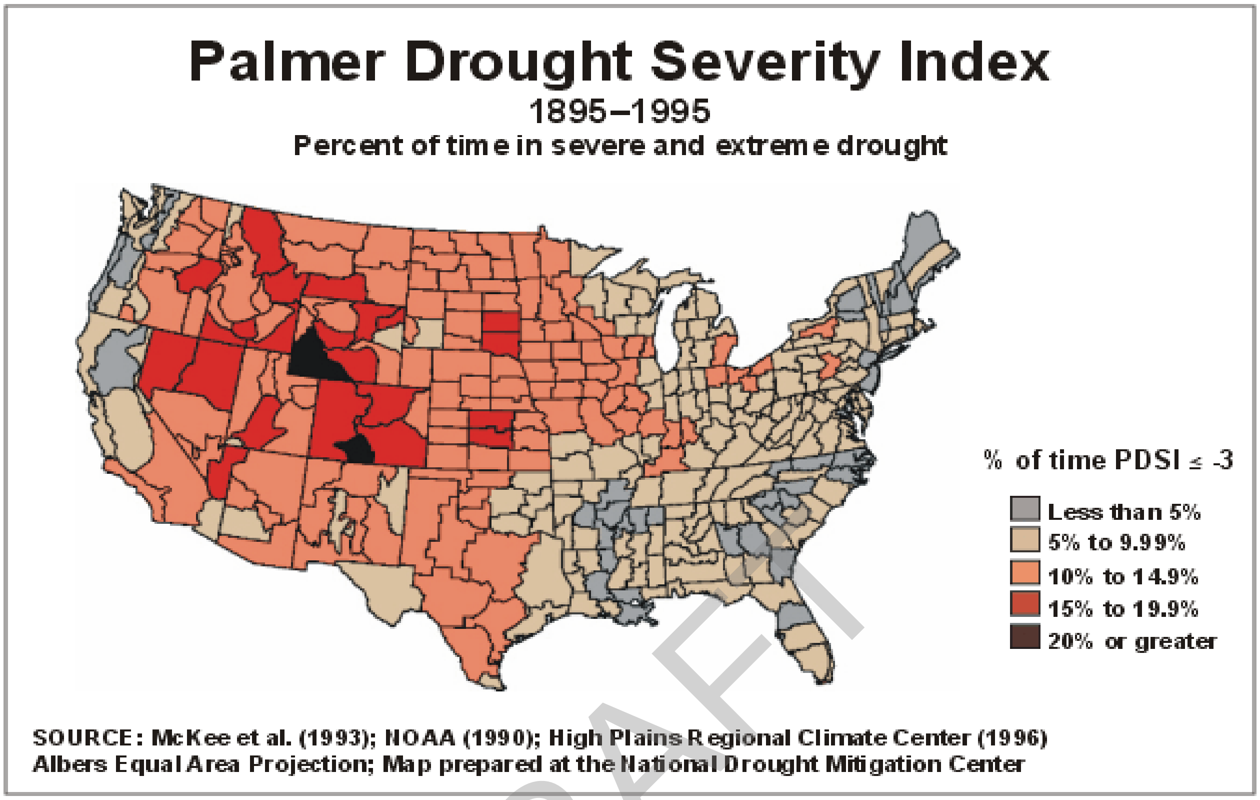
In July, 2004, the Bureau of Land Management announced it would remove 140 wild horses from the Fifteenmile Wild Horse Management Area, as severe drought conditions in the area had reduced natural drinking water sources. "The Fifteenmile HMA is in the midst of a fifth consecutive year of severe drought. Forage and water availability for wild horses is severely limited, and currently is not adequate to sustain the existing wild horse population until the next growing season."

(Source:
http://www.blm.gov/style/medialib/blm/wy/information/NEPA/wfodocs/15mile.Par.55833.File.dat/00dr_fonsi.pdf

Frequency/Likelihood of Future Occurrence

Figure 4.13 indicates that drought occurs approximately every five to 10 years in Region 6. Figure 4.13 indicates the planning area spent approximately 10-15% 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 ten years since the mid-20th century. An occurrence interval of roughly once every ten years corresponds to a **likely** frequency of occurrence. This is consistent with HMPC estimates.

Figure 4.13. Palmer Drought Severity Index 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. 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 4.7 and Table 4.8, the drought of 1999-2004 is as significant, if not more significant than any other droughts in the last 100 years for the entire state. The droughts noted in previously in Table 4.6, derived from the Wyoming Climate Atlas, indicates that the most significant droughts in the last century, in terms of precipitation deficit, were in 1952-1956 and 1999-2004. In order to determine which drought period had the most significant impact on Wyoming, crop production and livestock inventory data for the two periods were compared. 1957 and 2005 were wetter years, with annual statewide precipitation totals above the 1895-2015 average. Those two years were used as endpoints for the droughts that started in 1952 and 1999 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 peak decline (%) in production during drought compared to the 5-year pre-drought production average 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 1999-2004 drought than in the 1952-1956 drought. With the exception of dry beans, all commodities in the worst years of the 1999-2004 drought showed a greater percentage decline in production than in the 1952-1956 drought. As a result, the 1999-2004 drought will be used as the drought of historic record to calculate dollar impacts.

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)	Percent Change
Winter Wheat	5,072	1,000 bu.	2,346	1954	-54%
Spring Wheat	1,579	1,000 bu.	600	1954	-62%
Barley	4,414	1,000 bu.	2,700	1956	-39%
Oats	4,577	1,000 bu.	2,470	1954	-46%
Dry Beans	1,009	1,000 cwt.	589	1955	-42%
Sugarbeets	413	1,000 tons	421	1955	+2%
Corn	227	1,000 bu.	161	1953	-29%
Alfalfa Hay	490	1,000 tons	675	1954	+38%
Other Hay	674	1,000 tons	442	1954	-34%
Cattle/ Calves Inventory	1,050	1,000 head	1,096	1954	+4%

Table 4.8. Peak Commodity Production Changes from Pre-Drought (1994-1998) to Drought (1999-2004)

Commodity	5-Year Pre-Drought Production Average (1994-1998)	Units	Lowest Production During Drought (1999-2006)	Year of Lowest Production (1999-2006)	Percent Change
Winter Wheat	6,029	1,000 bu.	2,375	2002	-61%
Spring Wheat	648	1,000 bu.	96	2002	-84%
Barley	8,383	1,000 bu.	4,680	2002	-44%
Oats	1,648	1,000 bu.	600	2005	-64%
Dry Beans	691	1,000 cwt.	514	2001	-26%
Sugarbeets	1,151	1,000 tons	659	2002	-43%
Corn	6,328	1,000 bu.	4,165	2002	-34%

Commodity	5-Year Pre-Drought Production Average (1994-1998)	Units	Lowest Production During Drought (1999-2006)	Year of Lowest Production (1999-2006)	Percent Change
Alfalfa Hay	1,581	1,000 tons	1,150	2002	-27%
Other Hay	817	1,000 tons	450	2002	-45%
Cattle/ Calves Inventory	1,536	1,000 head	1,300	2004	-16%

Economic Impacts

Agricultural dollar impacts can also be used to show the effects of drought. For the Regional Plan data was obtained from the U.S. Department of Agriculture (USDA) Quick Stats database (https://quickstats.nass.usda.gov). Data was only available at statewide level.

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 impact value versus loss value. For example, with cattle and calves (Table 4.9 through Table 4.17) inventory, the inventory has decreased during the drought. Therefore the value of inventory on hand has decreased. The inventory decreased, however, because of the sale of the cattle and calves. The sales resulted in an increase in cash receipts to the farming and ranching community. The net result, however, is a decrease in inventory value, which is a negative drought impact.

Table 4.9. 1999 Production and Inventory Value Impact

Commodity	5-Year Pre-Drought Production Average (1994-1998)	Units	1999 Production	Value (USD)	Production and Inventory Value Impact (USD)
Winter Wheat	6,029	1,000 bu.	6,105	$2.12/bu	+ 161,120
Spring Wheat	648	1,000 bu.	264	$2.54/bu	- 976,376
Barley	8,383	1,000 bu.	7,310	$3.03/bu	- 3,251,190
Oats	1,648	1,000 bu.	1,539	$1.45/bu	- 158,050
Dry Bean	691	1,000 cwt.	788	$16.00/cwt	+ 1,555,200
Sugar Beet	1,150	1,000 tons	1,205	$39.00/ton	+ 2,145,000
Corn	6,328	1,000 bu.	6,136	$1.94/bu	- 372,480
Alfalfa Hay	1,581	1,000 tons	1,782	$67.00/ton	+ 13,467,000
Other Hay	817	1,000 tons	1,008	$60.00/ton	+ 11,436,000
Cattle/Calves Inventory	1,536	1,000 head	1,580	$770.00/head	+ 33,880,000
TOTAL					**+$57,886,224**

Table 4.10. 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
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**

Table 4.11. 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**

Table 4.12. 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
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**

Table 4.13. 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**

Table 4.14. 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**

Table 4.15. 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**

Table 4.16. 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**

Table 4.17. 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**

The 1999-2004 drought can be shown to be the drought of historic record. There have been significant impacts on the agricultural industry from the 1999-2004 drought. The worst-case year was 2002, with a negative dollar impact of $308,171,390 statewide. Region 6 is 14.7% of the State of Wyoming in land area. If it is assumed that the drought impact is equally distributed across the state, which in reality it is not, the potential drought impact in Region 6 for 2002 would be approximately $45,301,194. The total impact statewide for the 1999-2004 drought is $903,649,936. If it is assumed that the drought impact is equally distributed across the state, which in reality it is not, then the potential drought impact in Region 6 would be approximately $132,836,540.

Additionally, drought can exacerbate the risk of wildfires; increase the cost of municipal water usage; and deplete water resources used for recreation, affecting the economy.

Vulnerability Assessment

The vulnerability of the people, buildings, and economy of Region 6 to drought is very difficult to quantify. Typically, people and structures are not directly vulnerable to drought, though secondary or indirect impacts may eventually increase vulnerability ratings. However, some areas are more vulnerable overall than others and, therefore, benefit from adequate mitigation planning and implementation. For Region 6, the agricultural sector is the most vulnerable to drought and will benefit the most from mitigation efforts. Economic resources tied to agricultural production are extremely vulnerable to drought. Outdoor recreation, which is important to the Region 6 economy, is also vulnerable to drought. The geographic extent of the hazard is considered extensive. The probability of future occurrences is considered **likely to high**, and the potential magnitude/severity is **high**. In addition, the HMPC considers the hazard to have an overall impact rating of **high** for the County.

Future Development

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

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.

Table 4.18. Drought Hazard Risk Summary

County	Geographic Extent	Probability of Future Occurrence	Potential Magnitude/ Severity	Overall Significance
Big Horn	Extensive	Likely	Limited	Medium
Hot Springs	Extensive	Likely	Critical	High
Park	Extensive	Likely	Critical	High
Washakie	Extensive	Likely	Critical	High

4.2.5 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 and 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. 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 and Table 4.20). Seismic shaking is typically the greatest cause of losses to structures during earthquakes.

Table 4.19. Modified Mercalli Intensity (MMI) Scale

MMI	Felt Intensity
I	Not felt except by a very few people under special conditions. Detected mostly by instruments.
II	Felt by a few people, especially those on upper floors of buildings. Suspended objects may swing.
III	Felt noticeably indoors. Standing automobiles may rock slightly.
IV	Felt by many people indoors, by a few outdoors. At night, some people are awakened. Dishes, windows, and doors rattle.
V	Felt by nearly everyone. Many people are awakened. Some dishes and windows are broken. Unstable objects are overturned.
VI	Felt by everyone. Many people become frightened and run outdoors. Some heavy furniture is moved. Some plaster falls.

MMI	Felt Intensity
VII	Most people are alarmed and run outside. Damage is negligible in buildings of good construction, considerable in buildings of poor construction.
VIII	Damage is slight in specially designed structures, considerable in ordinary buildings, great in poorly built structures. Heavy furniture is overturned.
IX	Damage is considerable in specially designed buildings. Buildings shift from their foundations and partly collapse. Underground pipes are broken.
X	Some well-built wooden structures are destroyed. Most masonry structures are destroyed. The ground is badly cracked. Considerable landslides occur on steep slopes.
XI	Few, if any, masonry structures remain standing. Rails are bent. Broad fissures appear in the ground.
XII	Virtually total destruction. Waves are seen on the ground surface. Objects are thrown in the air.

Source: USGS. http://earthquake.usgs.gov/learn/topics/mercalli.php

Table 4.20. Modified Mercalli Intensity (MMI) Scale and Peak Ground Acceleration

MMI	Acceleration (%g) (PGA)
I	<0.17
II	0.17 – 1.4
III	0.17 – 1.4
IV	1.4 – 3.9
V	3.9 – 9.2
VI	9.2 – 18
VII	18 – 34
VIII	34 – 65
IX	65 – 124
X	>124
XI	>124
XII	>124

Source: 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 Washakie County and the historical earthquake record is short, accurate estimations of magnitude, timing, or location of future dangerous earthquakes in the County 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

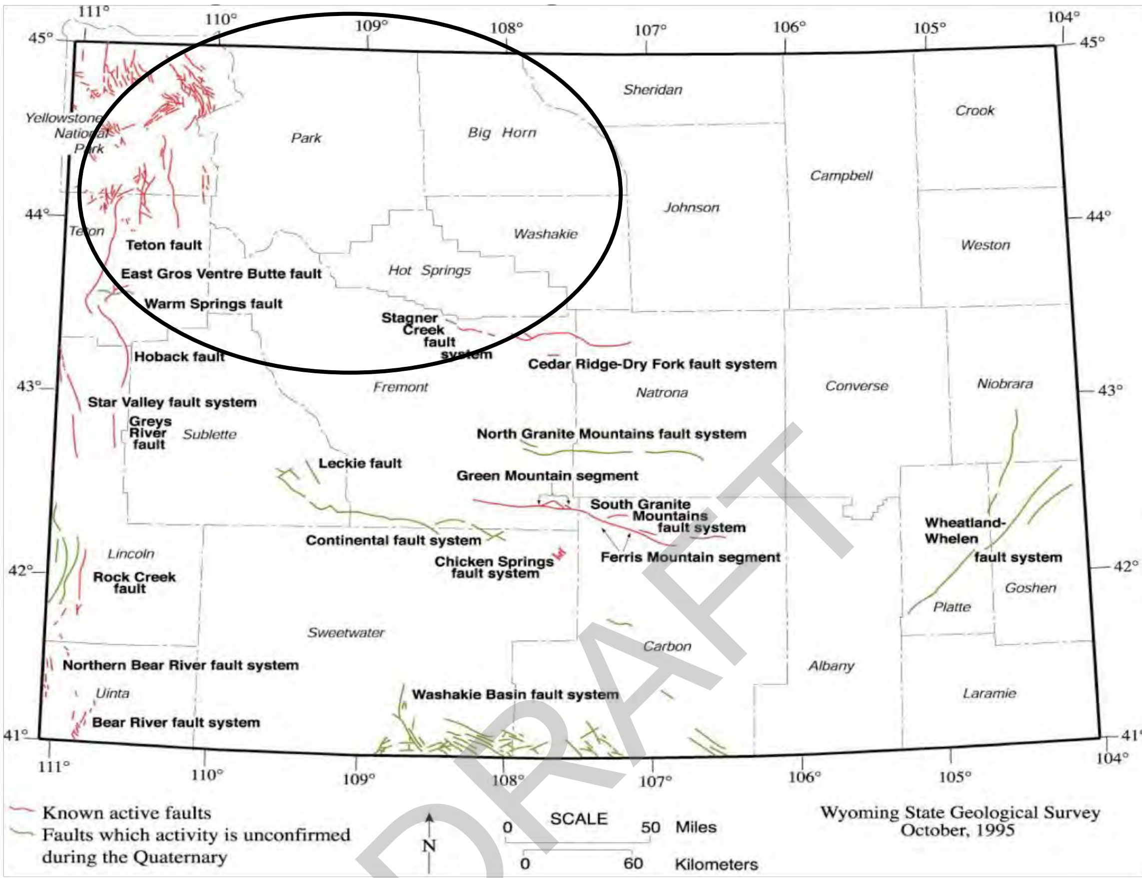
Yellowstone National Park is partially within the Region and one of the more seismically active areas in the United States. Most Wyoming earthquakes outside of Yellowstone National Park occur as a result of movement on faults. If the fault has moved within the Quaternary geological period, or last 1.6 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). Most of the exposed active faults are outside of Region 6. The

Teton fault, Star Valley fault, Greys River fault, Rock Creek fault, and the Bear River fault system in western Wyoming are capable of generating magnitude 7.0 to 7.5 earthquakes, and are considered to be overdue for reactivation. In central Wyoming, 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. Earthquake risks related to Boysen Dam are of concern to Region 6 counties as explained in the dam failure section of this plan.

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).

Figure 4.14. Exposed Known or Suspected Active Faults in Wyoming



Source: Wyoming Geological Survey

A fault system called the Cedar Ridge/Dry Fork fault system is present near the southern border of Washakie County in Natrona and Fremont Counties near Lysite. The 35-mile long Cedar Ridge fault comprises the western portion of the fault system, and the 15-mile long Dry Fork fault makes up the eastern portion. The only Pleistocene-age movement on the fault system was found in northeastern Fremont County (T39N R92W NE ¼ Section 10). A short scarp on the Cedar Ridge fault, approximately 0.8 miles long, was identified at that location. Since the entire fault system is approximately 50 miles long, and only one small active segment was discovered, Geomatrix (1988a) stated that the "age of this scarp and the absence of evidence for late Quaternary faulting elsewhere along the Cedar Ridge/Dry Creek fault suggest that this fault is inactive."

There is also no compelling reason to believe that the Cedar Ridge fault system is active. Based upon its fault rupture length of 35 miles, however, if the fault did activate it could potentially generate a maximum magnitude 7.1 earthquake (Wong et al., 2001). A magnitude 7.1 event could generate peak horizontal accelerations of approximately 7.4%g at Big Trails, approximately 3.8

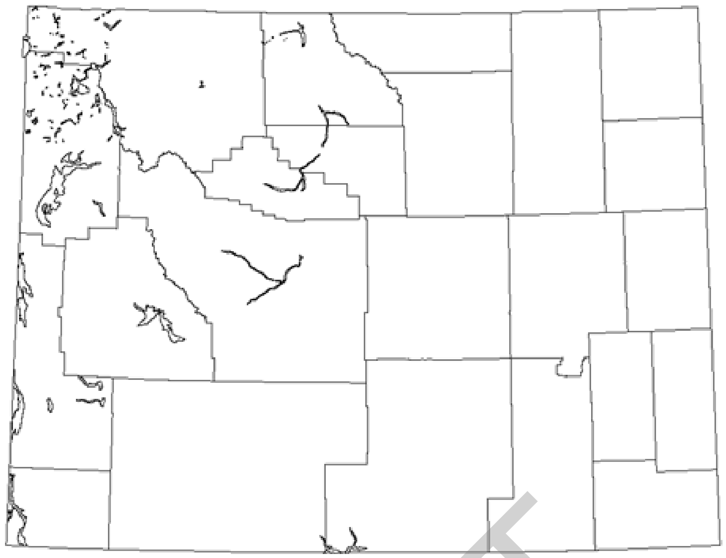
%g at Ten Sleep, and approximately 3.7%g at Worland (Campbell, 1987). Those accelerations would be roughly equivalent to an intensity V earthquake at Big Trails and intensity IV earthquakes at Ten Sleep and Worland. Minor damage could occur at Big Trails.

Although there is no compelling reason to believe that the Dry Fork fault system is active, if it did activate as an isolated system, it could potentially generate a magnitude 6.7 earthquake. This is based upon a postulated fault rupture length of 15 miles (Wong et al., 2001). A magnitude 6.7 earthquake on the fault system could generate peak horizontal accelerations of approximately 4.5%g at Big Trails, approximately 2.9%g at Ten Sleep, and approximately 2%g at Worland (Campbell, 1987). Those accelerations would be roughly equivalent to an intensity V earthquake at Big Trails and intensity IV earthquakes at Worland and Ten Sleep. Minor damage could occur at Big Trails. Again, there is no compelling reason to believe that the Dry Fork fault system is active.

Despite the lack of potentially active faults in Region 6, it is estimated that an earthquake of 6.5 magnitude is possible anywhere in the state (Source: Wyoming Multi-Hazard Mitigation Plan, 2016).

Figure 4.15 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. Portions of the Bear River Valley, Star Valley, Snake River Valley, Yellowstone National Park, Yellowstone River Valley, and the New Fork River Valley, as well as portions along the Wind and Bighorn rivers, have the necessary components to experience liquefaction.

Figure 4.15. Wyoming Liquefaction Coverage



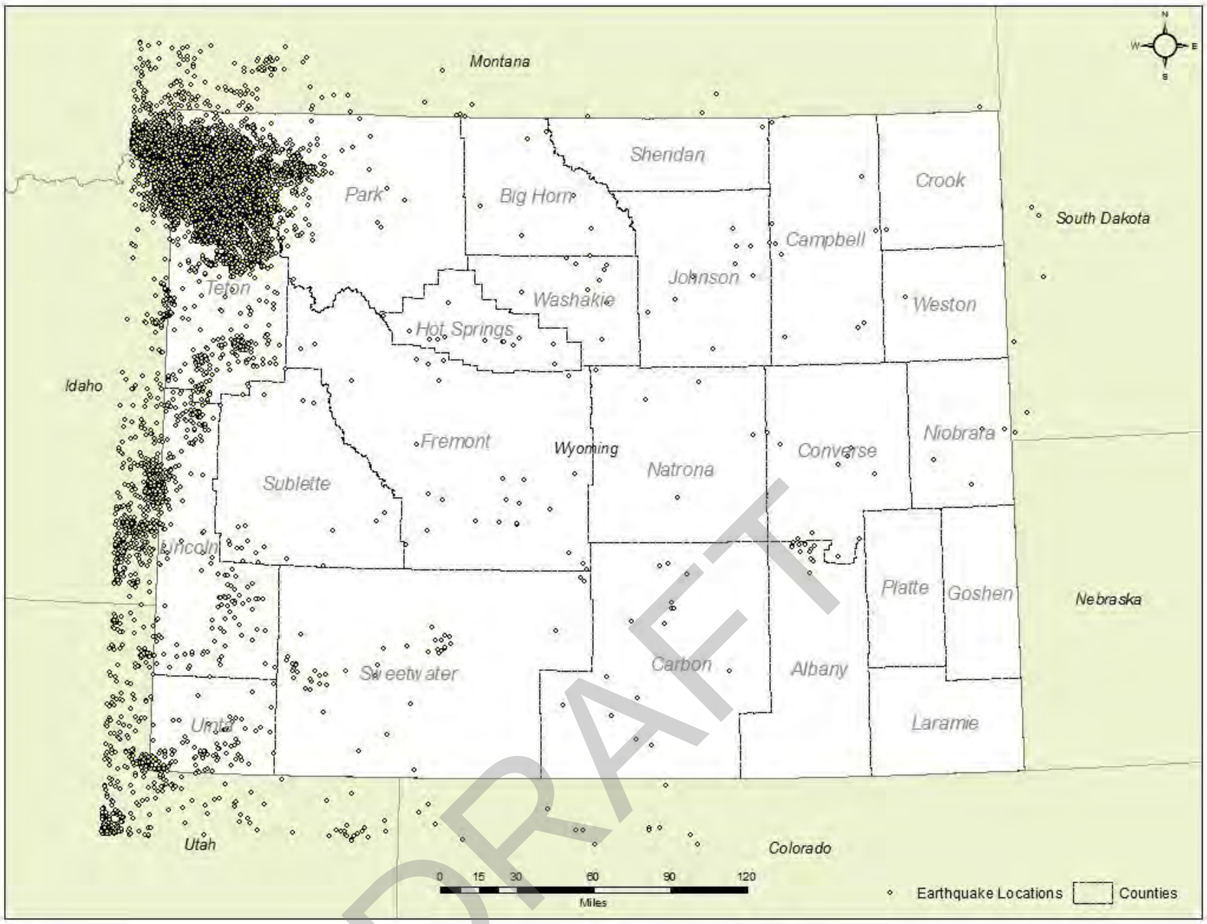
Source: Wyoming Geological Survey

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 4.16) where the majority of the active, or Quaternary Period, faults are identified.

Figure 4.16. Wyoming Historic Earthquake Occurrences Statewide Since 1963- 2010



Source: Wyoming Geological Survey - Wyoming Earthquake Hazard and Risk Analysis: HAZUS-MH Loss Estimations for 16 Earthquake Scenarios Report

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. Ten magnitude 4.8 and greater earthquakes have been recorded in the Region since 1973, all of which were in Park County and Yellowstone National Park. These earthquakes are noted in the tables below and discussed in further detail below by county. Another 4.9 earthquake occurred in Washakie County in 1970.

Table 4.21. Earthquakes Greater than 2.5 in Region 6: 1973-August 2016

County	Magnitude 2.5-2.9	3-3.9	4.0-5.8
Big Horn	1	1	0
Hot Springs	0	3	1
Park	73	135	350
Washakie	2	2	1

Source: Analysis of data from USGS Earthquake Hazards Program

Table 4.22. Highest Magnitude* Earthquakes in Region 6: 1973-June 2016

County	Magnitude	Date
Park	5.9	1975-06-30
Park	5.5	1976-12-08
Park	5.3	1976-10-19
Park	5.3	1976-10-19
Park	5.1	1975-6-30
Park	4.9	1976-12-19
Park	4.9	1976-12-09
Park	4.9	1975-06-30
Park	4.9	1974-06-09
Park	4.8	2014-03-30

*Based on instrumentally recorded earthquakes. Source: USGS Earthquake Hazards Program

Washakie County

The first earthquake recorded in Washakie County occurred on December 12, 1970. This magnitude 4.9 event was centered approximately 8 miles southwest of Ten Sleep. No damage was reported.

On September 19, 1974, a magnitude 4.4, intensity V earthquake occurred approximately 6 miles north-northwest of Ten Sleep. Residents reported that shock waves were felt in the Ten Sleep Canyon area (Casper Star-Tribune, September 21, 1974).

A magnitude 3.5 earthquake was detected approximately 10 miles south of Ten Sleep on November 16, 1993. No damage was reported from the event.

A magnitude 3.3 earthquake occurred in Washakie County on April 5, 2002. The earthquake's epicenter was located approximately 10 miles southwest of Worland. Although the Washakie County Emergency Management agency reported ground shaking, the earthquake did not cause any damage.

Park County

Park County includes portions of Yellowstone National Park, one of the most volcanically and seismically active regions in the United States. Many known active faults are exposed in the greater Yellowstone area and thousands of earthquakes have been recorded inside the Park boundaries since the late 1800s. Two significant earthquake swarms have occurred in Yellowstone Park in recent years. The first occurred between December 2008 and January 2009. The second earthquake swarm began on January 15, 2010, diminished to near-background levels by the end of February, 2010 and picked up somewhat in early April, 2010. These earthquakes were not significant in terms of damage or magnitude, but were noted because of their frequency in a short period of time. Smaller earthquake swarms occur in Yellowstone Park relatively frequently and are not necessarily signs of an imminent eruption or major earthquake (Wyoming Hazard Mitigation Plan 2016).

The first earthquake recorded in Park County occurred on February 2, 1920. This intensity III event was located in north-central Park County, approximately 18 miles northwest of Cody. People reported feeling it and hearing a rumbling sound (Humphreys, 1921).

On October 3, 1944, an intensity IV earthquake occurred in south-central Park County approximately six miles north of Pitchfork. Several people in Yellowstone National Park and at Flag Ranch reported feeling three distinct tremors that rattled dishes and canned goods, swung suspended objects, and even caused buildings to sway. "Subterranean sounds" were also reported from the Flag Ranch (Bodle, 1946).

Two earthquakes occurred in Park County during the 1950s. The first was recorded on April 10, 1950, 18 miles north of Wapiti. This intensity IV event shook lamps, rattled loose objects, and caused buildings to creak (Murphy and Ulrich, 1952). On April 25, 1952, an intensity III earthquake occurred approximately 35 miles west-northwest of Clark near the Wyoming/Montana border. The earthquake lasted for a few seconds and was felt by only one person (Murphy and Cloud, 1954).

Four earthquakes occurred in Park County during the 1960s. All four were recorded in western Park County near the Yellowstone National Park border. No one reported feeling the earthquakes (U.S.G.S. National Earthquake Information Center). The March 22, 1963 event was reported approximately 40 miles west-northwest of Clark in the extreme northwestern corner of Park County. On June 25, 1963, a magnitude 4.2 earthquake occurred 22 miles southwest of Valley. A magnitude 3.6 earthquake was recorded on May 15, 1965, approximately 22 miles southwest of Valley. Another magnitude 3.6 earthquake occurred 25 miles north-northwest of Wapiti on January 21, 1967.

On April 21, 1973, a magnitude 4.4 earthquake was recorded on the western edge of Park County approximately 36 miles west-northwest of Wapiti. People in the area reported feeling the earthquake (Coffman et al., 1975). On January 16, 1980, a magnitude 2.6 earthquake occurred 20 miles north-northwest of Wapiti. No one reported feeling this event (U.S.G.S. National Earthquake Information Center).

Two earthquakes occurred in the county during the 1990s. A magnitude 3.6 earthquake was recorded on January 1, 1994, and a year later, a magnitude 3.7 earthquake was felt on January 17, 1995. The earthquakes had epicenters approximately 29 and 28 miles west-northwest of Wapiti, respectively. No damage was reported and nobody reported feeling either event (University of Utah Seismograph Station Epicenter Listings).

Big Horn County

Several earthquakes have also occurred near Washakie County in surrounding counties. The first occurred on November 17, 1925, in the southeastern portion of Big Horn County. This intensity V event was located approximately 23 miles north of Ten Sleep. People in Ten Sleep, Sheridan, Fort McKenzie, and at Dome Lake Resort in the Big Horn Mountains reported feeling the earthquake tremors. The tremors shook cabins, pictures, and furniture. A “distinct roar” heard at Dome Lake was attributed to a possible earthquake-induced landslide (Casper Daily Tribune, November 18, 1925). No damage was reported.

Hot Springs County

The first earthquake that was reported in Hot Springs County occurred on February 13, 1928, approximately 10 miles south of Thermopolis. The intensity IV earthquake was felt as three shocks in Thermopolis, and was “felt sharply” in Worland, Owl Creek, Gebo, Crosby, and Kirby. It was also strongly felt at a mine in the Copper Mountain mining district near Bonneville. Reports indicate that two men entered their mine when aftershocks were occurring and found that many of the mine props were so loose that they could be moved by hand (Heck and Bodle, 1930).

On June 19, 1928, another intensity IV earthquake was reported in the area, with the epicenter located approximately 6 miles northwest of Thermopolis (Heck and Bodle, 1930). A single shock from this event was felt in Thermopolis, with sounds slightly preceding the earthquake.

Two earthquakes occurred in Hot Springs County in the 1940s. On October 11, 1944, an intensity IV earthquake was reported approximately 3 miles south of Thermopolis. Several landslides occurred as a result of the earthquake, and rocks fell onto the highway in Wind River Canyon. At Hot Springs State Park, there was a “caving of earth on the south rim of the large hot spring in the park” (Casper Tribune-Herald, October 13, 1944). Yet another intensity IV earthquake occurred in the same area on January 26, 1946. This event, which was felt for approximately ten seconds, rattled windows and dishes and clouded the water in Hot Springs State Park for a few days (Laramie Republican-Boomerang, January 29, 1946).

On January 23, 1950, an intensity V earthquake was felt near Hamilton Dome, approximately 22 miles northwest of Thermopolis. Houses shook and dishes rattled in the Hamilton Dome area, and the earthquake was felt in Thermopolis (Murphy and Ulrich, 1952). Another intensity V earthquake occurred approximately 3 miles south of Thermopolis on January 31, 1954 (Casper Tribune-Herald, February 2, 1954). No damage was reported from this event.

One of the largest earthquakes recorded in the Thermopolis area occurred on December 8, 1972. The magnitude 4.1, intensity V earthquake was centered approximately eight miles west of Thermopolis. It caused two cracks in the ceiling of a new addition to a Thermopolis rest home (Laramie Daily Boomerang, December 9, 1972), and the floor in a local lumberyard sank a few inches (Casper Star-Tribune, December 9, 1972). The earthquake was felt in Kinnear, Pavillion, and the Riverton area, and was reportedly felt as far away as Craig, Colorado.

On June 6, 1978, a magnitude 4.0 earthquake was recorded approximately 20 miles east of Thermopolis (Reagor, Stover, and Algermissen, 1985). No damage was associated with that earthquake.

On April 5, 2002 an earthquake of undetermined magnitude occurred in western Hot Springs County. The earthquake's epicenter was located approximately 11 miles northeast of Kirby. Although the Hot Springs County Emergency Management agency reported ground shaking, the earthquake did not cause any damage.

Nearby Counties

The largest earthquake recorded in the greater Yellowstone region occurred on August 17, 1959. This magnitude 7.5, intensity X event occurred outside Yellowstone National Park, near Hebgen Lake, in southwestern Montana. The event triggered a landslide that dammed the Madison River and created Earthquake Lake. Twenty-eight people lost their lives; most of them were buried in the campground located beneath the landslide. Numerous aftershocks, some as big as magnitude 6.5, occurred within or near Yellowstone National Park. The largest earthquake that occurred inside Yellowstone National Park boundaries was on June 30, 1975. This magnitude 6.4, intensity VII, event caused landslides and large cracks in the ground.

The most recent significant earthquake since the last plan update occurred in Fremont County September 21, 2013. The epicenter of the M4.9 earthquake was nine miles west of Ft. Washakie, Wyoming. The USGS event 'Did You Feel It?' web page shows 217 people went on line to say they felt the quake, with a maximum intensity IV reported (Wyoming Hazard Mitigation Plan 2016).

On April 12, 1966, an earthquake of no specified magnitude or intensity was detected in Johnson County approximately 22 miles northeast of Ten Sleep. No one reported feeling this event (U.S.G.S. National Earthquake Information Center).

Two earthquakes were recorded in northern Fremont County on April 26, 1967. A magnitude 4.7 event and a magnitude 4.2 event occurred approximately 32 miles southwest and approximately

38 miles west-southwest of Thermopolis, respectively (Reagor, Stover, and Algermissen, 1985). No damage was associated with either earthquake.

On August 7, 1991, a magnitude 3.5 earthquake was recorded in northern Fremont County, approximately 35 miles southwest of Thermopolis. This non-damaging earthquake was felt in Thermopolis.

A magnitude 3.0 earthquake occurred on November 8, 2000, in northeastern Fremont County. This event was centered approximately 29.5 miles southeast of Thermopolis. No one reported feeling this earthquake (U.S.G.S. National Earthquake Information Center).

Another earthquake occurred in Johnson County on August 30, 1992. This magnitude 3.6, intensity IV earthquake was centered near Mayoworth, approximately 23 miles east-southeast of Big Trails. It was felt in Barnum and Kaycee, but no damage was reported.

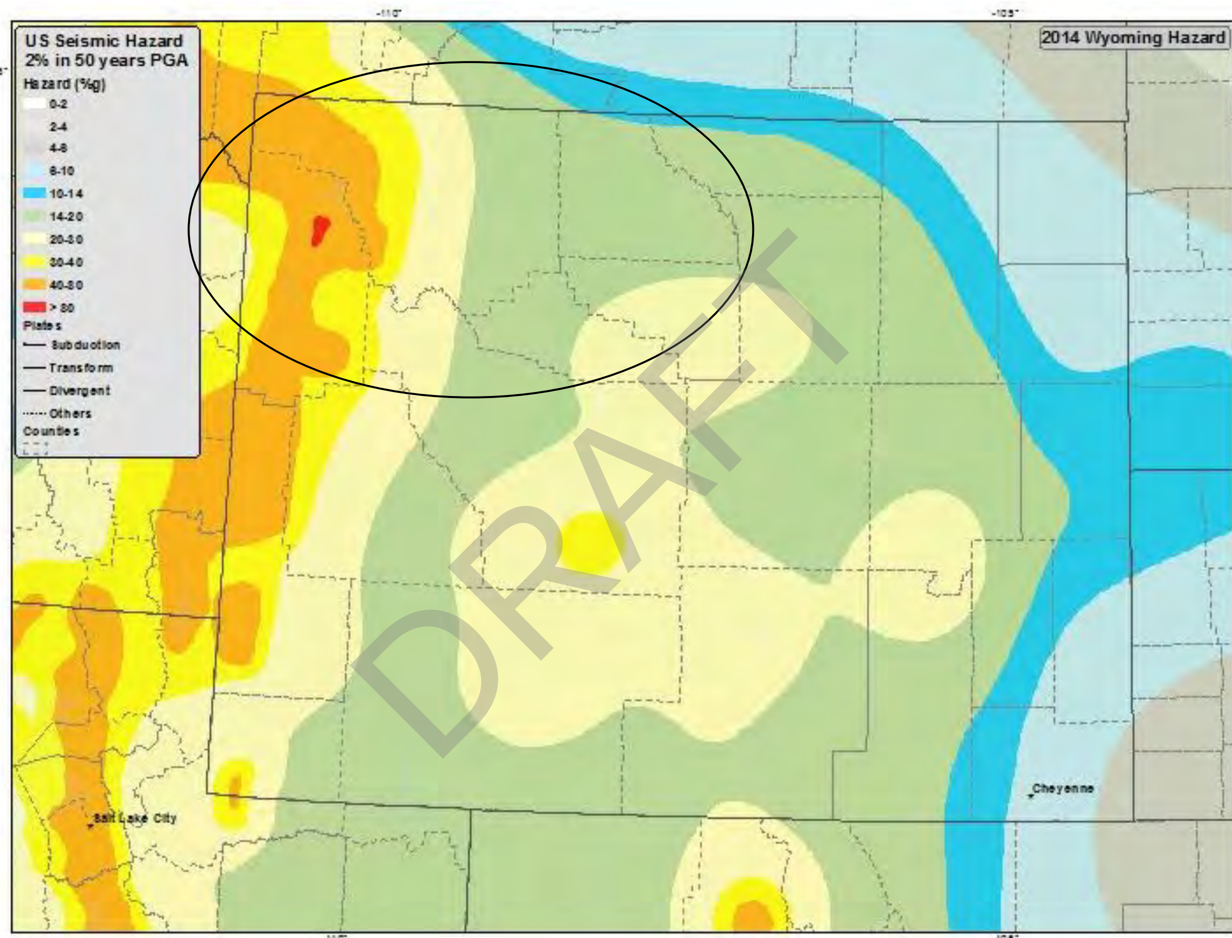
On November 9, 1999, the U.S.G.S. National Earthquake Information Center reported a 3.10 earthquake in northwest Natrona County. This event was centered approximately 21 miles south-southwest of Big Trails. No one reported feeling the earthquake. Finally, a magnitude 3.0 earthquake was detected in northeastern Fremont County on November 7, 2000 (U.S.G.S. National Earthquake Information Center). The earthquake's epicenter was located approximately 29 miles southwest of Big Trails. Again, no one reported feeling this event.

Frequency/Likelihood of Future Occurrence

Based on past occurrences the Region is likely to experience one 3.0 or greater earthquake approximately every ten to fifteen years; however also based on past occurrences, the earthquakes are likely to cause little to no damage. This equates to between 1 and 10 percent chance of occurring in the Region in the next year, or an **occasional** occurrence rating. 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 county. Because of the uncertainty involved, and based upon the fact that the new 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 4.17. 2500-year probabilistic acceleration map (2% probability of exceedance in 50 years) – Region 6 in oval



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, with damage increasing from the northwest to the east. More specifically, the probability-based worst-case scenario could result in the following damage at points throughout the counties in the Region, expressed in terms of earthquake Modified Mercalli Intensity:

Intensity VII Earthquake Areas: In intensity VII earthquakes, damage is negligible in buildings of good design and construction, slight-to-moderate in well-built ordinary structures, considerable in poorly built or badly designed structures such as un-reinforced masonry buildings. Some chimneys will be broken.

- Hot Springs
  - East Thermopolis
  - Thermopolis
- Washakie
  - Big Trails
  - Ten Sleep
- Park
  - Valley
  - Wapiti

Intensity VI Earthquake Areas: In intensity VI earthquakes, some heavy furniture can be moved. There may be some instances of fallen plaster and damaged chimneys.

- Hot Springs
  - Gebo
  - Grass Creek
  - Hamilton Dome
  - Kirby
  - Lucerne
- Washakie
  - Worland
- Park
  - Clark
  - Cody
  - Elk Basin
  - Garland
  - Meeteetse
  - Pitchfork
  - Powell

<u>Intensity V Earthquake Areas:</u> Intensity V earthquakes are characterized by moderate shaking with very light damage. Dishes and windows can break and plaster can crack. Unstable objects may overturn. Tall objects such as trees and power poles can be disturbed.

- Big Horn
  - Cowley
  - Deaver
  - Frannie

Vulnerability Assessment

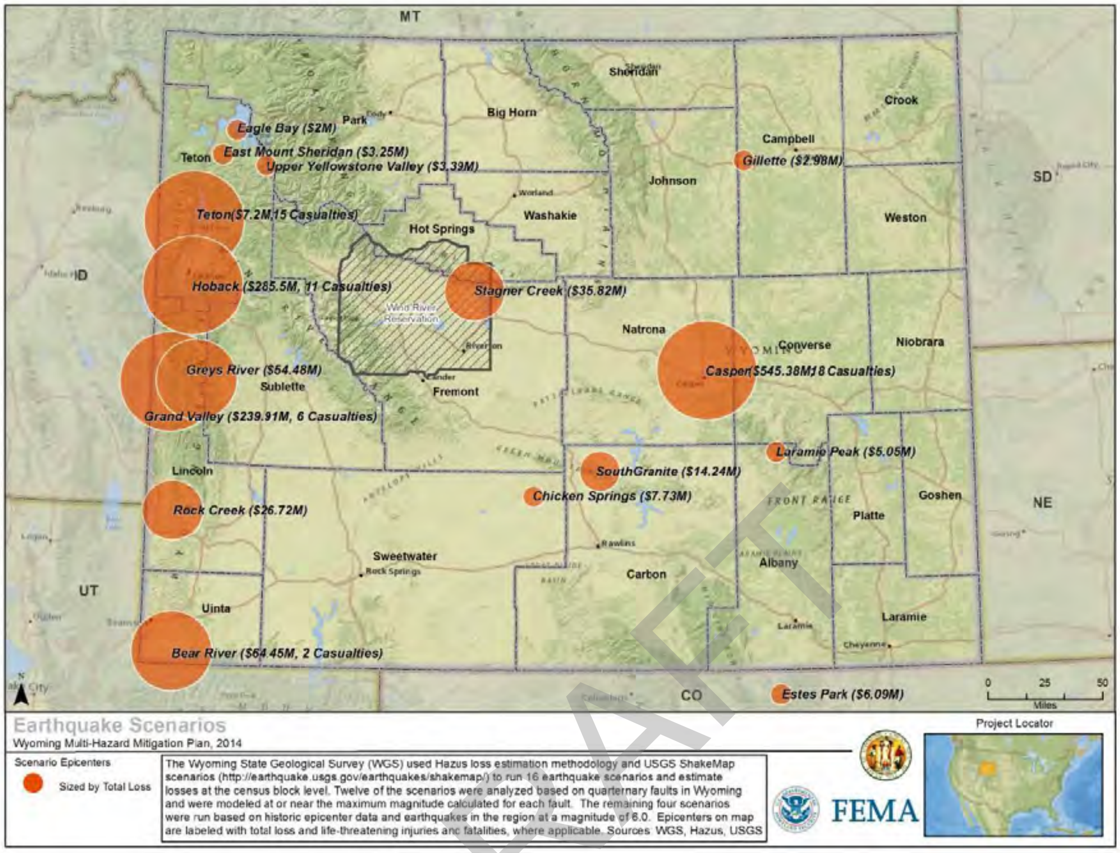
The Wyoming State Geological Survey conducted a study in 2011 to model loss estimations for 16 earthquake scenarios in order to quantify the magnitude of earthquake impacts around the state. The scenarios included four random event scenarios run on the basis of data from historic earthquakes that occurred 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 4.18 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. None of the scenarios modeled indicated losses in Big Horn County

Figure 4.18. HAZUS-MH Earthquake Scenarios for Wyoming, 2011



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

Fault Based Scenario – Region 6

Of the 16 modeled scenarios the Stagner Creek fault scenario had the most impact on the Region. The earthquake scenario was modeled at magnitude 6.75. The earthquake would cause damage in Fremont, Hot Springs, Park, and Washakie Counties. Scenario results estimate that very light damage would be expected up to 45 miles from the epicenter, including Worland and Jeffrey City (Figure 4.18). Light damage would be expected as far as 30 miles, including the towns of Riverton, Thermopolis and Kirby. The total population in the scenario region is 45,719 based on the 2000 census. The scenario results estimate that of the 45,719 people 14 households would be displaced, and eight people would seek temporary shelter. There are 25,836 buildings in the area and scenario results show that 1,198 of those would sustain at least moderate damage from the earthquake. The earthquake would generate 17,000 tons of debris.

Thermopolis schools would range from 65-68% functional at day one, with the exception of the Big Horn Basin Children's Center which would be 77% functional. The schools in Thermopolis, except for the Big Horn Basin Children's Center, would be 80% functional by day 7 and fully functional by day 30. The remaining schools in the area would greater than 86% functional at day 1 and most would be fully functional by day 7.

The modeled earthquake on the Stagner Creek fault system would cause a total economic loss of $53.15 million dollars for the region. Direct economic losses are estimated in three categories: buildings, transportation, and utilities. Estimated ground shaking levels are described for essential facilities

Buildings

Direct economic losses for buildings, which include structural and content damage, would total $35.819 million dollars for the region. Hot Springs County would experience the greatest loss at $17.195 million dollars, while Fremont County is modeled to have $16.805 million dollars in losses. Washakie County is predicted to have 1.812 million dollars of loss, and Park County would have less than 10 thousand dollars in losses.

Transportation

Fremont County would have the highest transportation losses at $2.393 million dollars. The losses include damage to highways, bridges, and facilities for railways, buses, and airports. Hot Springs County would expect $942 thousand dollars in losses to bridges, railway segments and airport facilities. Washakie County would have $111 thousand dollars in losses to bridges and airport facilities. Park County would not be expected to incur direct economic losses for transportation systems.

Utilities

The regional direct economic loss for utilities would be $13.884 million dollars. Hot Springs County would have the highest losses to utilities, totaling $7.377 million dollars. Losses to potable water, waste water, and natural gas facilities and pipelines, along with communication facilities would be expected. Fremont County's losses are predicted to be to the same utility types as Hot Springs County; however the losses would be $6.123 million dollars. Washakie County's loss estimation would be $378 thousand dollars; the losses come from potable water pipelines, and waste water and natural gas pipelines and facilities. Less than $10 thousand dollars of losses are expected for Park County.

Essential Facilities

Essential facilities include fire stations, hospitals, police stations, and schools. Several details on the estimated impacts to these facilities can be referenced in the WYGS report. Of note the Thermopolis VFD is predicted to experience strong shaking (17%g) and would have a 33% chance of sustaining at least slight damage. The remaining fire stations in the region would expect moderate shaking, however little or no damage is predicted. Of the five hospitals in the region only the Hot Springs County Memorial Hospital would experience strong shaking (17%g). The probability of at least slight damage at the Hot Springs County Memorial Hospital would be 44%, and the hospital would have a 29% chance of sustaining at least moderate damage. The other hospitals in the region would expect moderate ground motions, but the probability for at least slight damage would be 12% or less. The Thermopolis PD HQ and the Hot Springs County SD are expected to experience strong shaking (17%) and have a 33% probability of sustaining at least slight damage. In Thermopolis schools would undergo strong ground shaking (17%g). The Big Horn Basin Children's Center would have the lowest probabilities of damage, 23% chance of slight and 5% chance of moderate, while the other schools in Thermopolis would have a 32-35% chance of slight damage and a 18-21% chance of moderate damage. The remaining schools in the region are predicted to experience moderate to strong shaking, but probabilities of slight damage are less than 15%.

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 a.m., 2 p.m., and 5 p.m. 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 4.23. 2500-Year Probabilistic Scenario Loss Estimates, 2015 Valuations

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	30-Oct
2	Lincoln	$528	63%	190-220	50-60	0-20	20-Oct
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.

Consideration may be given to the higher seismic risk of Boysen Dam located in Fremont County and the Buffalo Bill Cody Dam in Park County and bordering Yellowstone National Park. Should either of those Bureau of Reclamation dam structures fail, impacts to all counties in the Region through flooding on the Big Horn or Shoshone Rivers would result in minor to significant damage to the counties and towns along those waterways. Readers should refer to the Dam Failure Profile of this Plan for further discussion.

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. If it were to occur it would most likely affect isolated areas of Park County within Yellowstone National Park, and could affect roads and infrastructure.

Future Development

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

Summary

In summary, within Region 6 Park County and Hot Springs County have higher risk due to the closer proximity of potentially active faults within and near these counties. It is estimated that if a worst-case event occurred in Park County, $79 million in combined capital stock and income losses could occur. HAZUS estimates that 3,222 buildings (64% of the total in the county), would be at least moderately damaged, and an estimated 379 buildings would be completely destroyed. Though the probability is low, WSGS studies indicate the possibility of a 6.5 magnitude could occur anywhere in the state.

Table 4.24. Earthquake Hazard Risk Summary

County	Likelihood	Spatial Extent	Potential Magnitude	Significance
Big Horn	Occasional	Limited	Negligible	Low
Hot Springs	Occasional	Significant	Critical	Medium
Park	Occasional	Significant	Critical	Medium
Washakie	Occasional	Limited	Limited	Medium

4.2.6 Expansive Soils

Hazard/Problem Description

Soils and swelling bedrock 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 and bedrock. In general, the term refers to both soil and bedrock contents although the occurrence of the two materials may occur concurrently or separately. The difference between the materials is that swelling soil contains clay, while swelling bedrock contains claystone. (Source: Colorado Geological Survey Department of Natural Resources, *A Guide to Swelling Soils for Colorado Homebuyers and Homeowners*. (Denver, Colorado.) 1997. p 15-16.)

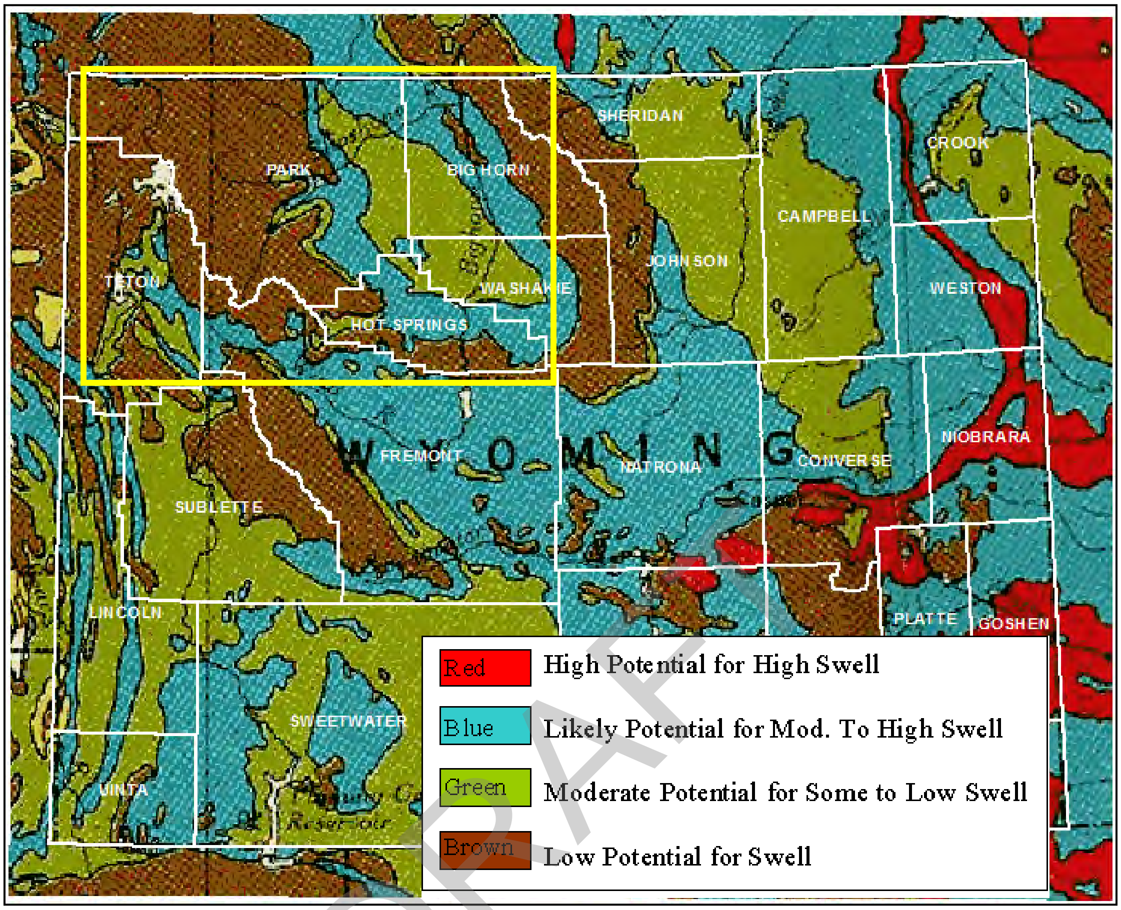
The clay materials in swelling soils are capable of absorbing large quantities of water and expanding 10 percent or more as the clay becomes wet. The force of expansion is capable of exerting pressures of 15,000 pounds per square foot or greater on foundations, slabs, and other confining structures. (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

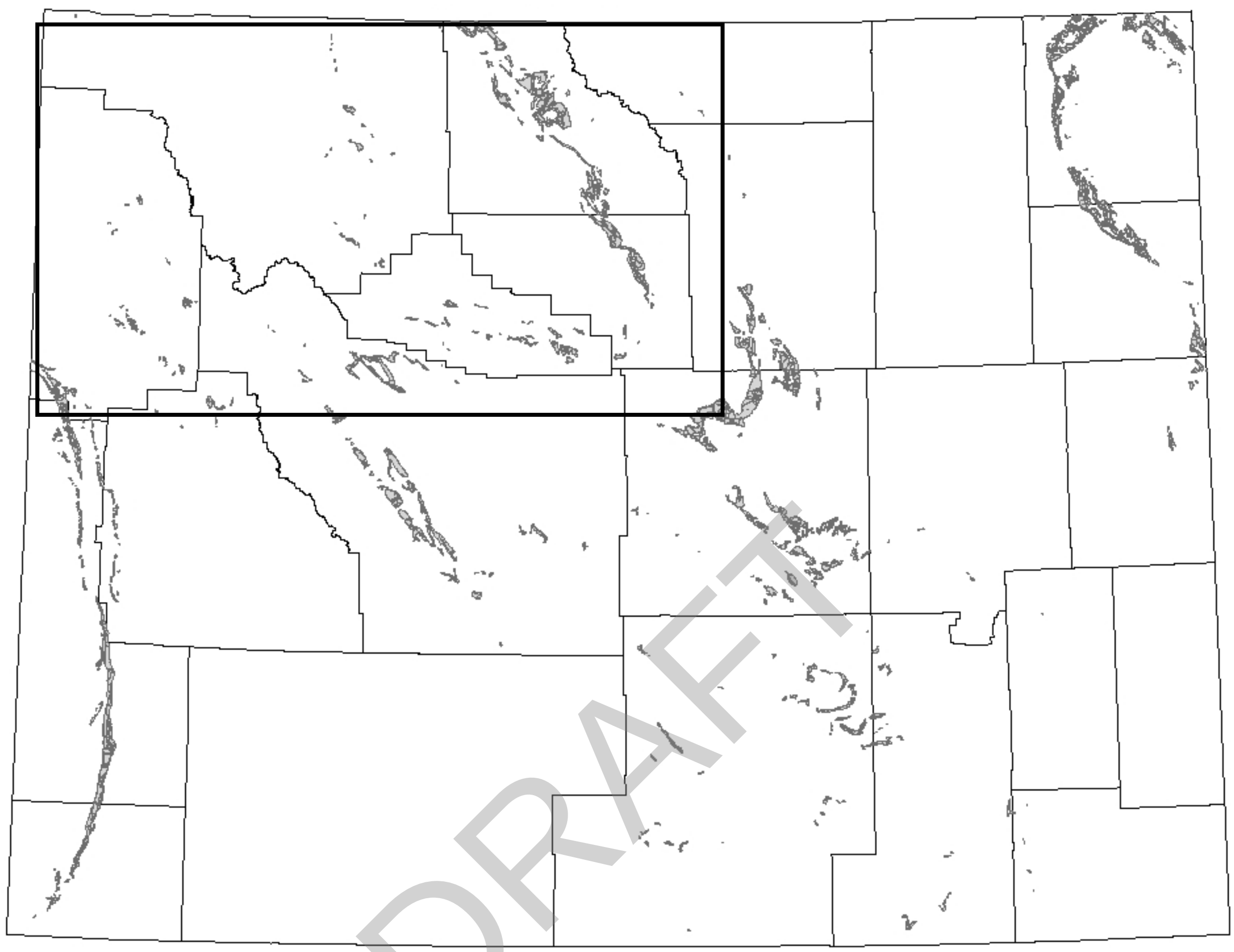
Expansive soils are known to be present in the eastern side of the Big Horn Basin. Figure 4.19 and Figure 4.20 illustrate possible expansive soils locations in Wyoming. Figure 4.20 is based on select geologic formations from the Love and Christiansen 1985 Geologic Map of Wyoming. Those formations selected have characteristics that could lead to expansive soils where they outcrop. Based on these figures, Washakie and Big Horn Counties have the largest amount of potentially swelling soil, but areas exist in Park and Hot Springs as well. In Washakie County Ten Sleep and the surrounding area are most likely to face problems related to expansive soils. Deposits of calcium montmorillonite can also contribute to swelling problems, but these areas have not been completely mapped. Based on the figures below, expansive soils are estimated to affect a **limited** portion of the planning area. The Washakie County Office of Homeland Security performed GIS studies on expansive soils in the planning area in 2010. These studies are on file at the County's Office of Homeland Security.

Figure 4.19. Expansive Soil Potential in Wyoming



Source: The map above is based upon "Swelling Clays Map of the Conterminous United States" by W. Olive, A. Chleborad, C. Frahme, J. Shlocker, R. Schneider and R. Schuster. It was published in 1989 as Map I-1940 in the USGS Miscellaneous Investigations Series. Land areas were assigned to map soil categories based upon the type of bedrock that exists beneath them as shown on a geologic map. In most areas, where soils are produced "in situ", this method of assignment was reasonable. However, some areas are underlain by soils which have been transported by wind, water or ice. The map soil categories would not apply for these locations.

Figure 4.20. Wyoming Mapped Formations with Potential for Expansive Soils



Source: State of Wyoming Multi-Hazard Mitigation Plan 2008

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 the Big Horn Basin region. 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

Expansive soils will most likely be an **occasional** problem for the counties in Region 6.

Potential Magnitude

The potential magnitude of expansive soils events and damages is estimated to be **negligible** for the counties in the Region. No impacts related to expansive soils have been reported thus far. Because damages from expansive soils tend to happen over an extended period of time, it is difficult to estimate the potential severity of a problem. Many deposits of expansive soils do not inflict damage over large areas. Instead, these deposits can often create localized damage to individual structures and supply lines, such as roads, railways, bridges and power lines.

Vulnerability Assessment

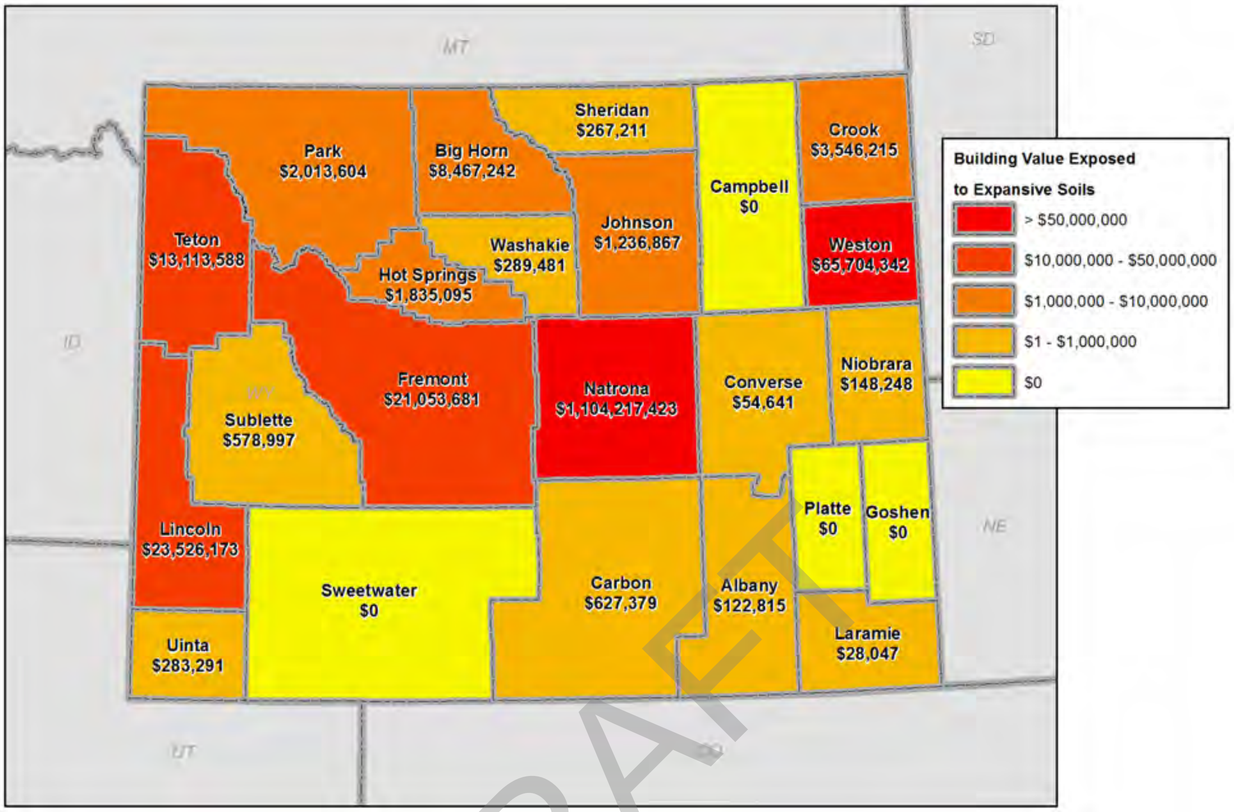
According to the Wyoming State Multi-Hazard Mitigation Plan there are two measurements used for calculating future impacts: historic dollar damages and building exposure values. There is not enough current data to accurately estimate historic damages.

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. These values represent exposure and the potential for damage, not a true loss estimate. Damage from these soils will be individual events, which will cause damage to a small number of buildings or road segments over time.

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.

Figure 4.21. Wyoming Exposure to Shrinking/Swelling Soils by County



Source: State of Wyoming Multi-Hazard Mitigation Plan

Summary

Overall, expansive soils are a **low** significance hazard for the counties in the region.

Table 4.25. Expansive Soil Hazard Risk Summary

County	Likelihood	Spatial Extent	Potential Magnitude	Significance
Big Horn	Occasional	Limited	Negligible	Low
Hot Springs	Occasional	Limited	Negligible	Low
Park	Occasional	Limited	Negligible	Low
Washakie	Occasional	Limited	Negligible	Low

Municipalities Impacted: Ten Sleep, Thermopolis

4.2.7 Extreme Cold

Hazard/Problem Description

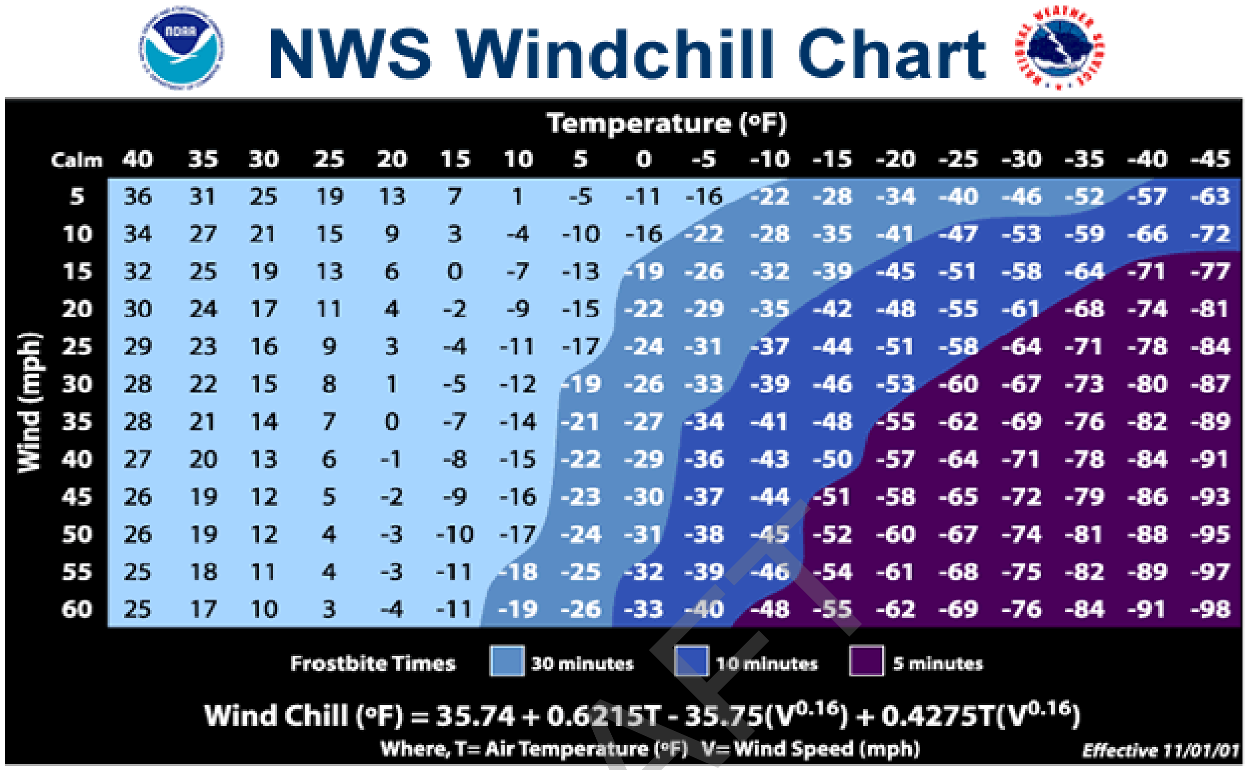
Extreme cold often accompanies a winter storm or is left in its wake. It is most likely to occur in the winter months of December, January, and February. Prolonged exposure to the cold can cause frostbite or hypothermia and can become life-threatening. Infants and the elderly are most susceptible. Pipes 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 4.22. National Weather Service Wind-Chill Chart



NWS Windchill Chart

Temperature (°F)

Wind (mph)	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
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

Geographical Area Affected

The inherent nature of extreme cold makes it a regional threat, impacting most or all of the planning area simultaneously as well as extending the effects into the surrounding jurisdictions. Therefore, it is considered to have an extensive geographic impact rating.

Past Occurrences

In 2009, 2,300 homes in Washakie County lost power when temperatures reached -19° F. By the following morning, temperatures had dipped to -31° F. Fortunately, the power lines were repaired before that point, but this incident illustrates how dangerous extreme cold can be. During this time, the USDA designated six counties as natural disaster areas for severe freezes including Fremont, Hot Springs, Johnson, Sheridan, Teton and Washakie. Another severe cold event occurred in the late 1970s. This event saw 62 days of below zero weather. Frozen pipes were an issue for the planning area, and there were claims that some people were even driven to suicide by the event.

Local Office of Homeland Security data also indicates that Washakie County experienced severe cold temperatures in December 1995, January 1996 and February 1996 which likely affected other counties in the Region. During an extreme cold event in 1975, the Wyoming Sugar Company pumped warm water into the drinking water system in order to keep it from freezing. According to SHELDUS data, two extreme cold events occurred in Washakie County, one in 1983 and the other in 1996; these incidents caused almost $57,000 in damages.

The National Climactic Data Center records four separate incidents and six separate days with extreme cold and wind chill conditions since 1996. The NCDC records $25,000 property damage in February 1996, though it does not differentiate what the damage was.

The following table shows regional temperature profiles based on data from the Western Regional Climate Center for sensor locations in each county. Note the record low of -51 degrees in Worland in 1930.

Table 4.26. Region 6 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
Big Horn	Greybull 1S	7.16°F	86.9°F	109°F June 30, 2010	-40°F December 22, 1990	46.5	183.6
Hot Springs	Thermopolis	9.43°F	87.6°F	107°F July 25, 1929	-44°F January 16, 1930	50.3	31.6
Park	Cody 21 SW	16.03°F	79.2°F	100°F July 13, 2002	-40°F December 21, 1990	11	185.5
Washakie	Worland	5.03°F	85.9°F	107°F July 15, 2002	-51°F January 17, 1930	46.52	190.3

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

Frequency/Likelihood of Occurrence

Based on data provided by the HMPC and historical records, extreme cold and wind-chill is an annual occurrence in all counties in Region 6. Thus, this hazard has a high likelihood of occurrence. Damaging events occur less frequently.

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. Certain hazards occur more frequently in specific areas. Therefore, the residents of these areas are less likely to report events that seem commonplace in the planning area, even though the events may be considered extreme in other locations.

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. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of common occurrence. Based on SHELDUS and NCDC records, the event of record for extreme cold in the Region occurred on December 20, 1983. This event resulted in $113,987 in damages (adjusted for 2016 dollars).

Overall, extreme temperature impacts would likely be limited in the Region, with 10 to 25 percent of the planning area affected. Extreme cold can occasionally cause problems with communications facilities and utility transmission lines. Danger to people is highest when they are unable to heat their homes and when water pipes freeze. Extreme cold can also impact livestock and even crops if the event occurs during certain times of the year.

Vulnerability Assessment

Population

While everyone is vulnerable to extreme cold/wind chill events, some populations are more vulnerable than others. 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.

General Property

Extreme cold/wind chill presents a minimal risk to the structures of Region 6. 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

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.

Summary

Extreme cold can cause occasional impacts, contributes to ice jam flooding, and in the valleys of the Big Horn Basin can be a significant hazard in some counties in Region 6. It often contributes to agricultural losses and utility outages (power and water).

Table 4.27. Extreme Cold Hazard Risk Summary

	Geographic Extent	Probability of Future Occurrence	Potential Magnitude/Severity	Overall Significance
Big Horn	Extensive	Likely	Limited	Medium
Hot Springs	Extensive	Likely	Limited	Medium
Park	Extensive	Likely	Negligible	Low
Washakie	Extensive	Likely	Critical	High

4.2.8 Flood

Hazard/Problem Description

Floods can and have caused significant damage in Region 6 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 many 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
- 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 percent 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.

Region 6 is susceptible to multiple types of floods including riverine flooding, flash floods, slow rise floods, ice jams and possibly dam or levee failure.

Riverine flooding is defined as when a watercourse exceeds its "bank-full" capacity and 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.

Floods can occur for reasons other than precipitation or rapidly melting snow. They can also occur because of ice jams, which have occurred in Washakie and Big Horn Counties. 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. These types of floods 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 is 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. 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 6 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 cause flooded roads and flood adjacent properties. Refer to the County Annexes for a description of localized problems.

Increased flooding can also be created by other events 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 in each County's attached annex.

The counties of Region 6 are predominantly located in the Wind/Big Horn River Basin of Wyoming. The northwest portion of Park County, Yellowstone National Park, lies in a separate drainage basin which drains to the north into Montana.

This Big Horn River Basin's mainstem is made up of the Wind and Bighorn Rivers. The Wind originates in the mountainous terrain between the Absaroka and Wind River Ranges and flows southeast through the Wind River Indian Reservation. At Riverton the river turns north and forms Boysen reservoir (in Fremont County) with a capacity of over 800,000 acre-ft. Once the river exits the Wind River Canyon near Thermopolis, it becomes the Bighorn which continues northward, passing through Hot Springs, Washakie and Big Horn Counties and the communities of Thermopolis, East Thermopolis, Worland, Manderson, Basin and Greybull.

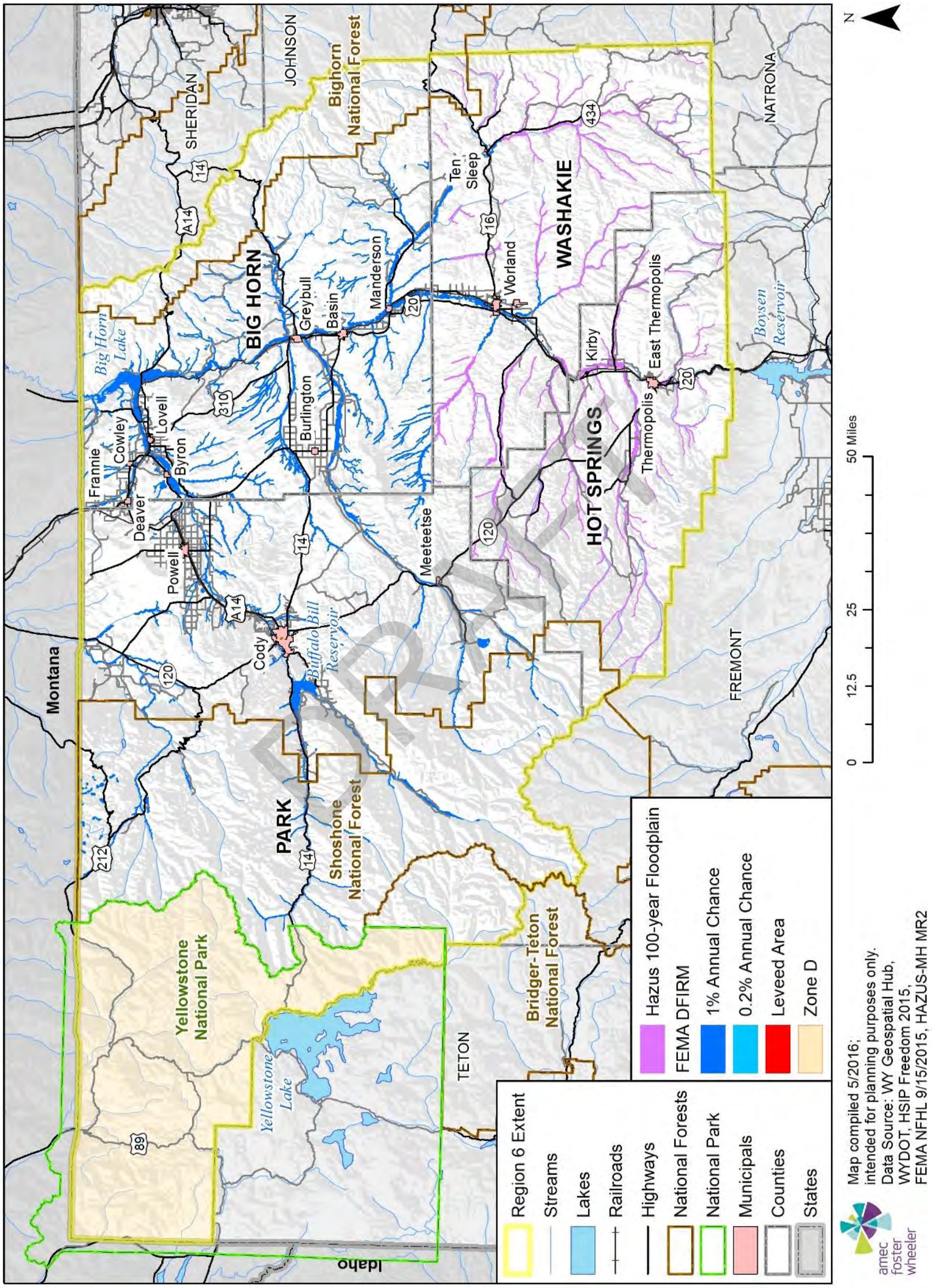
At Worland, Sage Creek enters the Big Horn. At the Town of Manderson it receives the Nowood River. At Greybull it receives the Greybull River and about 30 mi north of this confluence it enters Bighorn Lake.

The Shoshone River traverses Park County through the communities of Cody and Powell and enters Big Horn County where it passes through the communities of Byron, and Lovell on its way to its confluence with the Big Horn River at Bighorn Lake.

The geographic extent rating for Region 6 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.

Figure 4.23 shows the Region 6 Flood Hazards. More detailed mapping is shown in the County annexes.

Figure 4.23. Region 6 Flood Hazards



Past Occurrences

A brief history of significant floods is presented below, while a more extensive summary is included in the county annexes. A damaging flood occurs in the area every year on average, based upon the historical data presented below.

The documented flood history for the Region extends back to 1917, when a 100 year flood occurred in Hot Springs County along the Big Horn River and impacted Thermopolis. Cool weather preserving the heavy snowfall in the mountains until hot weather melted the snow quickly caused flooding according to FEMA Flood Insurance Study (March 23, 1999). The flood caused washed out bridges, destroyed irrigation flumes, and flooded low lying ground.

One of the most significant flooding events in the region occurred in July, 1923, in Hot Springs County. A 300-year flood producing 4.10 inches of rain was caused by a cloudburst. The cause was cool weather preserving the heavy snowfall in the mountains, when hot weather melted the snow suddenly. Damage was to bridges, irrigation flumes, highways, and railroads. In Thermopolis, a city pump station was flooded, no water was available to the public, and loss of power to the city was due to severed gas line. Damage estimate was well over $100,000 (roughly $1.4 M in 2016 dollars). (FEMA Flood Insurance Study March 23 1999)

In July of 1962 a damaging flood occurred in northern Big Horn Basin when severe thunderstorms and heavy rains of 4 to 6 inches with 6 to 9 inches of hail and high gusty winds caused widespread damage and flash flooding in the Cowley, Byron, Penrose, and Lovell areas. Total damage was estimated at $2,475,000.

On May 15, 1978, heavy wet snow and record rains did very extensive damage to property, crops, and livestock in 12 counties (Park, Big Horn, Campbell, Converse, Crook, Johnson, Natrona, Sheridan, Washakie, Weston, Hot Springs, and Niobrara). Hundreds of homes were damaged, and many totally destroyed. Numerous bridges and sections of roads were washed out, power lines downed, with much damage to cars and personal property. Total estimated damages came to $15,500,000 (roughly $60.7 M in 2016 dollars).

In May, 1988 a notable flood occurred from a winter-like storm system. It produced heavy snowfall above 6000 feet and drenching rainfall below, between 1.5 and 5.0 inches of rain fell in less than 24 hours. This flood damaged newly planted crops of beets and barley. Estimated damage to houses, washed out bridges, damaged culverts and canals, damaged roads, and other damage to irrigation works and utility lines ranged from $500,000 to more than $1 million (roughly $1-2 M in 2016 dollars). Most of the flood damage occurred in Park County, which was later declared a disaster area. At least 17 bridges or crossings were destroyed and six roads washed away by the flood waters in Park County.

In March, 1996, ice jams caused flooding in lowland areas around Greybull on the Big Horn River. Other rivers and streams in the southern part of the Big Horn Basin also had flooding due to ice jams. A one hundred foot long footbridge was washed out between Ten Sleep and Manderson on March 13 on the Lower Nowood River. Flooding also occurred between Manderson and Basin, shortly after midnight on March 13. A factory on the north side of Greybull was flooded. The sewer lagoon for the city was also underwater during this time

In March, 2007 there was significant damage in the region due to ice jams. Ice built up on area rivers following very cold temperatures through February and early March. The last cold snap in early March was followed by a round of unseasonably warm temperatures that caused the ice to begin melting and to break-up on the Big Horn and Nowood rivers in Big Horn and Washakie counties. The result was ice jam flooding that impacted areas from Worland to north of Greybull on the Big Horn River, and from near Ten Sleep to Manderson on the Nowood River**.** The flooding caused damage in Worland. Reported damage was $250,000 (roughly $300,000 in 2016 dollars). Flooding of two ranches occurred along the Nowood River north of Ten Sleep. The ice jams formed on several bends in the serpentine river flooding ranch lands. At least one resident evacuated their residence as the water level climbed. Reported damage was $50,000 (roughly $59,000 in 2016 dollars).

In late June 2011, following a winter with excessive snowpack, the warmest temperatures of the summer season produced snowmelt runoff in the drainages of the western Bighorn Mountains. Creeks and streams in Big Horn and Washakie counties quickly rose in response to the increased runoff. The flood waters washed out roads and flooded residential yards. Reported damage was $100,000 (roughly $109,000 in 2016 dollars).

This extended warm period in late June, 2011, also caused the high waters at the confluence of the Lamar River and Soda Butte Creek in Park County to undercut and damage a 200-foot-section of Yellowstone National Park's Northeast Entrance road. Road closures were needed to complete repairs. Reported damage was $160,000 (roughly $174,000 in 2016 dollars).

By late July, 2011, excessive snowmelt runoff filled Big Horn Lake from late June through mid-July. Gusty winds combined with the already high water in the lake caused significant problems on area roads in late July. Reported damage was $351,500 (roughly $382,000 in 2016 damages).

In March, 2014 ice built up on area rivers following very cold temperatures through February and early March. The last cold snap in early March was followed by a round of unseasonably warm temperatures that caused the ice to begin melting and to break-up on the Big Horn and Nowood rivers in Big Horn and Washakie counties. The result was ice jam flooding that impacted areas from Worland to north of Greybull on the Big Horn River, and from near Ten Sleep to Manderson on the Nowood River.

The flooding began on Friday morning, March 7, in Worland near the Highway 789 bridge on the west side of town. Several homes received at least minor flooding, the local radio station had to be sandbagged to protect it, and at least 80 people were evacuated. A gas pipeline also broke in Riverside Park under the weight of the massive chunks of ice that were as big as trucks. The ice jams affecting Worland gradually gave way and moved downstream on March 8, but downstream areas north to the Big Horn County line still experienced flooding for the next few days. Flooding on the Nowood River in Washakie County inundated ranch lands, corrals, and a barn, and caused at least one resident to evacuate their home.

In Big Horn County, the town of Manderson, near the confluence of the Big Horn and Nowood, was threatened for a couple of days as the ice jams moved down both rivers. One business was flooded and water surrounded more than a few homes on March 9 and 10. At one time, water was flowing down the main street of town. Aggressive sandbagging efforts diverted water around Manderson School and the water treatment plant. Farther downstream on the Big Horn River, flooding threatened the town of Greybull. A levee system served well to protect the community and only three homes outside the levee received minor flooding. Water levels rose to within two feet of the top of the Greybull levee on March 9th. Overall, the levee performed as designed enduring the ice jamming without breach and experiencing no visible damage from the chunks and slabs of ice that had caused water levels to rise. Even where the river reached its closest point to the top of the levee, the jam itself prevented the slabs of ice, which had settled along the levee's riverside bank, from moving and gouging into the levee embankment. The Spence Oil Field north of Greybull and other low-lying areas north of town were flooded during the ice jam episode. Total reported damage was $750,000 (roughly $763,000 in 2016 dollars).

May and June of 2015 were particularly wet months for the Region, with damaging storms in Park, Hot Springs and Big Horn Counties. The most significant event occurred on May 24, 2015. A slow-moving upper level low south of Wyoming sent waves of moisture northward over central and eastern Wyoming during the Memorial Day holiday weekend. Measured and estimated rainfall totals ranged from two to around five inches. This resulted in flooding and flash flooding in several areas. The greatest impact was felt in Hot Springs County where very heavy rains in the Wind River Canyon resulted in several mud and rock slides that closed State Highway 789 between Thermopolis and Shoshoni. The slides also damaged several sections of railroad track in the same area subsequently shutting down rail traffic. Additional slides on the west side of the Wind River Canyon destroyed several sections of railroad track that resulted in a halt of train traffic for several days. Damage reported was $1,500,000.

The abbreviated flood history below (Table 4.28) was in large part derived from the monthly Storm Data reports generated and released by the National Oceanic and Atmospheric Administration's National Climate Center and the SHELDUS database. Other sources include the FEMA Flood Insurance Studies for each County and HMPC accounts. The table represents floods that have caused damage, injuries, or loss of life. While significant damage has occurred in the Region, no injuries nor deaths have been reported. More detailed flood histories are included in each County's Annex.

Table 4.28. Flood Occurrences per County

County	Events	Period of Record
Big Horn	33	1928-2016
Hot Springs	15	1917-2016
Park	31	1957-2016
Washakie	24	1923-2016

Source: NCDC, SHELDUS, HMPC records

Frequency/Likelihood of Occurrence

Judging by the historical flood record for the Region, a flood of at least minimal magnitude occurs roughly every 2-7 years on average somewhere in the planning area. Most of these floods were less than the 100-year flood; the chance of a 100-year flood occurring within any 30-year period is 26%. The chance of a 100-year flood occurring in any 100-year period is approximately 63%. Using the formula in Section 4.2, this yields a 10-100 % probability. This corresponds to a **Likely** occurrence rating, meaning that a flood has a 10-100 percent 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 6 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 loss of income to businesses relying on recreational uses of regional waterways;
- 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, and 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, and the time of year.

The magnitude and severity of the flood hazard is usually determined by not only the extent of impact it has on the overall geographic area, but also by identifying the most catastrophic event in the previous flood history. Sometimes it is referred to as the "event of record." The flood of record is almost always correlated to a peak discharge at a gage, but that event may not have caused the worst historic flood impact in terms of property damage, loss of life, etc. The flood of record on the Big Horn River occurred in 1923 in Hot Springs County. Highways and railroads were both out of commission. Domestic water was unavailable due to the flooding of the Town of Thermopolis' pump station. A break in the gas line to the power plant caused a town-wide loss of power. The 29,800 cfs discharge was representative of the 300-year flood.

Flooding from the Bighorn River has been reduced since the construction of Boysen Reservoir Dam. Ice jamming has caused minor damage in recent years to properties along the river.

The potential magnitude for a flood event in the Region is estimated to be **limited**. An event of limited magnitude would result in some injuries, a complete shutdown of critical facilities for over a week, and damages to more than 10% of the planning area. This is consistent with the flood event history in the Region. The flood history indicates that damaging floods have occurred consistently in Region 6. Fortunately, there has been no loss of life or any significant injury caused by floods in the Region.

Vulnerability Assessment

Population

Vulnerable populations in Region 6 include residents living in known flooding 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 of movement, fiscal income, challenges in receiving and understanding warnings, or unfamiliarity with surroundings.

As part of this 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) on 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 county. The average household factor was 2.66 in Big Horn County, 2.12 in Hot Springs County, 2.37 in Park County and 2.39 in Washakie County. The results are displayed below in Table 4.29.

Table 4.29. Flood Vulnerable Population Estimate in Region 6

	Total # of Buildings	Population Estimate
100 yr. flood	659	1,211
Protected by Levee	778	1,764
500 yr. flood	303	515
Total flood**	1,740	3,490

Property and Economic Losses

GIS analysis was used to estimate Region 6's potential property and economic losses. The four 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 layer. The centroid was placed over the existing structure within the parcel. In most cases, the building footprint spatial file was utilized to determine where the structure was located; in other cases, the aerial imagery was utilized. For the purposes of this analysis, the flood zone that intersected the centroid was assigned as the flood zone for the entire parcel. In some cases, there are parcels in multiple flood zones, such as Zone A and X 500. 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. The summarized results for each community are shown in the tables and maps provided within each County Annex.

Table 4.30 shows the count and improved value of parcels in the region, broken out by each county, that fall in a floodplain, by 100yr. flood, 500yr. flood, and total flood (100yr. and 500yr. floods combined). 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; the total 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 25% of the structure's replacement value).

Table 4.30. Region 6 FEMA Flood Risk Summary by County

Jurisdiction	Flood Type	Building Count	Improved Value	Est. Content Value	Total Exposure	Potential Loss	Population
Big Horn County	1% Annual Chance	242	$28,525,808	$23,669,561	$52,195,369	$13,048,842	436
	Protected by Levee	778	$64,306,971	$39,162,692	$103,469,663	$25,867,416	1,764
Hot Springs County	1% Annual Chance FEMA/HAZUS	120	$15,923,967	$10,750,128	$26,674,095	$6,668,524	191
	0.2% Annual Chance	114	$7,052,271	$4,598,360	$11,650,631	$2,912,658	216
Park County	1% Annual Chance	209	$50,902,993	$30,079,975	$80,982,968	$20,245,742	441
Washakie County	1% Annual Chance FEMA/HAZUS	88	$17,927,085	$15,363,051	$33,290,136	$8,322,534	143
	0.2% Annual Chance	189	$14,742,116	$12,062,261	$26,804,377	$6,701,094	299
Total	**1 % Annual Chance**	**659**	**$113,279,853**	**$79,862,714**	**$193,142,567**	**$48,285,642**	**1,211**

Based on this analysis, the Region 6 planning area has significant assets at risk to the 100-year and greater floods. There are 659 improved parcels within the 100-year floodplain (1% annual chance) for a total value of $113,279,853. There are 778 improved parcels within an area protected by a levee for a total value of $64,306,971. There are 303 improved parcels within the 500-year floodplain (0.2% annual chance) for a total value of $21,794,387. Overall, Region 6 counties potentially face almost $84 million in losses from flooding. Approximately $48.3 million of that is based on damage estimates from the 1% annual chance flood, with the remaining $35.5 million in damages resulting from potential flooding behind levees and the 0.2% annual chance flood.

HAZUS-MH Flood Loss Estimation

HAZUS, FEMA's loss-estimation software program, was also used to calculate potential losses from flooding in Region 6. Ultimately, the DFIRM analysis above was used for this plan update, when data was available, as DFIRM results tend to be more accurate than HAZUS. However, HAZUS is able to capture certain economic losses that cannot. Therefore, the subject still merits discussion for the purposes of this plan.

Planning level flood loss estimates were made available for every county in Wyoming with the 2010 update to the Wyoming Hazard Mitigation Plan. FEMA used HAZUS-MH MR2 to model the 100-year floodplain and perform associated building and population risk assessments. HAZUS-MH is FEMA's GIS-based natural hazard loss estimation software. The HAZUS-MH flood model results include analysis for each county in Region 6, modeling streams draining a 10 square mile minimum drainage area, using 30 meter (1 arc second) Digital Elevation Models (DEM). Hydrology and hydraulic processes utilize the DEMs, along with flows from USGS regional regression equations and stream gauge data, to determine reach discharges and to model the floodplain. Losses are then calculated using HAZUS-MH national baseline inventories (buildings and population) at the census block level.

HAZUS-MH produces a flood polygon and flood-depth grid that represents the 100-year floodplain. The 100-year floodplain represents a flood that has a 1% chance of being equaled or exceeded in any single year. While not as accurate as official flood maps, these floodplain boundaries are available for use in GIS and could be valuable to communities that have not been mapped by the National Flood Insurance Program. HAZUS-MH generated damage estimates are directly related to depth of flooding and are based on FEMA's depth-damage functions. For example, a two-foot flood generally results in about 20% damage to the structure (which translates to 20% of the structure's replacement value). The HAZUS-MH flood analysis results provide number of buildings impacted, estimates of the building repair costs, and the associated loss of building contents and business inventory. Building damage can cause additional losses to a community as a whole by restricting the building's ability to function properly. Income loss data accounts for losses such as business interruption and rental income losses as well as the resources associated with damage repair and job and housing losses.

Potential losses derived from HAZUS-MH used default national databases and may contain inaccuracies; loss estimates should be used for planning level applications only. The damaged building counts generated are susceptible to rounding errors and are likely the weakest output of the model due to the use of census blocks for analysis. There could also be errors and inadequacies associated with the hydrologic and hydraulic modeling of the HAZUS-MH model. In rural Wyoming, census blocks are large and often sparsely populated or developed; this may create inaccurate loss estimates. HAZUS-MH assumes population and building inventory to be evenly distributed over a census block; flooding may occur in a small section of the census block where there are not actually any buildings or people, but the model assumes that there is damage to that block. There could also be errors and inadequacies associated with the hydrologic and hydraulic modeling of the HAZUS-MH model. In addition, excessive flood depths may occur due to problems with a DEM or with modeling lake flooding. Errors in the extent and depth of the floodplain may also be present from the use of 30 meter digital elevation models. HAZUS Level II analyses based on local building inventory, higher resolution terrain models, and DFIRMs could be used in the future to refine and improve the accuracy of the results.

Results

A series of maps and analysis results were compiled for each county in Region 6, which are summarized here. More detailed information and community maps are provided in each County's Annex. Building and contents value loss estimates, income-related loss estimates, and displaced population and shelter needs estimates are included in the following table. These loss estimates have been grouped by county to demonstrate how the risk varies across the region. Per Capita Loss was calculated using total building loss and Census 2009 estimates to the municipal and county –level population. Percent Building Loss and Percent Contents Loss were calculated using building and contents loss estimates, and HAZUS building and contents exposure data.

Table 4.31. HAZUS Flood Loss by County

	Bldg. Loss ($K)	Contents Loss ($K)	Inventory Loss ($K)	Reloc-ation Loss ($K)	Capital Related Loss ($K)	Wages Loss ($K)	Rental Income Loss ($K)	Total Loss ($K)	# of Displaced People	# of People Needing Short Term Shelter
Big Horn	58,455	62,264	1,577	144	204	1,123	62	123,829	2,272	1,059
Hot Springs	15,471	29,080	553	64	137	661	26	45,992	712	375
Park	9,420	8,314	347	7	18	45	5	18,156	533	82
Washakie	23,666	38,086	3,316	86	107	706	37	66,004	1,278	730
TOTAL	**107,012**	**137,744**	**5,793**	**301**	**466**	**2,535**	**130**	**253,981**	**4,795**	**2,246**

Table 4.32. HAZUS Additional Analysis

	2009 Population*	Total Exposure ($K)	Building Loss ($K)	Building Exposure ($K)	% Building Loss	Contents Loss ($K)	Contents Exposure ($K)	% Contents Loss	Total Loss ($K)	Per Capita Loss ($)
Big Horn	11,581	1,158,802	58,455	705,984	8.3%	62,264	452,818	13.8%	123,829	10,692
Hot Springs	4,590	539,165	15,471	323,208	4.8%	29,080	215,957	13.5%	45,992	10,020
Park	27,976	3,050,414	9,420	1,799,930	0.5%	8,314	1,250,484	0.7%	18,156	649
Washakie	7,911	891,220	23,666	527,795	4.5%	38,086	363,425	10.5%	66,004	8,343
TOTAL	**52,058**	**5639601**	**107,012**	**3356917**	**3.2%**	**137,744**	**2282684**	**6.0%**	**253981**	**4,879**

*US Census Bureau

According to the HAZUS model output, the counties in Region 6 would suffer a total of $253,981,000 in total direct economic loss to buildings and 4,879 people would be displaced in the event of a region wide 100-year flood.

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. This information is not comprehensive, because it only reflects the communities which participate in the NFIP, but it is a useful overview of 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 32 flood insurance claims filed between 1/1/1978 and 4/30/2016. The total of the payments made on these claims was $417,275. As of 4/30/2016, there were 98 flood insurance policies in force in the Region for a total coverage of $26,239,000. More details on National Flood Insurance Program participation can be found within the county annexes.

Table 4.33. NFIP Policy and Insurance Claim Data for Region 6

County	Policies	Claims Made Since 1978	Payments Since 1978
Big Horn	6	8	$107,000
Hot Springs	13	1	$0
Park	62	19	$310,275
Washakie	17	4	$0

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 4/30/2016

According to Mr. Kim Johnson, State of Wyoming National Flood Insurance Program Coordinator, there are no repetitive loss structures in the Region. These are defined as an NFIP-insured structure that has had at least two paid flood losses of more than $1,000 each in any 10-year period since 1978.

None of the communities in the Region are currently enrolled in the National Flood Insurance Program's (NFIP) Community Rating System (CRS). This 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.

Critical Facilities and Community Assets

GIS analysis of flood hazards in Region 6 indicates that there are 211 critical facilities and/or community assets that are potentially exposed to flood hazards. There are 196 facilities in the 100-year floodplain, six in the 500-year floodplain and nine located behind levees. The majority of these facilities are bridges. Tables 4.34 through 4.36 summarize the facilities that are potentially at risk.

The Town of Thermopolis water and wastewater facilities are not in the GIS database but are located in the 1% annual chance floodplain. There is an abandoned bridge that crosses the Big Horn River by the water treatment plant. This bridge has very reduced freeboard during high flows, has potential to collect debris and push more water into the treatment plant and also poses a safety risk to boaters on the river. According to the HMPC there are utility lines on the bridge.

In Park County the analysis indicated flood risk to Wapiti Elementary and the Luckinbill Airstrip and several bridges. The County Planner/Floodplain Manager said Wapiti Elementary was in a poorly mapped Zone A floodplain; the river is nearby but incised so it's unlikely that water would get high enough to be an issue. The bridge analysis only indicates which bridges are in a floodplain, but not which ones can pass 100 year flows. The County Planner also indicated that they have more detailed bridge information that could be used to further assess flood risk.

Tables 4.34 through 4.36 summarize the Critical Facilities by County and by floodplain type.

Table 4.34. Critical Facilities within 1% Chance FEMA or Hazus Flood Zone

County	Facility Type	Facility Count
Big Horn	Bridge	43
	Fire Station	1
	HAZMAT	1
	Law Enforcement	1
	Public School	2
	Total	**48**
Hot Springs	Bridge	14
	Total	**14**
Park	Air Facility	1
	Bridge	76
	Communications	36
	Day Care Center	1
	EMS	1
	Fire Station	1
	Law Enforcement	2
	Public School	1
	Scour Critical Bridge	4
	Total	**123**
Washakie	Bridge	10
	HAZMAT	1
	Total	**11**
	Grand Total	**196**

Table 4.35. Critical Facilities within 0.2% Chance FEMA Flood Zone

County	Facility Type	Facility Count
Hot Springs	Communications	2
	HAZMAT	1
	Public School	1
	Total	**4**
Washakie	Bridge	1
	Communications	3
	HAZMAT	1
	Law Enforcement	1
	Total	**6**

Table 4.36. Critical Facilities within Area Protected by Levee

County	Facility Type	Facility Count
Big Horn	Public School	3
	Bridge	1
	Communications	1
	EMS	1
	Fire Station	1
	Law Enforcement	1
	Public Health Department	1
	Total	**9**

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, 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 damaged by flooding, tourism and outdoor recreation could potentially suffer. Portions of the Hot Springs State Park in Thermopolis are within the floodplain, including a motel.

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. Lack of adequate flood hazard mapping can make it a challenge to assess risk to future development in Hot Springs County.

Summary

Overall, flooding presents a **medium risk** for the counties and communities of Region 6. Somewhere in the region floods every 2-7 years. Flooding has damaged homes, infrastructure (roads and bridges), and caused agricultural losses in the region in the past. Ice jam flooding has caused problems on the Big Horn River in all counties except Park. Big Horn County has levees and thus a greater risk to floods that exceed the 1% annual chance event or events that cause levee failure. Hot Springs County is provided some flood protection by Boysen Reservoir but lacks flood hazard mapping. Flood risk varies by jurisdiction and this risk is detailed further in the county annexes.

Table 4.37. Flood Hazard Risk Summary

County	Geographic Extent	Probability of Future Occurrence	Potential Magnitude/ Severity	Overall Significance
Big Horn	Significant	Highly Likely	Limited	Medium
Hot Springs	Significant	Highly Likely	Limited	Medium
Park	Significant	Highly Likely	Limited	Medium
Washakie	Significant	Highly Likely	Critical	High

4.2.9 Hail

Hazard Description

Damaging hail events occur sporadically throughout Region 6, 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 2.75 inches in diameter has been recorded by the NCDC in the Region (Washakie County, 1978). Hail causes more than a billion dollars of property damage nationally each year. 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.

Past Occurrences

Climatologically, Wyoming averages five to nine days of hail annually. A comprehensive history of damaging hailstorms historically affecting the counties in Region 6 is included in Table 4.38. 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 NCDC records any hail events with hailstones that are .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 NCDC definition, there have been 207 separate hail incidents over 119 day affecting at least one of the four counties in the region since 1955. The cumulative hail incidents had a total recorded property damage of $736,000 and a total recorded crop damage of $1,355,500. No deaths and one injury have been associated with these storms in the region during this timeframe. Statewide, 4 injuries have been reported since 1955. One injury was to a boy seeking shelter from the storm; he ran through a glass door and severely lacerated his arm. The other three causes of injury were not recorded, though they all occurred during the storm. 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.

Table 4.38. Summary Hail History, Region 6

County	Incidences
Big Horn	54
Hot Springs	55
Park	54
Washakie	44
Total	207

Table 4.39. Region 6 Hail History with Impacts 1955-2015

County	Location	Date	Time	Hail Size	Deaths	Injuries	Property Damage	Crop Damage
Park	-	07/20/1995	14:00	0.00	0	0	$50,000	$0
Park	Cody	07/01/1998	13:43	1.75	0	0	$35,000	$0
Park	Powell	06/09/2000	12:40	1.75	0	0	$500,000	$0
Big Horn	Lovell	06/14/2006	12:25	2.00	0	0	$12,000	$500
Big Horn	Lovell	06/14/2006	12:25	1.75	0	0	$12,000	$275,000
Park	Meeteetse	06/05/2009	16:25	1.00	0	0	$0	$20,000
Big Horn	Burlington	08/07/2009	15:44	1.25	0	0	$0	$25,000
Big Horn	Greybull	08/07/2009	16:10	2.00	0	1	$75,000	$0
Big Horn	Greybull	08/07/2009	16:17	2.00	0	0	$2,000	$0

County	Location	Date	Time	Hail Size	Deaths	Injuries	Property Damage	Crop Damage
Washakie	Ten Sleep	08/30/2010	12:57	1.50	0	0	$20,000	$25,000
Park	Ralston	07/30/2013	17:15	0.50	0	0	$0	$1,000,000
Big Horn	Hyattville	08/01/2013	15:41	0.75	0	0	$0	$10,000
Hot Springs	East Thermopolis	06/16/2015	13:22	2.00	0	0	$20,000	$0
				Total	**0**	**1**	**$736,000**	**$1,355,000**

Source: National Climactic Data Center

Historically, 13 of the 207 NCDC recorded incidents had some level of recorded impact. While most storms don't have much impact, history shows a few outliers, summarized below:

On June 9, 2000, a severe thunderstorm produced a swath of large hail form the Cody area northeast to Powell and into extreme northwest Big Horn County. The largest hail fell in the vicinity of Powell, with official reports of golf ball size hail, and unofficial reports of softball size hail. Preliminary crop damage estimates were expected to reach in the millions of dollars. Severe damage to sugar beet, barley and bean crops was experienced. NCDC recorded $500,000 in property damage due to this storm.

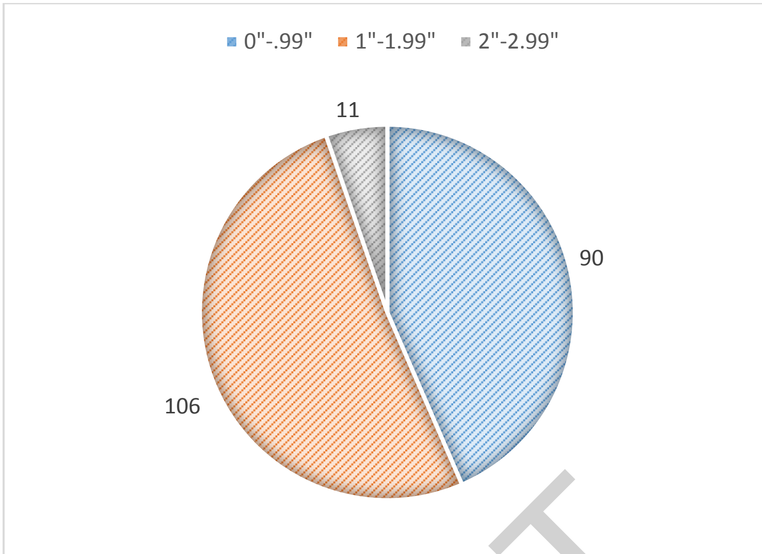
On June 14, 2006, a severe thunderstorm developed quickly near Byron and tracked northeast over Lovell toward the Bighorn Canyon National Recreation Area. Large hail of around two inches in diameter fell five to six miles east of Lovell, where two homes sustained roof and siding damage. Approximately 900 acres of sugar beets, over 100 acres of corn, and about 40 acres of alfalfa were destroyed by the large hail.

On July 30, 2013, a strong storm developed over the northern Absaroka Mountains and moved east across open country in northern Park County. The storm produced 50 mph wind, one-half inch diameter hail, and a little more than one-half inch of rain. Extensive crop damage occurred in the Powell Valley north of Ralston to areas near Garland. A combination of hail, wind and rain caused extensive damage to crops in the Powell Valley. Most of the damage occurred to barley, but beans and beets were also impacted. NCDC records $1 million in damage to crops for this storm. Region 6 has experienced 207 separate hail incidents over 60 years; this correlates to 3-4 incidents somewhere in the region each year.

Likelihood of Future Occurrences

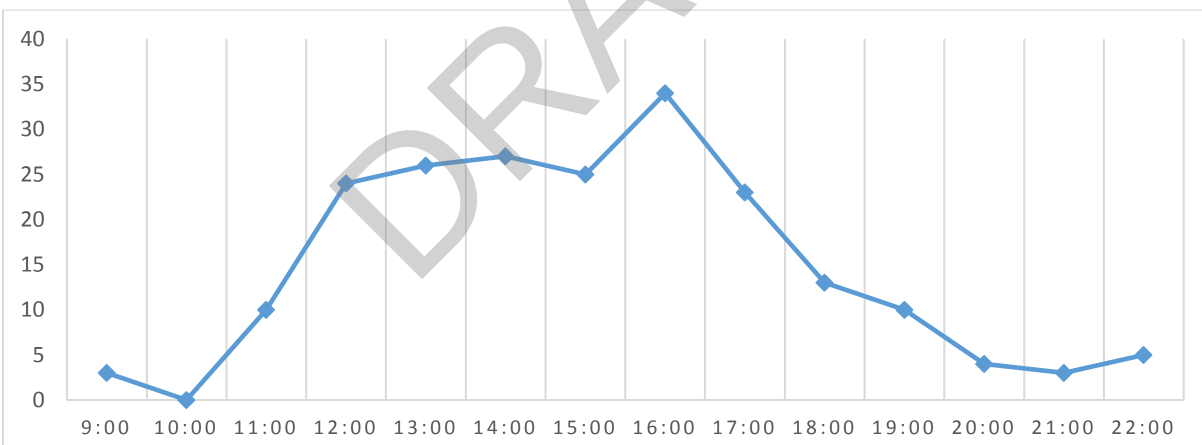
Based on historical data, an average hail event in the Region occurs in between June and August, somewhere between 12 p.m. and 5 p.m. It drops hail with a diameter less than two inches. While most historical hail storms in the Region don't result in major damage, recordable damage to property and crops could be in the hundreds of thousands of dollars, with up to $1 million in crop damage recorded. Insured loss related to hail storms could be in the millions, depending on the location and parameters of the storm.

Figure 4.24. Hail Incidents by Hail Diameter Region 6 1955-2015



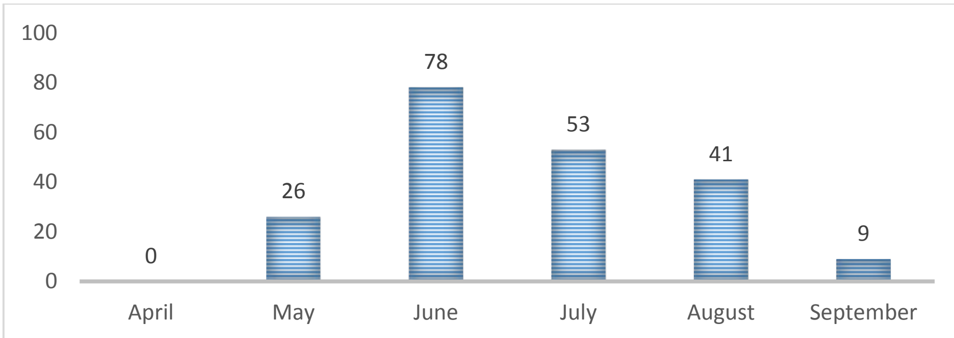
Source: National Climactic Data Center

Figure 4.25. Time of Day Hail Events in Region 6 1955-2015



Source: National Climactic Data Center

Figure 4.26. Month of Occurrence - Hail Events in Region 6 1955 to 2015



Source: National Climactic Data Center

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.

The incident of record occurred in Park County near Powell on June 9th, 2000. Hail up to 1.75 inches in diameter caused $500,000 in property damage. Softball sized hail was reported, but unconfirmed.

The incident of record for crop damage occurred July 30th, 2013 in Park County. The storm caused extensive crop damage in the Powell Valley, with most damage to barley crop, beets and beans. Damages were estimated at $1 million.

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.

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 6 will continue to experience on an annual 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 4.40. Hail Hazard Risk Summary

	Geographic Extent	Probability of Future Occurrence	Potential Magnitude/Severity	Overall Significance
Big Horn	Low	High	Medium	Medium
Hot Springs	Low	High	Medium	Low
Park	Low	High	Medium	High
Washakie	Low	High	Medium	Medium

4.2.10 Hazardous Materials

Hazard 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 6 is home to several gas plants, refineries and mines, and numerous pipelines and rail lines run across the Region, creating a likely potential for hazardous materials releases.

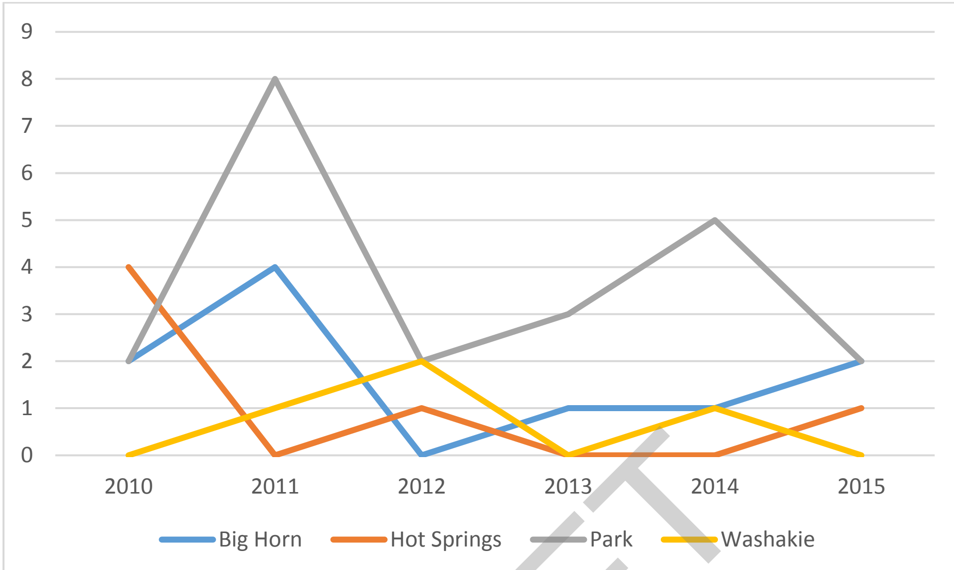
Geographical Areas Affected

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. 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 county annexes.

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 five-year record for reported incidents in the four counties in Region 6.

Figure 4.27. Hazardous Materials Spills/ Accidents Reported to the NRC Region 6: 2010-2015



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

According to the data, during the time period between 2010 and 2015 the Region saw anywhere from 12-21 NRC-reported incidents per year, which means that each county can reasonably expect multiple hazardous materials responses annually. The county data is further broken down in the table below:

Table 4.41. NRC-Reported Incidents by County: 2010-2015

	2010	2011	2012	2013	2014	2015	6-Year Total
Big Horn	2	4	0	1	1	2	**10**
Hot Springs	4	0	1	0	0	1	**6**
Park	2	8	2	3	5	2	**22**
Washakie	0	1	2	0	1	0	**4**

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

According the NRC site, the incident types with the highest rates of reports included fixed-site incidents, pipeline incidents, railroad incidents and mobile incidents.

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 6 RERT is located in Worland, in Washakie County. The following table shows records of Region 6 RERT mission assignments pertaining to hazardous materials releases, according the 2016 Wyoming State Hazard Mitigation Plan.

Table 4.42. Region 6 RERT Mission Assignments – Hazardous Materials: 2004-2015

Type	Number
Fixed Facility	4
Truck/Highway	6
Rail	1
Pipeline	1
Aircraft	-
Orphan Drum	1
Total	**13**

Source: 2016 Wyoming State Hazard Mitigation Plan

According to the HMPCs, small-level hazardous materials incidents occur frequently throughout the year in Region 6. During discussions, the committees noted roads, rail and pipelines throughout the county.

Likelihood of Future Occurrence

Each county in the Region experiences multiple hazardous materials incidents each year, with various degrees of impact; there is a 100% chance that the counties in 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 6 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 6 will have at least one of the impacts listed above, and probably more.

Vulnerability Assessment

The counties in Region 6 have energy pipelines, railroad tracks which carry many types of hazardous materials, and state highways running through the counties. 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.

There are 10 RMP facilities located in four counties in Region 6, as noted in Table 4.43 below. Hot Springs County didn't have any listed RMP facilities. Some of these are discussed in more detail in the County Annexes.

Table 4.43. RMP Facilities in Region 6

County	Community	Number of Facilities
Big Horn	Byron	1
Hot Springs	N/A	0
Park	Powell	4
	Meeteetse	2
Washakie	Worland	3
	Total	10

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

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. 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. If an uptick in oil and gas development and extraction occurs, this could result in greater exposure for transportation incidents.

Summary

Table 4.44. Hazardous Materials Hazard Risk Summary

	Geographic Extent	Probability of Future Occurrence	Potential Magnitude/Severity	Overall Significance
Big Horn	Limited	Likely	Limited	Medium
Hot Springs	Significant	Likely	Limited	High
Park	Limited	Likely	Limited	Medium
Washakie	Limited	Likely	Limited	Medium

4.2.11 High Winds and Downbursts

Hazard Description

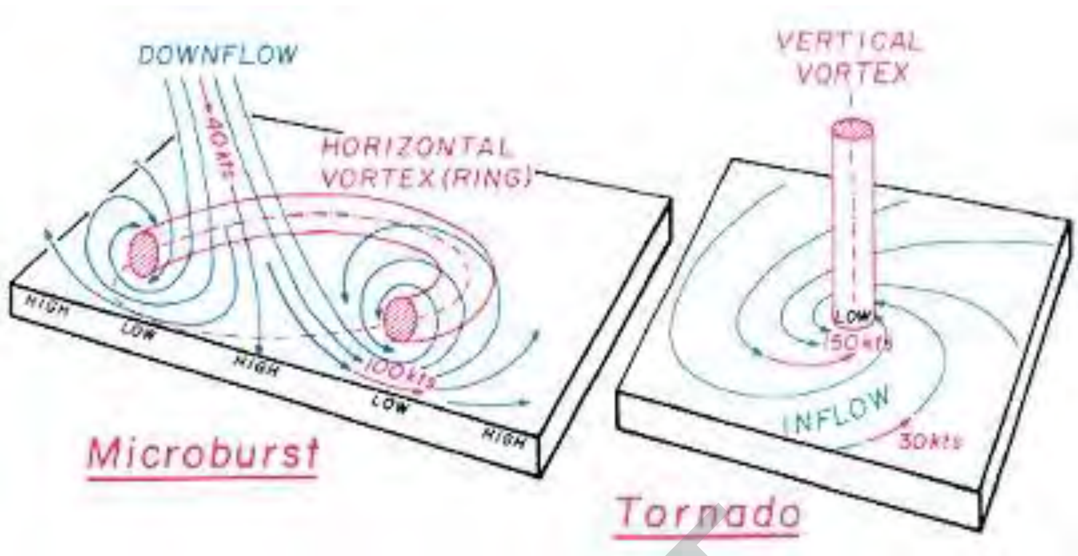
Wind, because of its constant presence in Wyoming, can be overlooked as a hazard. Upon analysis, wind can be a damage-inducing hazard and warrants review in Region 6. Wyoming's wind is also becoming an economic factor as renewable wind energy is developed around the state.

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.

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.

Figure 4.28. Schema of Microburst and Tornado



Source: www.erh.noaa.gov

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.

Figure 4.29. Aerial Image of Downburst Damage

Source: T. Fujita

In this photograph, trees are blown down in a straight line - a very strong indication of a downburst as opposed to a tornado.

Geographical Area Affected

All counties in the Region can experience damaging wind events. Park County in particular has areas along the eastern front of the Absaroka Range that are susceptible to strong downslope winds.

Past Occurrences

In the counties in Region 6, most documented wind events causing damage typically range between 58 and 88 mph; max wind speeds of up to 127 mph have been recorded. It should be noted that the data is limited by what the NCDC 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 county planning teams noted that high winds are a consistent issue in the four counties.

Table 4.45. Summary of Wind Weather Events and Impacts

Region 6 (1962-2015)						
Total Number of High Wind Events	Total Property Damage	Total Crop Damage	Total Fatalities	Total Injuries	Average Recorded Wind Speed	Max Recorded Wind Speed
372	$992,200	$1.001M	1	6	72 mph	127 mph
Big Horn County (1975-2015)						
49	$182,000	$1,000	0	0	64 mph	85 mph
Hot Springs County (1975-2015)						
26	$3,000	$0	0	0	64 mph	81 mph
Park County (1964-2015)						
58	$30,000	$0	0	0	66 mph	94 mph
Washakie County (1962-2015)						
40	$80,200	$1M	0	1	53 mph	85 mph
Zonal Incidents (1996-2015)						
199	$690,000	$0	0	0	78 mph	127 mph

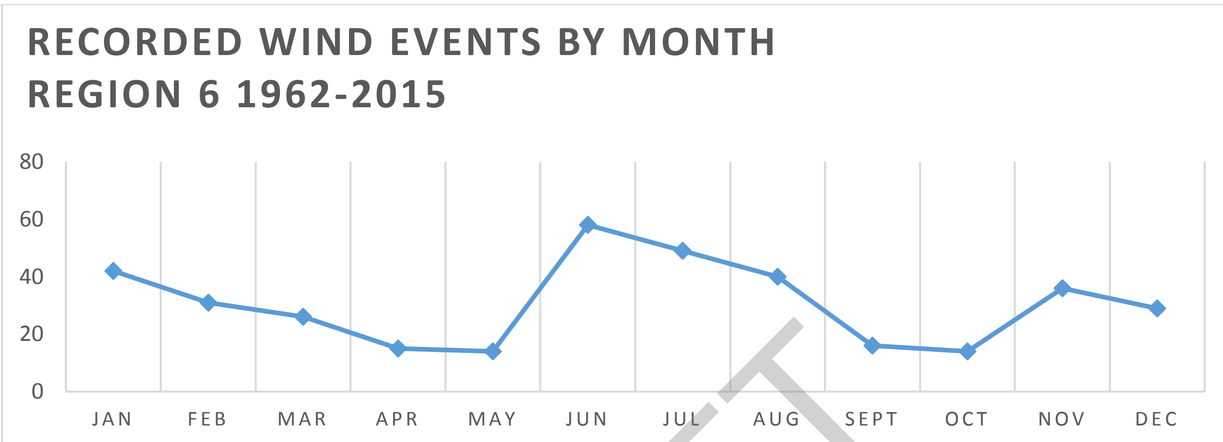
Source: NCDC

NCDC also records wind damage on a zonal basis; while these zones show up in search results, they are not always tied to specific counties. NCDC records an additional 199 wind incidents from 1996 to 2015 in these zones. The zones may contain multiple counties, both within and outside the regional boundaries.

Likelihood of Future Occurrences

NCDC records 335 confirmed and documented high wind incidents specifically impacting the Region since 1962. This means that the region can expect multiple high wind incidents each year.

Figure 4.30. High Wind Events by Month for Big Horn County 1962-2015



Source: NCDC

The Region experiences an average of six significant high wind events per year somewhere in the four counties, with a damaging event being recorded by NCDC approximately once every 1.3 years. Based on NCDC data, incidence of recorded events appears to spike between May and September, with another spike in January.

Vulnerability

Vulnerability as it relates to location is mostly random, as damaging winds have occurred everywhere in the Region. The Park County planning team noted that winds along the mountain from Clark to Meeteetse are especially strong, especially the Clark area, which experiences very high winds. 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 NCDC for the county include downed power lines, torn off roofs and building damage, and downed tree limbs and debris.

Specific examples from high wind incidents that caused damages or casualties include:

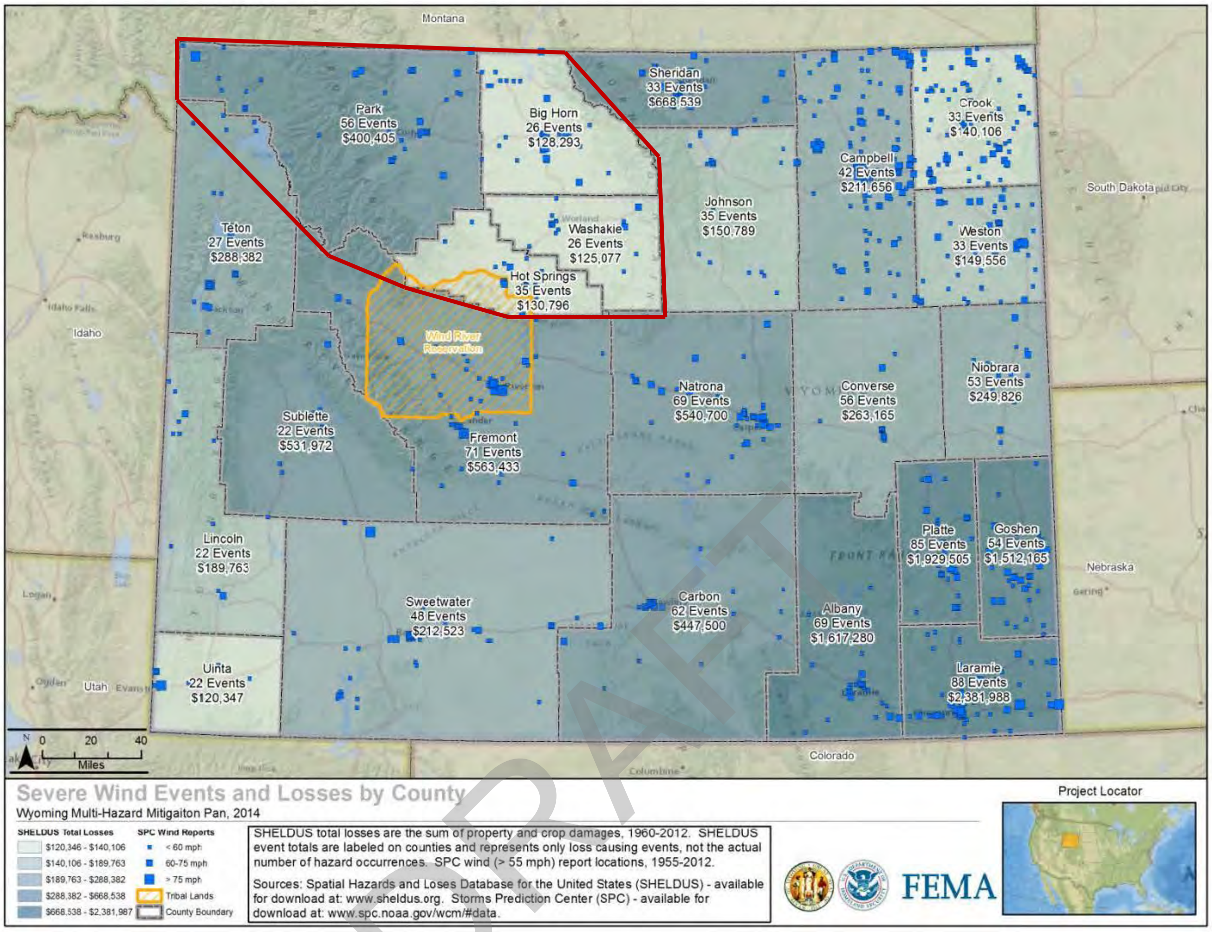
- **Park County, November 1999** – Strong gusty crosswinds caused a two-vehicle accident between Cody and Meeteetse on WY Highway 120; one fatality and one injury was recorded.
- **Big Horn County, June 2006** – A severe thunderstorm cut a path of damage more than 60 miles long across Park and Big Horn Counties. Damaging wind was responsible for snapping seven power poles along U.S. Highway 14A east of Lovell. A storm damage survey revealed numerous trees snapped mid-trunk in the Bighorn Mountain foothills.
- **Hot Springs County, July 2009** – Microburst winds of 50 to 60 mph uprooted a 50 foot cottonwood tree and blew a one-inch diameter branch about 50 feet into Hot Springs State Park. The wind was also responsible for moving a metal shed across a street near the Hot Springs County fairgrounds.
- **Washakie County, July 2013** – Wind gusts estimated at 60 mph combined with one-half inch diameter hail to devastate barley and corn fields in northern Washakie County. There were a few cottonwood trees downed by the wind, one of which fell across State Highway 433. The same thunderstorm caused one irrigation ditch to fill quickly and produce minor flooding of a nearby road. The storm caused $1 million in damage to crops.
- **Park County, February 2015 -** The Town of Meeteetse water system was shut down by a power failure that lasted a week. The town purchase a generator in response to this event.

The county planning teams provided additional information on historical impacts of high winds. The Park County planning team noted the prevalence of power outages due to high winds breaking power poles; the team noted a high rate of power outages for Cody. These power outages can also have secondary impacts, such as the water system issue in Meeteetse. Additionally, the planning teams noted impacts including semi-truck blow overs and snowdrifts. The Park County planning team also noted winds strong enough to blow asphalt off the roads around Clark.

Potential Losses

According to the Spatial Hazards and Losses Database for the United States (SHELDUS) and the 2016 Wyoming Hazard Mitigation Plan, Region 6 suffered 143 damage causing wind events between 1960 and 2012, and a cumulative $784,571 in damage as a result of these events ($5,487/event average).

Figure 4.31. Wind Events and Losses, Wyoming 1960-2012 / Region 6 Outlined in Red



Source: Wyoming Multi Hazard Mitigation Plan, 2016

Future Development

Historical data demonstrates that the most critical area of the state for high wind hazards is the eastern one third, excluding the counties of Region 6. Nevertheless, future residential or commercial buildings built to code should be able to withstand wind speeds of at least 150 miles per hour.

Summary

Many areas of the United States are prone to damaging wind events, and while the counties of Region 6 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 4.46. High Winds and Downbursts Hazard Risk Summary

	Geographic Extent	Probability of Future Occurrence	Potential Magnitude/Severity	Overall Significance
Big Horn	Significant	Highly Likely	Critical	High
Hot Springs	Significant	Highly Likely	Negligible	Low
Park	Significant	Highly Likely	Limited	Medium
Washakie	Significant	Highly Likely	Negligible	Low

4.2.12 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 accompanies 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.

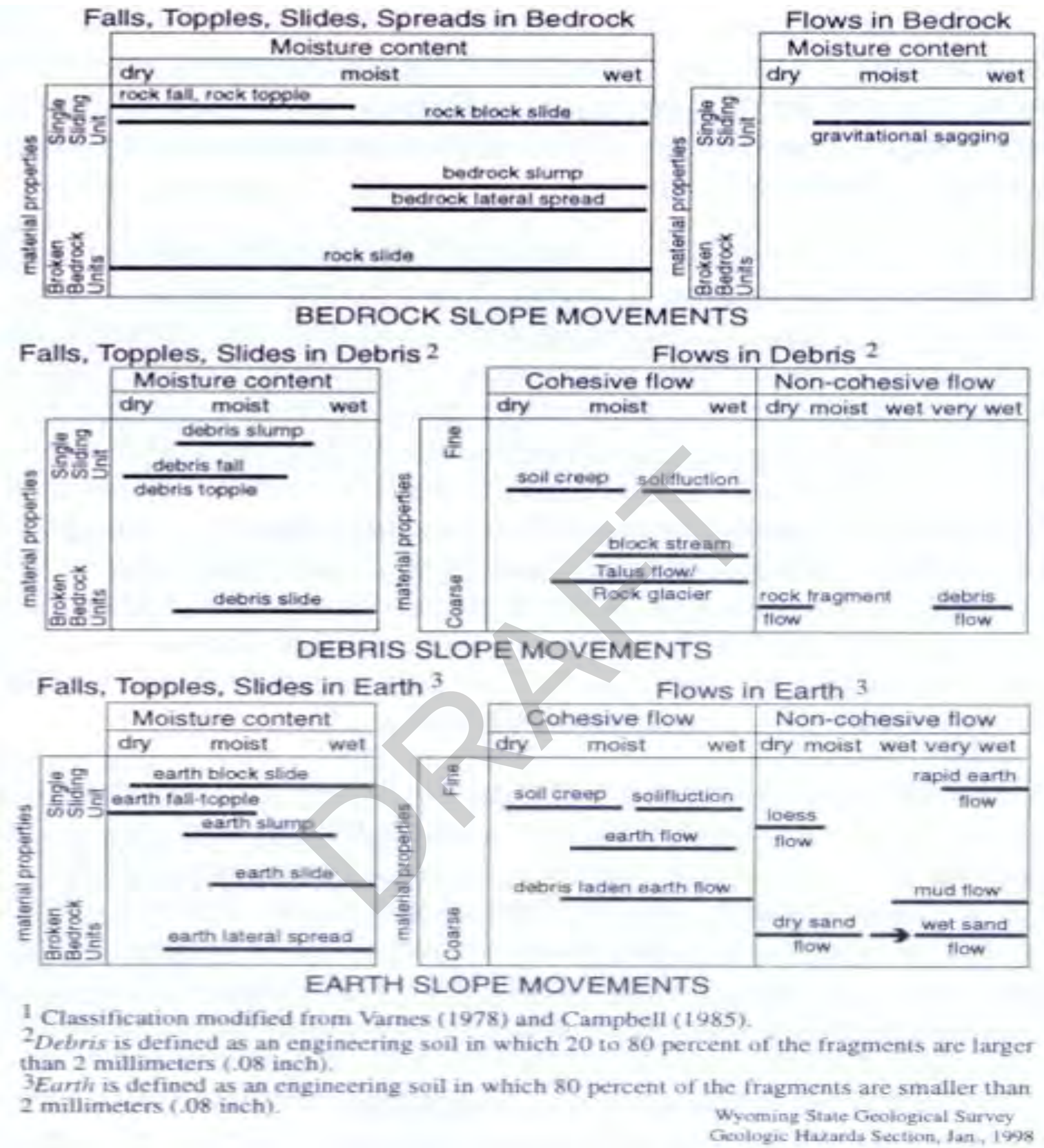
Areas that are generally prone to landslide hazards include existing old landslides; the bases of steep slopes; the bases of drainage channels; and developed hillsides where leach-field septic systems are used. Landslides are often a secondary hazard related to other natural disasters. Landslide triggering 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 type, the Geologic Hazards Section developed a landslide classification modified from Varnes (1978) and Campbell (1985). As can be seen in Figure 4.32, 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 4.32. Wyoming Landslide Classifications



Rockfall

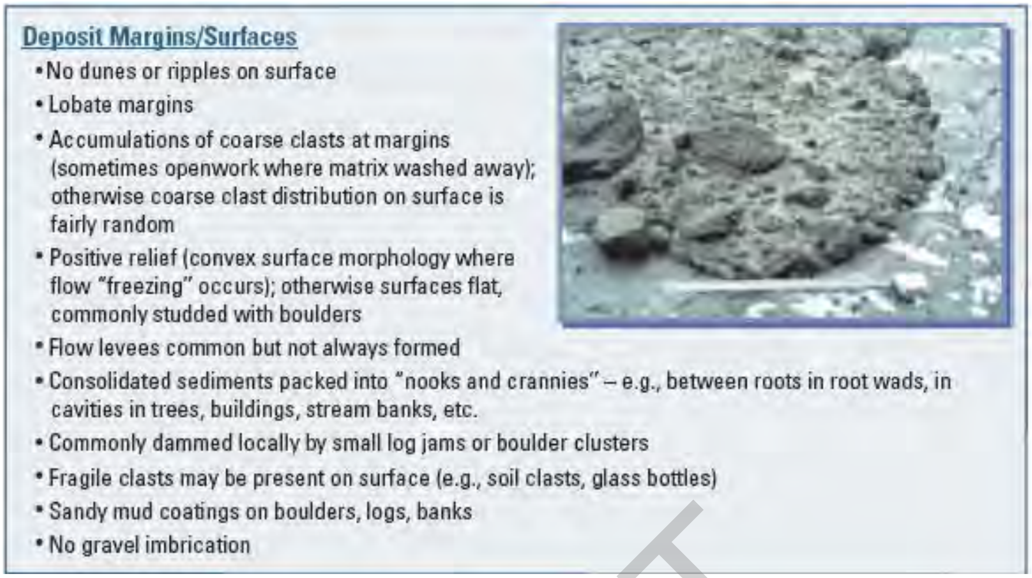
A rockfall is the falling of a detached mass of rock from a cliff or down a very steep slope. Weathering and decomposition of geological materials produce conditions favorable to rockfalls. Rockfalls are caused by the loss of support from underneath through erosion or triggered by ice wedging, root growth, 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. Rockfall occurs 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 slope 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 4.33 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 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 4.33. Field Evidence of Debris Flow



Geographical Area Affected

Landslides are one of the most common geologic hazards in Wyoming, with some of the highest landslide densities found in Region 6 counties notably Park County. Figure 4.34 below shows mapped landslides in the Region. Note the relatively high concentration of landslide deposits in Park County and northwestern Wyoming in general. Many of these slide areas have been studied by the Wyoming Geological Survey, WYDOT and others.

Washakie County Landslide Areas

In Washakie County the primary area of concern is along Highway 16 about 10 miles east of Ten Sleep. The County Planning Team estimates that the highway through Ten Sleep Canyon is partially blocked three times per year by landslides, primarily rock falls, with boulders varying in size up to 1,000 or more pounds. Additionally, the Gallatin Canyon Campgrounds area along highway 16 could be affected by landslides. The Region 6 Landslide Attachment includes descriptions of geologic investigations of specific problem areas with more details. Many areas studied include the risk of landslide dams

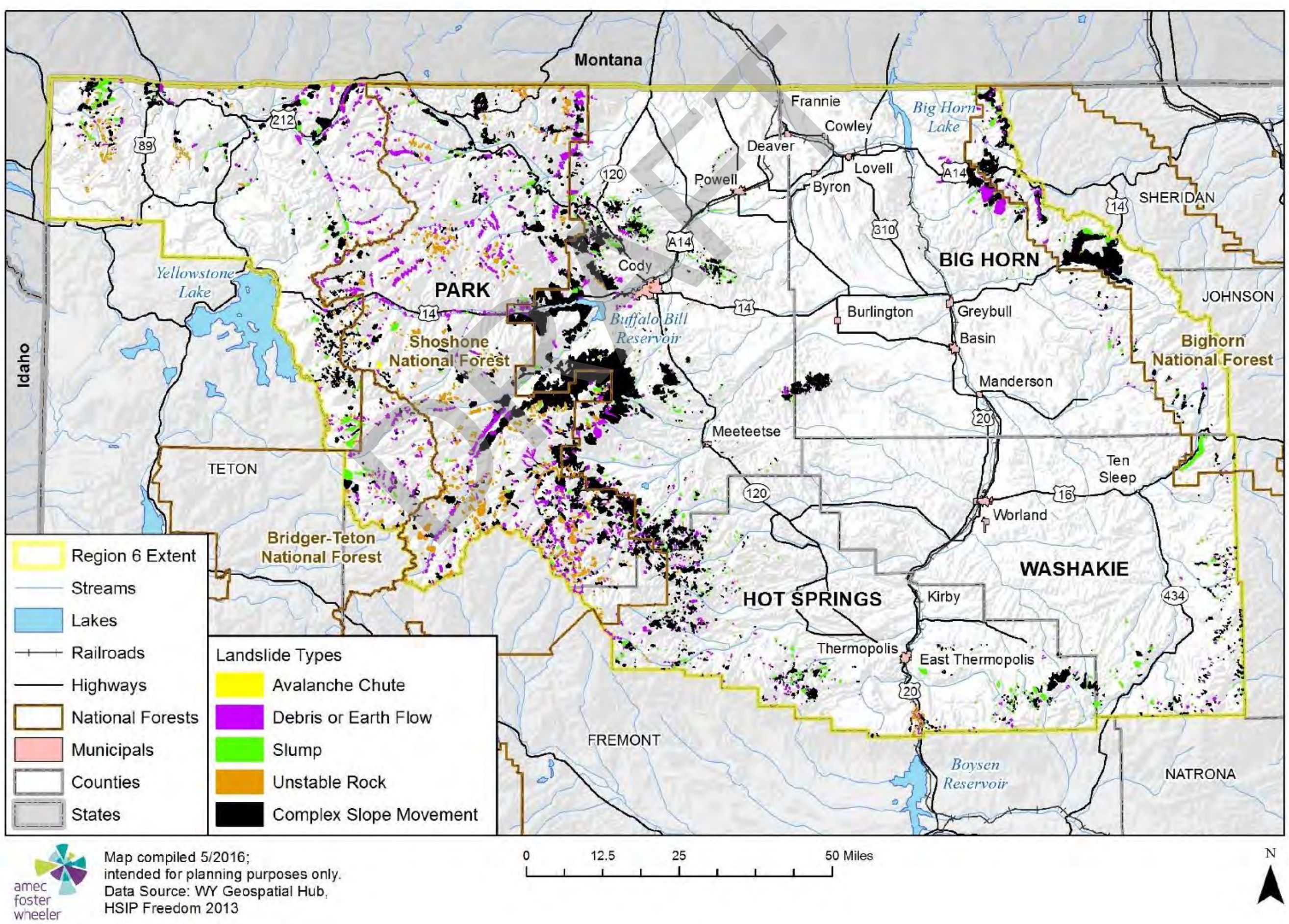
Park County Landslide Areas

One of the largest landslide complexes in the country is located southwest of Cody. The Carter Mountain landslide was more than 5 miles wide and 20 miles long. Based on WGS studies, debris flows near Highway 14/16/20 are a recurring problem. A water plant near Cody may also be affected if the landslide reactivates. Power transmission lines could also be affected in parts of the county. Rockslide and debris flow/alluvial fan complexes have apparently dammed many creeks and rivers in the area, including the South Fork of the Shoshone River and Marston Creek. State Highway 296 crosses through a blockslide in T55N R103W Sections 23 and 24.

Hot Springs County Landslide Areas

The Wind River Canyon has had several landslides destabilize and cause damage to the railroad. The railroad, U.S. Highway 20, and several homes and structures are at risk of being damaged if any of the landslides in the Wind River Canyon activate. There is also a remote possibility that a large debris flow reactivation may dam or partially dam the Wind River, and many smaller creeks within the county could be dammed as well by landslide activity. This could create a flash flood hazard downstream if the landslide dam fails or is overtopped.

Figure 4.34. Region 6 Landslide Areas



Past Occurrences

Since landslides, debris flows, and rockfalls occur regularly in Wyoming, previous occurrences are limited to those that caused a particular high amount of damage or incurred some other cost or unique impact. Selected incidents that occurred in or near the planning area are profiled below.

In September - October of 2015 a giant 'crack' in the earth formed near Lysite in the southern portion of Washakie County. This was caused by landslide activity that was associated with a wet spring and movement across a cap rock. Due to its size and unique appearance the incident received nationwide attention. However it did no damage as it occurred in an undeveloped area.

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, and the Wind River Indian Reservation. This declaration made Public Assistance funding available.

The Wind River Canyon in Hot Springs County has been impacted by several landslide, debris flow and rockfall events over the years. In June of 2015 mudslides closed some roads in Sunlight Basin near Cody in Park County and in the Wind River Canyon in Hot Springs County. According the State Hazard Mitigation Plan in July 1937 landslides in the Big Horn Basin destroyed large sections of railroad tracks, and washouts swept away a large number of highway bridges. Railroads and highways were washed out and mining property was damaged. Heavy flood damage also occurred in the Big Horn Basin, particularly in the Wind River Canyon and in the vicinity of Shoshoni. The damage in the Wind River Canyon resulted from landslides, which took out several sections of highway and railroad. In all, highways suffered damage in 12 counties. Severe damage occurred in the Upper Big Horn Basin. There were more than 3,000 feet of railway washed out and much was covered by landslides. The highway was badly damaged from Riverton to Thermopolis and traffic was suspended temporarily. Near Shoshoni traffic was possible only by long detours. Highways were considerably damaged in ten other counties in the eastern half of the state. (Source: State of Wyoming Multi-Hazard Mitigation Plan 2008, pg. 11.9)

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 it is reasonable to assume that damaging events have between 10 and 100 percent chance of occurrence in next year, or a recurrence interval of 10 years or less. Therefore, landslides, rockfalls or debris flows are **likely** to occur. Hazard areas discussed in the Landslide Hazard Attachment note that 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.

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 to high maintenance costs where 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 **limited**. However even a small isolated event has potential to close state or US highways in the region that can result 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. There are areas prone to rockfall in Ten Sleep Canyon along Highway 16 in Washakie County.

General Property

During the 2016 development of this regional plan a GIS analysis of exposure to landslide hazard areas was performed. Table 4.47 summarizes landslide exposure in the county, based on an intersect of improved parcels with landslide hazard areas. There are 244 properties in landslide hazard zones based on this analysis. The greatest risk to general property is in Park County.

Table 4.47. Landslide Exposure by County

Jurisdiction	Property Type	Building Count	Improved Value	Est. Content Value	Total Exposure	Population
Big Horn County						
Big Horn Unincorporated	Agricultural Production	1	$212,610	$212,610	$425,220	
	Residential	2	$257,720	$128,860	$386,580	
	Total	**3**	**$470,330**	**$341,470**	**$811,800**	**5.32**
	Grand Total	**3**	**$470,330**	**$341,470**	**$811,800**	
Park County						
Cody	Residential	1	$321,808	$160,904	$482,712	
	Total	**1**	**$321,808**	**$160,904**	**$482,712**	**2.37**
Park Unincorporated	Agricultural Production	12	$6,802,211	$6,802,211	$13,604,422	
	Commercial	6	$4,050,039	$4,050,039	$8,100,078	
	Residential	213	$65,183,622	$32,591,811	$97,775,433	
	Total	**231**	**$76,035,872**	**$43,444,061**	**$119,479,933**	
	Grand Total	**232**	**$76,357,680**	**$43,604,965**	**$119,962,645**	**504.81**
Washakie County						
Washakie Unincorporated	Agricultural Production	1	$511	$511	$1,022	19.12
	Residential	8	$857,282	$428,641	$1,285,923	
	Total	**9**	**$857,793**	**$429,152**	**$1,286,945**	
	Grand Total	**9**	**$857,793**	**$429,152**	**$1,286,945**	

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. This includes Highway 14 in Park and Big Horn counties and A14 in Big Horn, Highway 16 in Washakie east of Ten Sleep, and Highway 20 in the Wind River Canyon south of Thermopolis. 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. A water plant near Cody may also be affected if a landslide nearby reactivates. Power transmission lines could also be affected in parts of Park County.

During the 2016 development of this regional plan a GIS analysis of highway and county road infrastructure risk was conducted. The exposure to landslide hazard areas was estimated by overlaying road networks on hazard areas and summarizing results. The results are summarized by county in the following tables. Park County has the greatest exposure of road networks on landslide areas.

Table 4.48. Major Road Infrastructure Exposed to Landslide Hazards

County	Road Type	Segment Count	Length (ft)	Length (m)
Big Horn	County Road	4	16,965	3.2
	US Highway	16	84,721	16.0
	Total	**20**	**101,686**	**19.3**
Hot Springs	County Road	14	14,397	2.7
	State Highway	7	7,498	1.4
	Total	**21**	**21,895**	**4.1**
Park	County Road	43	159,944	30.3
	State Highway	4	4,103	0.8
	US Highway	51	111,209	21.1
	Total	**98**	**275,256**	**52.1**
Washakie	County Road	2	3,538	0.7
	State Highway	1	91	0.02
	US Highway	2	3,419	0.6
	Total	**5**	**7,048**	**1.3**
	Grand Total	**144**	**405,884**	**76.9**

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. Development in landslide areas frequently consists of vacation homes and represents a potential risk for injury, loss of life and property. There are small landslide areas near Cody. Future development in these areas should be done carefully to prevent landslide damage to property or people. Adverse effects can be mitigated by early recognition and avoiding incompatible land uses in these areas or by corrective engineering. Improving mapping and information on landslide hazards and incorporating this information into the development review process could prevent siting of structures and infrastructure in identified hazard areas.

Summary

Overall, landslides, rockfalls and debris flows range from **low** to **high** 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. Hot Springs ranked the significance as high to reflect risk to transportation (highway and rail) and travelling public in Wind River Canyon and economic impacts of highway and rail closures, as well as the potential to trigger a transportation hazardous materials incident. Secondary impacts could include landslide dams forming on creeks and overtopping, causing flash flooding in valleys below.

Table 4.49. Landslide Hazard Risk Summary

County	Likelihood	Spatial Extent	Potential Magnitude	Significance
Big Horn	Likely	Limited	Negligible	Low
Hot Springs	Likely	Limited	Critical	High
Park	Likely	Limited	Limited	Medium
Washakie	Likely	Limited	Negligible	Low

Municipalities impacted: Ten Sleep, Thermopolis (indirect impacts); Cody (direct and indirect impacts)

4.2.13 Lightning

Hazard 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.

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 NCDC, 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 NCDC records lightning incidents that have some sort of measurable impact; Table 4.50 includes all lightning incidents recorded by the NCDC for the four counties in Region 6. Washakie and Hot Springs counties had no lightning incidents recorded by the NCDC during this timeframe.

Table 4.50. Region 6 Lightning History 1969– 2015

County	Date	Fatalitie s	Injuries	Property Damage	Crop Damage
Washakie	05/06/1969	1	1	$50	$0
Washakie	11/11/1973	0	0	$21,739	$0
Washakie	07/10/1988	0	0	$5,555	$0
Washakie	07/17/1988	0	0	$8,333	$0
Washakie	08/14/1988	0	0	$7,143	$0
Washakie	07/05/1994	0	0	$50,000	$0
Big Horn	08/18/1996	0	0	$0	$0
Park	08/01/2000	0	5	$0	$0
Park	06/16/2010	0	0	$20,000	$0
Park	06/2010	1	0	$0	$0
Park	06/25/2014	0	4	$0	$0
Totals		**2**	**10**	**$112,820**	**$0**

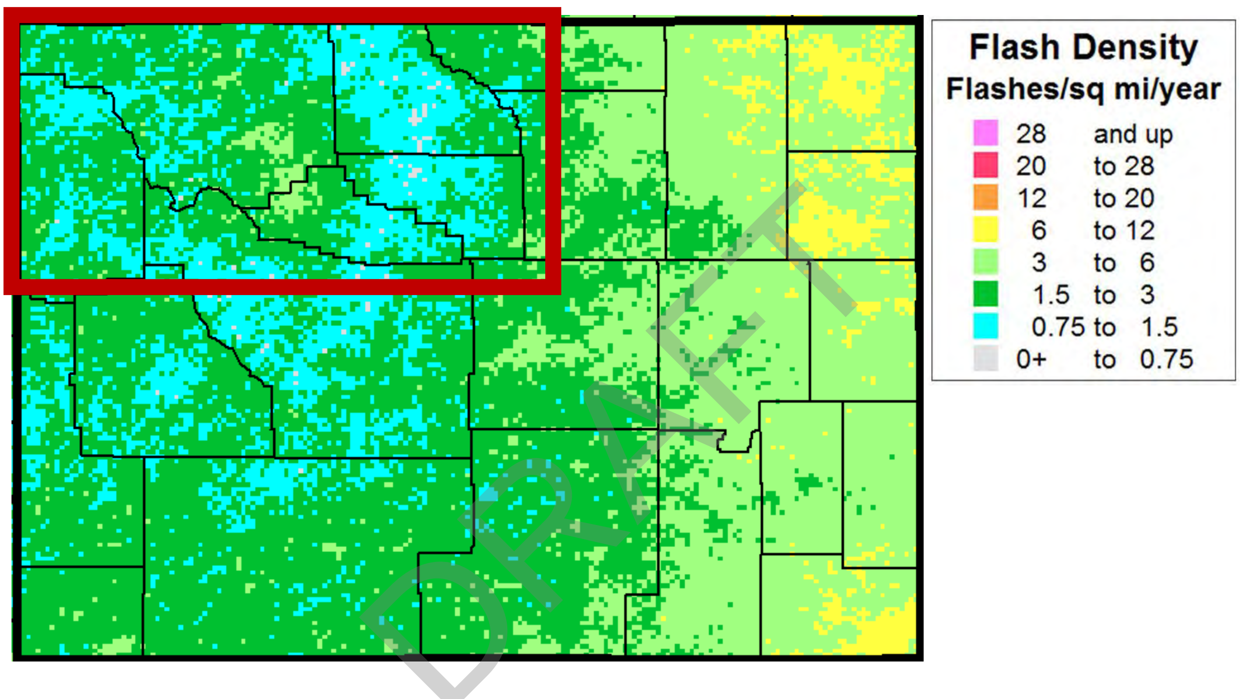
According to the HMPCs of the four counties, the lightning impacts noted by NCDC underrepresent the lightning history in the region. The committees noted multiple lightning injuries and fatalities not recorded by the NCDC.

Likelihood of Future 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 4.35 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. The Region's flash density is relatively low, ranging from 0.75 to 3 flashes per square mile per year across most of the planning area. A few isolated spots have slightly greater flash densities in the higher elevations of Park and Hot Springs counties. Despite annual variation, the locations of maximum and minimum strikes do not change much from year to year. A warming climate may also affect the frequency of lighting; in 2014 researchers at the University of Berkeley conducted a study that found that for every one degree Celsius rise in the average global temperature, there will be a 12 percent increase in the amount of lightning strikes.

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

Figure 4.35. 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. Lightning caused one death and nine recorded injuries between 1997 and 2015; these injuries were to people caught unprotected during a lightning storm. The 2010 Pitchfork strike killed a 70 year old man southwest of Meeteetse while on a camping and fishing trip. The 2000 strike in Cody injured 5 campers near Yellowstone Park, and the 2014 Garland strike injured four golfers. The Hot Springs County planning team noted an additional lightning fatality – a tourist near the Middle Forks Corrals.

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 percent 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 percent 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.

Past events in Region 6 indicate that the potential magnitude of lightning events will likely be limited—isolated deaths and/or injuries and illnesses 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 percent 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 6. 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.

General Property

According to the event details collected in the NCDC 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.

Lightning doesn't just strike unprotected people, as both the NCDC and the HMPCs reported that lightning causes the death of unprotected livestock. The 1996 strike in Burlington killed 11 head of cattle.

Structure fire ignition is also a concern; the 2010 strike in Wapiti started an attic fire, culminating in extensive damage to the home.

Finally, lightning can also have many cascading impacts, including power failure and ignition of wildfires. The Park County planning team noted that lightning can have major impacts on the electrical system. The Hot Springs County planning team noted that many towers are grounded, mitigating their vulnerability to lightning strikes; some electrical substations are as well.

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 the four counties in Region 6, although strikes with recorded impacts 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. Region 6 will remain vulnerable to lightning strikes for the foreseeable future. Unsheltered outdoor workers, outdoor enthusiasts and livestock will remain susceptible to lightning strikes. Lightning caused wildland fires may result in more extensive damage.

Table 4.51. Lightning Hazard Risk Summary

	Geographic Extent	Potential Magnitude/Severity	Probability of Future Occurrence	Overall Significance
Big Horn	Significant	Limited	Likely	Low
Hot Springs	Significant	Limited	Likely	Low
Park	Significant	Limited	Highly likely	Medium
Washakie	Significant	Limited	Likely	Low

4.2.14 Mine Subsidence

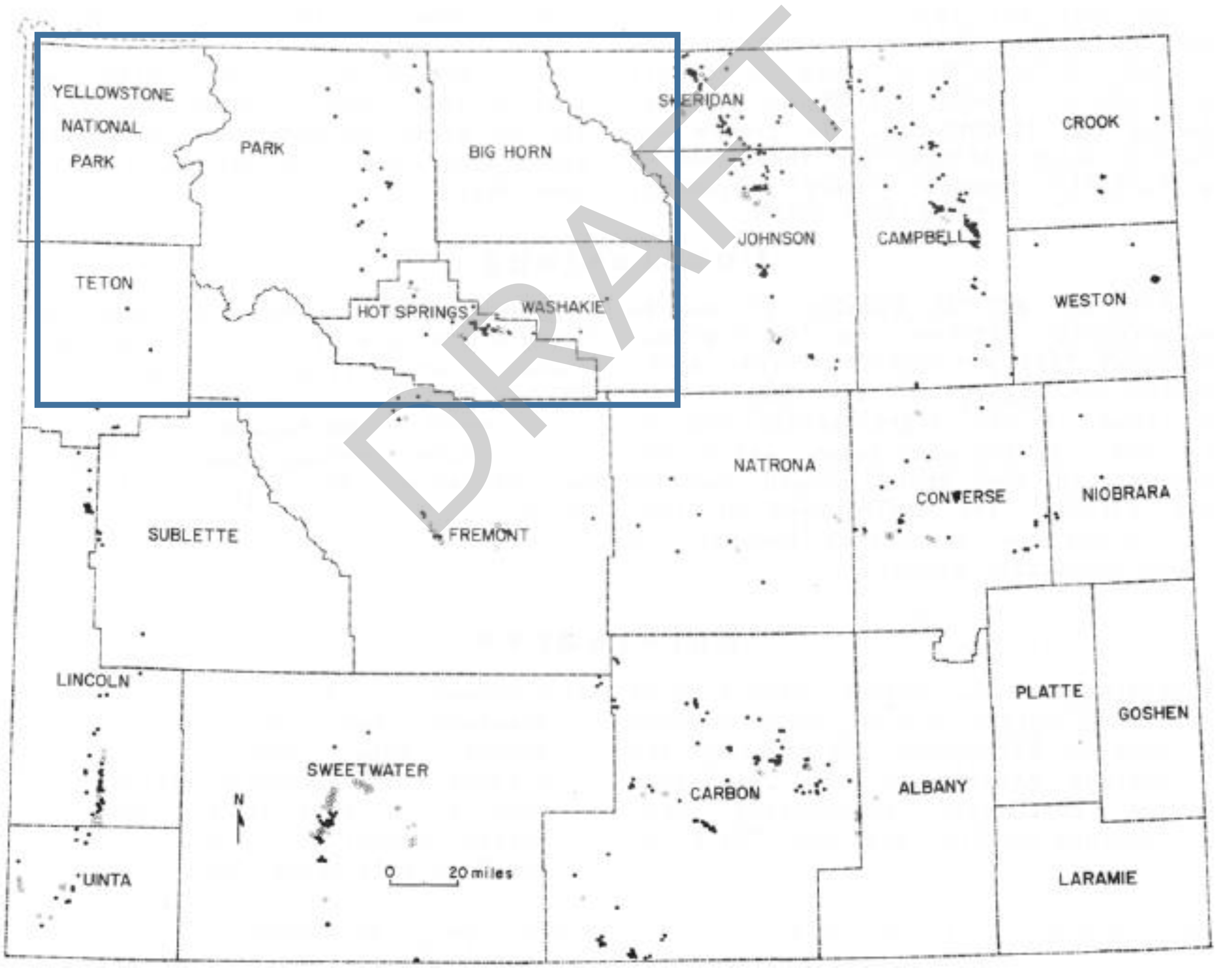
Hazard/Problem Description

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 the effect of the collapse reaches the surface, a subsidence pit or trough forms. Not all subsidence from mining is due to poor design, however. 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 fires occurred in the mines, resulting in a loss of strength in the pillars and caprock.

Geographical Area Affected

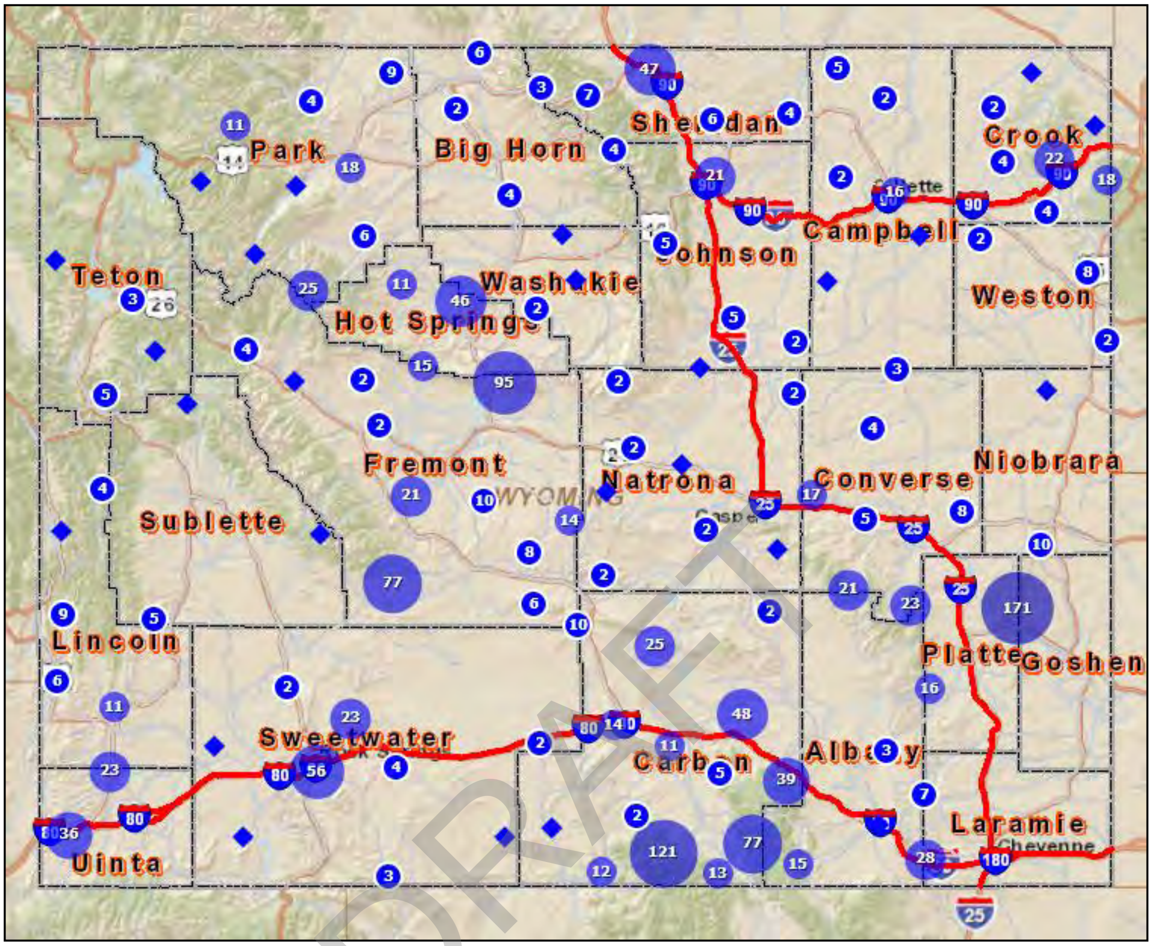
A map showing documented subsidence is shown in Figure 4.36 and Figure 4.37 Mined-out areas and mine subsidence in Wyoming. Gray areas represent mined-out areas with subsidence

Figure 4.36. Mine Subsidence in Wyoming



Solid areas represent mined-out areas with no known subsidence.
Source: 2016 Wyoming Multi-Hazard Mitigation Plan

Figure 4.37. Abandoned Mine Sites with Subsidence-Prone Underground Workings



There are numerous abandoned underground coal mines in Hot Springs County, with some near Kirby

Abandoned mine sites identified within the Kirby USGS 1:24,000 scale map quadrangle include:

- Burnell No. 2 - T44N R95W Section 10
- Cowboy Mine – T44N R94W Section 22
- Crosby Mine – T44N R94W Section 7 and 18; T44N R95W Sections 12 and 13
- Eagle Mine – T44N R94W Sections 17,18,19, 20
- Gebo Mine – T44N R94W Sections 3, 4, 9-14
- Price and Jones Mine – T44N R94W Section 22
- Steins No. 1 – T44N R94W Section 18
- Steins No. 2 – T44N R94W Section 19
- Wyckoff Mine – T44N R94W Section 22
- 3 Unnamed mines – T44N R95W Section 10
- 3 Unnamed mines – T44N R95W Section 11

- 3 Unnamed mines – T44N R95W Section 13

Although some of these may have been reclaimed, no development should be allowed at the sites until it can be shown that reclamation has occurred and that the reclamation has been successful.

Past Occurrences

According to the 2016 Wyoming Hazard Mitigation Plan over the past several years, in addition to a large number of traditional mine reclamation projects on both coal and non-coal mine sites, the Wyoming Abandoned Mine Lands (AML) Program at Wyoming Department of Environmental Quality (DEQ) has funded two or three large subsidence mitigation projects annually, along with smaller projects to protect individual homeowners, done at the request of individual homeowners. Recent subsidence mitigation projects have focused on protecting critical infrastructure.

Frequency/Likelihood of Future Occurrence

Although many areas of the state have already had 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 percent probability of occurrence in the next year, or has a recurrence interval of 11 to 100 years).

Vulnerability Assessment

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

The dollar impact 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).

Specific to the Region it is considered that vulnerability to the mine subsidence hazard is generally negligible.

Future Development

Locations where mine subsidence may occur are located throughout the state 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 all mined out areas in Wyoming have been mapped, it is unknown if all locations of potential subsidence have been located. The uncertainty regarding the locations of more potential subsidence areas means there is the possibility development may occur in a subsidence-prone location without the knowledge of contractors or developers prior to development. Given this fact, there is no way to determine with certainty the likelihood development will occur in a subsidence-prone location. Therefore, it is difficult to put a risk factor to this hazard as it relates to development within Wyoming's borders.

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.

Table 4.52. Mine Subsidence Hazard Risk Summary

County	Likelihood	Spatial Extent	Potential Magnitude	Significance
Big Horn	Occasional	Limited	Negligible	Low
Hot Springs	Occasional	Limited	Negligible	Low
Park	Occasional	Limited	Negligible	Low
Washakie	Occasional	Limited	Negligible	Low

Municipalities impacted: Kirby

4.2.15 Tornado

Hazard 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 is 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 4.53. 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	Devastatin g 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.

Recent Changes to Tornado Rating Scale

Devastating tornadoes in Jarrell, Texas on May 1997 and Moore/Oklahoma City on May 1999 demonstrated to 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 4.54. 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

Geographical Areas Affected

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

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 6 are given low ratings on the Fujita Scale (F0s and F1s) simply because these tornadoes are often formed over open land and result in little or no damage.

Since 1950, there have been 53 tornadoes between the four counties in Region 6, as documented by the National Climatic Data Center. From 1950-2015, there was one injury, two fatalities, and $527,750 in total recorded property damage in Region 6. A full accounting of those tornadoes can be found at the end of this chapter.

Table 4.55. Tornado History by County, Region 6

County	Incidences
Big Horn	32
Hot Springs	5
Park	9
Washakie	7
Total	53

Source: National Climatic Data Center

Table 4.56. Tornado History, Region 6

Location (City or County)	Date	Time	Magnitude	Deaths	Injuries	Property Damage	Crop Damage
Big Horn	6/3/1958	1600	F2	0	0	$25,000	0
Big Horn	6/26/1959	1600	F2	1	1	$2,500	0
Big Horn	7/28/1959	1730	-	0	0	$2,500	0
Big Horn	6/12/1962	1600	F2	0	0	$2,500	0
Big Horn	7/9/1962	1600	F2	0	0	$2,500	0
Big Horn	6/5/1964	1510	-	0	0	$25,000	0
Park	6/26/1964	1600	F2	0	0	$25,000	0
Big Horn	7/24/1967	1600	F2	0	0	$2,500	0
Big Horn	6/20/1974	1500	F1	0	0	$2,500	0
Big Horn	6/20/1974	1530	F1	0	0	$2,500	0
Big Horn	7/20/1974	2030	F1	0	0	$2,500	0
Washakie	6/18/1975	1709	F0	0	0	0	0
Washakie	6/17/1976	1540	F0	0	0	$2,500	0
Park	6/26/1976	1830	F1	0	0	$2,500	0
Big Horn	7/4/1976	1700	F1	0	0	0	0
Big Horn	6/18/1978	2100	F1	0	0	$25,000	0
Big Horn	7/4/1978	1430	F2	0	1	$250,000	0
Park	7/11/1978	1620	F2	0	0	$25,000	0
Big Horn	7/24/1981	1500	F1	0	0	0	0
Big Horn	5/3/1984	1830	F0	0	0	$2,500	0
Park	6/20/1984	1400	F0	0	0	$250	0
Hot Springs	6/20/1985	1744	F0	0	0	$25,000	0
Big Horn	8/2/1985	1330	F3	0	0	0	0

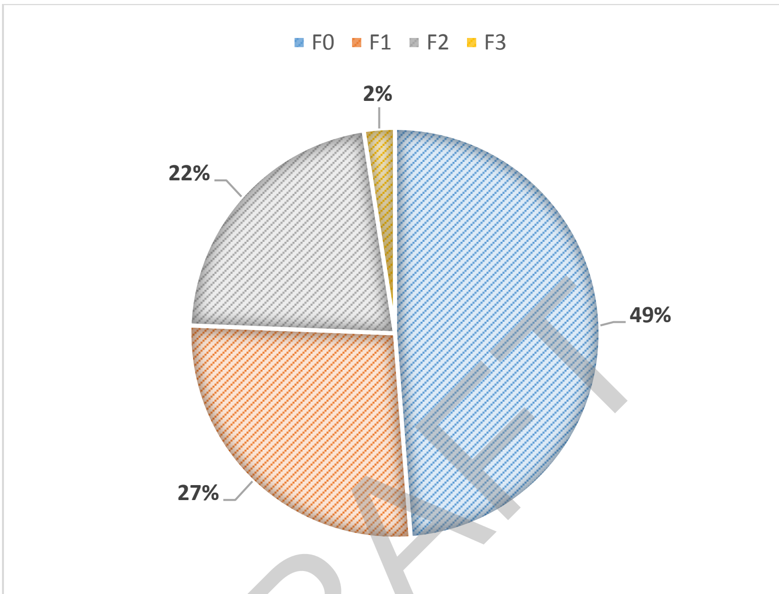
Location (City or County)	Date	Time	Magnitude	Deaths	Injuries	Property Damage	Crop Damage
Park	8/25/1986	530	F1	0	0	$25,000	0
Washakie	5/18/1987	1509	F0	0	0	0	0
Big Horn	6/18/1987	1708	F0	0	0	0	0
Park	5/18/1991	1807	F1	0	0	0	0
Big Horn	7/12/1992	1255	F0	0	0	0	0
Big Horn	6/6/1997	1658	F0	0	0	0	0
Big Horn	6/6/1997	1700	F0	0	0	0	0
Big Horn	6/6/1997	1710	F1	0	0	0	0
Big Horn	6/13/1997	1825	F0	0	0	0	0
Big Horn	7/24/1997	1509	F0	0	0	0	0
Washakie	8/11/1999	1535	F0	0	0	0	0
Washakie	8/28/1999	1445	F0	0	0	0	0
Big Horn	6/26/2001	1742	F0	0	0	0	0
Big Horn	6/26/2001	1756	F1	0	0	0	0
Hot Springs	7/10/2001	1530	F2	0	0	0	0
Park	6/1/2005	1217	F0	0	0	0	0
Big Horn	6/1/2005	1229	F0	0	0	0	0
Big Horn	6/1/2005	1238	F0	0	0	0	0
Big Horn	6/1/2005	1240	F0	0	0	0	0
Hot Springs	5/29/2008	1134	EF0	0	0	0	0
Big Horn	6/1/2009	1458	EF1	0	0	$5,000	0
Hot Springs	6/14/2009	1353	EF0	0	0	0	0
Washakie	8/14/2009	1627	EF0	0	0	0	0
Big Horn	8/12/2010	1411	EF0	0	0	0	0
Washakie	8/30/2010	1251	EF1	0	0	$70,000	0
Park	5/27/2013	1000	EF0	0	0	0	0
Big Horn	5/24/2014	1336	EF0	0	0	0	0
Hot Springs	6/3/2014	1107	EF0	0	0	0	0
Park	5/16/2015	1213	EF0	0	0	0	0
TOTALS				**1**	**2**	**$527,750**	**0**

Source: National Climatic Data Center

The Hot Springs County planning team noted an additional tornado occurring on May 25, 2016.

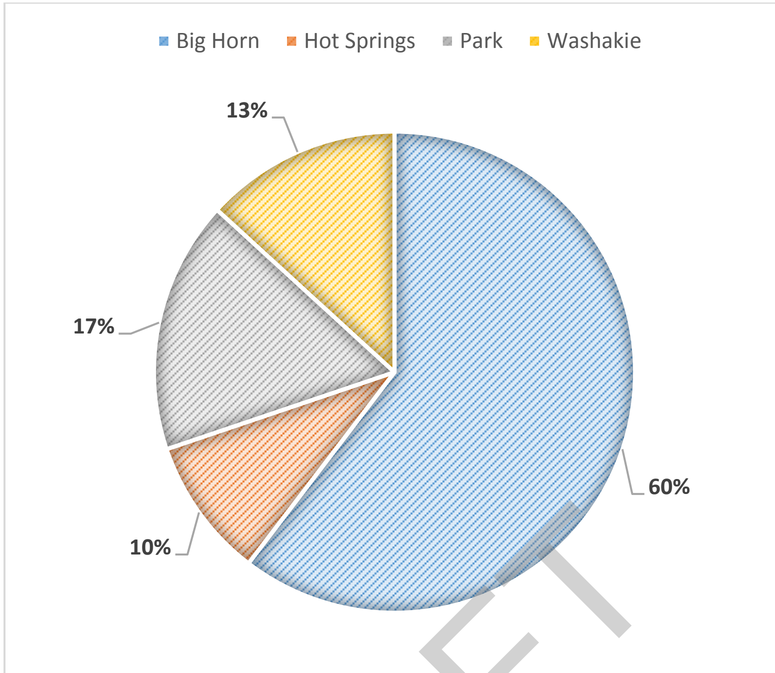
The NCDC data allows for examination and statistical analysis of tornadoes occurring in the county. 49% of the historical tornadoes were rated F0; when the EF scale was introduced, 80% of the ten EF-rated tornadoes were rated EF-0.

Figure 4.38. F-Scale Tornadoes by Rating



Analysis can also be done on the ratings of tornadoes per county. Historically, Big Horn County has seen the majority of the tornadoes in the region, with 32 of the 53 twisters occurring in that county alone.

Figure 4.39. Rated Tornadoes by County



Finally, the data allows for the development of profiles on historical time periods of tornadoes. Figure 4.40 and Figure 4.41 give historical perspective on the time of year and time of day that tornadoes in the region have occurred.

Figure 4.40. Historical Tornadoes by Month: 1958-2015

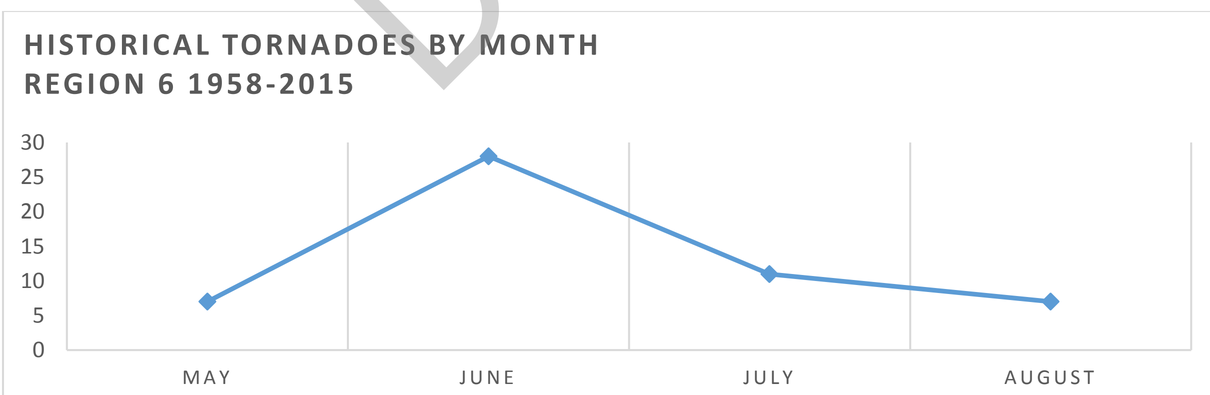
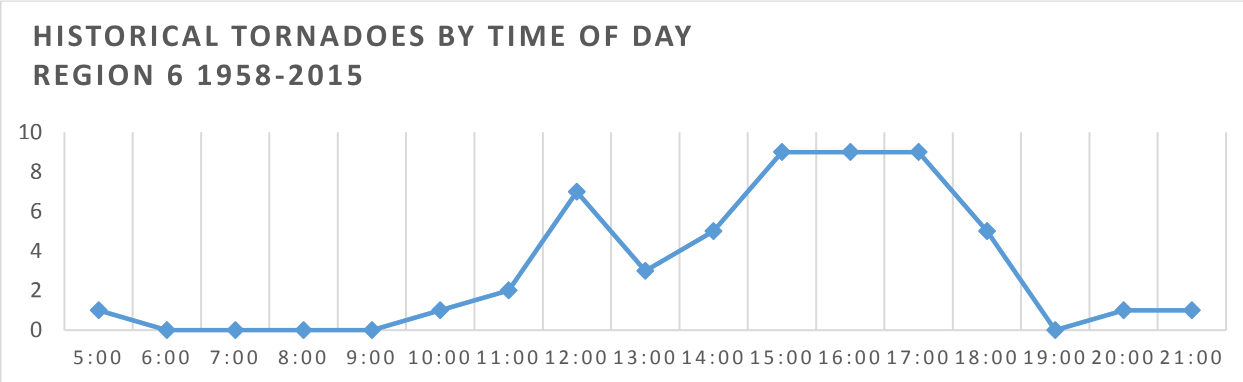
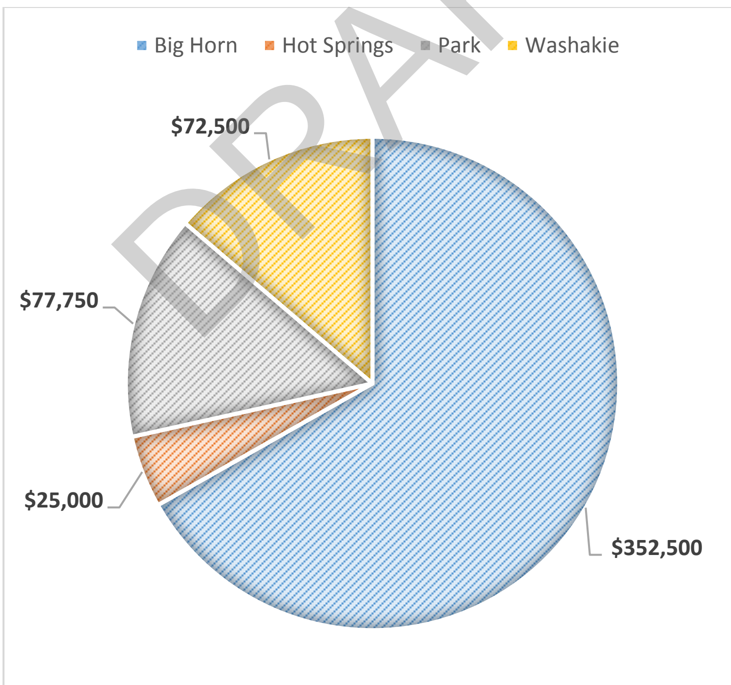


Figure 4.41. Historical Tornadoes by Time of Day: 1958-2015



Most tornadoes recorded in the four counties in Region 6 cause no recorded injuries, no recorded fatalities, and little to no damage to property ($2,500 - $25,000 range). Of the 53 tornadoes that have been recorded by the NCDC in Region 6 from 1958 to 2015, 22 have caused property damage and none have caused crop damage.

Figure 4.42. Damage by County: 1958-2015



Frequency

On average, at least one of the counties in Region 6 experiences a tornado almost annually. Recorded tornadoes in Region 6 occurred during the months of May through August, between 5 a.m. and 9 p.m. Historical ratings vary between F0 and F2 on the F-scale; after the advent of the

EF-scale, the Region has experienced 8 EF-0 tornadoes and 2 EF-1 tornadoes. Most recorded tornadoes in the Region are rated as F-0 or EF-0.

NCDC has not recorded any injuries or fatalities that are attributed to these tornadoes. Cumulatively, the storms have caused $527,750 in recorded property damage, and no recorded crop damage. Almost two-thirds of the recorded property damage occurred during two storms:

- On July 4, 1978, an F-2 tornado 200 yards wide travelled 5 miles near Greybull in Big Horn County. Reports stated that the tornado uprooted numerous trees in over 800 acres of forest as it traveled northeast. One woman was injured in a camper as it was rolled over by winds. Damages to a lodge at a dude ranch were also noted. In total, the storm caused $250,000 worth of property damage.
- On August 30, 2010, an EF-1 tornado 30 yards wide traveled 4.5 miles into the Nowood River Valley in Washakie southeast of Ten Sleep. The tornado destroyed several well-built buildings and tore down trees on ranches in the valley.

The NCDC database describes the property damage as downed tree limbs and power outages, damage to homes, sheds and outbuildings to include roofs and chimneys, and downed timber on forest lands.

Most tornadoes recorded in the four counties in Region 6 cause no recorded injuries, no recorded fatalities, and little to no damage to property ($2,500 - $25,000 range). Of the 53 tornadoes that have been recorded by the NCDC in Region 6 from 1958 to 2015, 22 have caused property damage and none have caused crop damage.

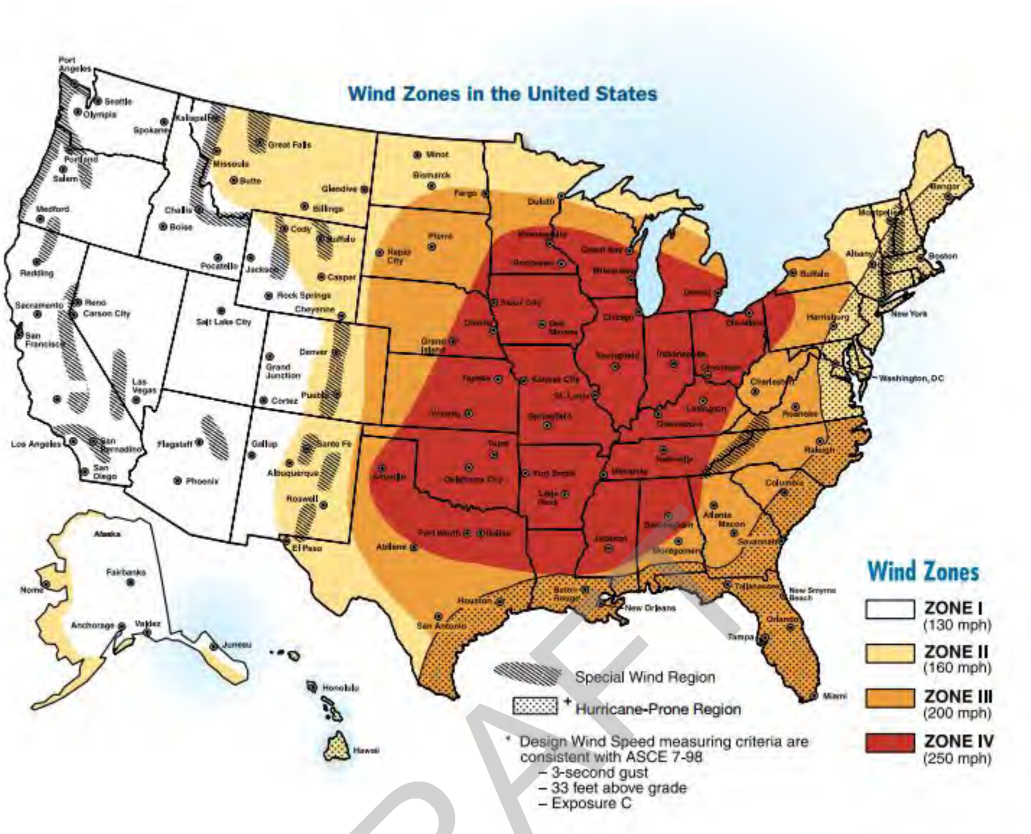
Likelihood of Occurrence

According to the NCDC, a tornado occurs somewhere in the Region almost annually. An average tornado occurs in June in the evening, is rated EF-0 or EF-1, and causes less than $25,000 worth of damage to property, though it mostly strikes rural areas causing no damage. This is due more to chance than any environmental factor, however, as inhabited areas are statistically equally at risk of a tornado strike; the potential for injuries, fatalities and damage in these areas is much greater.

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. Most of the Region is in Zone II, which could expect winds up to 160 mph.

Figure 4.43. Wind Zones in the United States



According to NCDC records, the storm of record for the four counties in the Region occurred in Big Horn County on July 4, 1978 when an F2 tornado near Greybull damaged trees and did damage to a lodge at a dude ranch. Total damages were recorded at $250,000. The tornado caused one injury in a rolling camper.

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. 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 jurisdiction; 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 6. Depending on a tornado's size, ferocity and path, it can cause devastating damage to people, property and infrastructure.

Table 4.57. Tornado Hazard Risk Summary

	Geographic Extent	Potential Magnitude	Probability of Future Occurrence	Overall Significance
Big Horn	Significant	Critical	Highly Likely	High
Hot Springs	Significant	Negligible	Highly Likely	Low
Park	Significant	Limited	Highly Likely	Medium
Washakie	Significant	Limited	Highly Likely	Medium

4.2.16 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 6, 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.

Geographical Area Affected

Winter storms are a yearly feature of the Wyoming climate and may occur anywhere in the state. Generally, severe winter storm 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, the impacts and effects of a regional hazard are still felt within the planning area. Therefore, 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.

Past Occurrences

The winter storm history in the Region 6 counties extends from January 1996 to March 2016. The counties in Region 6 experienced 173 separate days with a recorded winter weather incident. Total damages in the Region amounted to $1,015,000 in property damage; $1 million of this occurred in a single storm on October 15th, 1998, and included tree damage, power outages and utility damage, and vehicle accidents. There has been no recorded history of crop damage due to severe winter weather.

Frequency/Likelihood of Occurrence

Winter storms 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 almost six days with a recorded severe winter incident per year.

Potential Magnitude

The damages caused by severe winter storms and blizzards very 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.

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

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.

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.

General Property

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.

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.

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 and local highway and 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.

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

Winter Storms are generally a medium significance hazard in the Region.

Table 4.58. Winter Storm Hazard Risk Summary

	Geographic Extent	Probability of Future Occurrence	Potential Magnitude/Severity	Overall Significance
Big Horn	Extensive	Likely	Limited	Medium
Hot Springs	Extensive	Likely	Limited	Medium
Park	Extensive	Highly Likely	Limited	High
Washakie	Extensive	Likely	Limited	Medium

4.2.17 Wildfire

Hazard/Problem Description

Wildfire is defined as a highly destructive fire or any instance of uncontrolled burning in grasslands, brush or woodlands. Wildfire has encroached into urban interface situations 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 direction in which 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 more significant the risk of wildland fire hazard. 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 these 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.

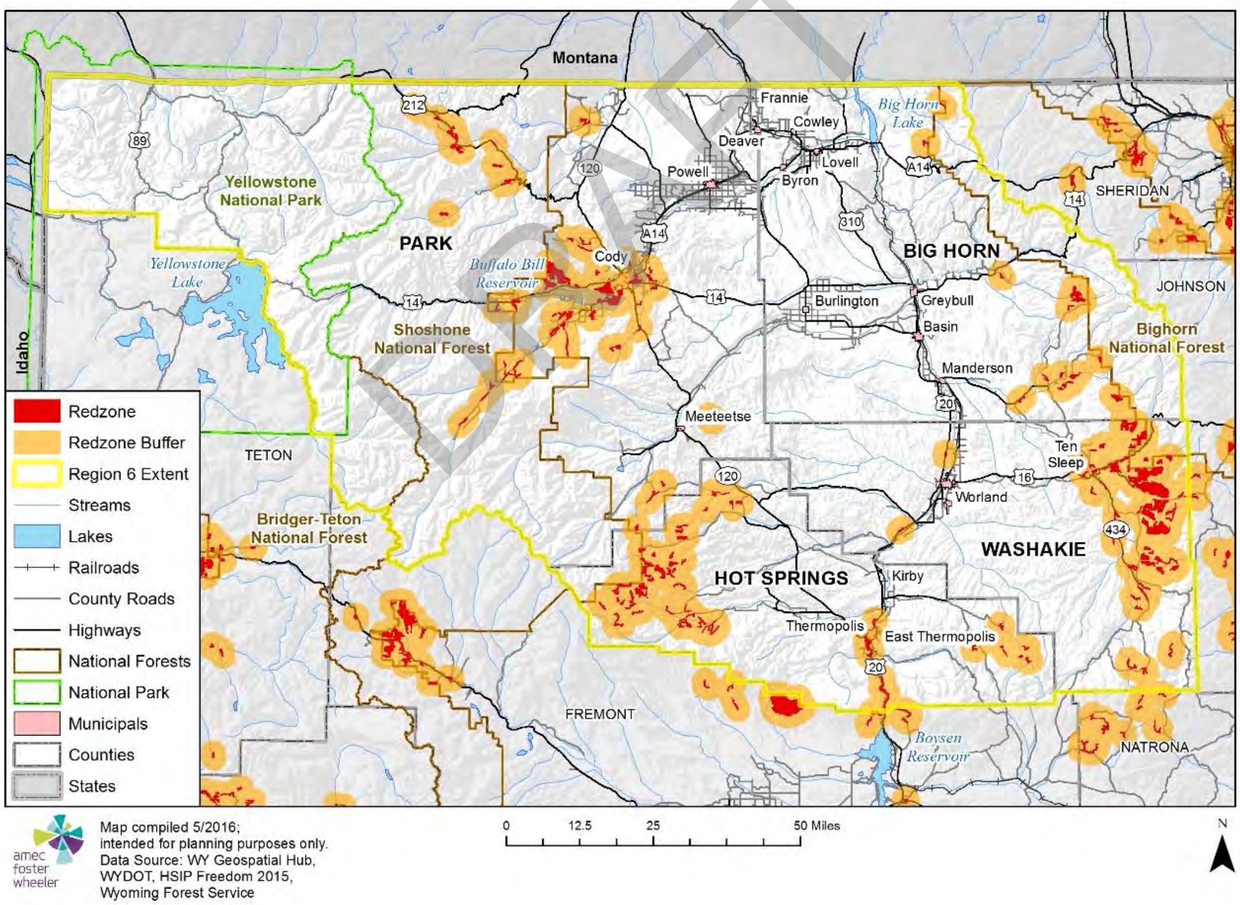
Geographical Area Affected

Certain areas of the counties in Region 6, because of their semi-arid climate and availability of fuel, are vulnerable to catastrophic wildland fires, and, of the all fires in Wyoming, over 50%

involve wildland areas. The entire Region could potentially burn from 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 4.44, 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 first fire-hazard mapping program of its kind). The Assessment maps fire hazard incorporating population density against slope, aspect, and fuels. 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 (Redzones) for catastrophic wildland fires.

Figure 4.44. Wildland Fire Redzones



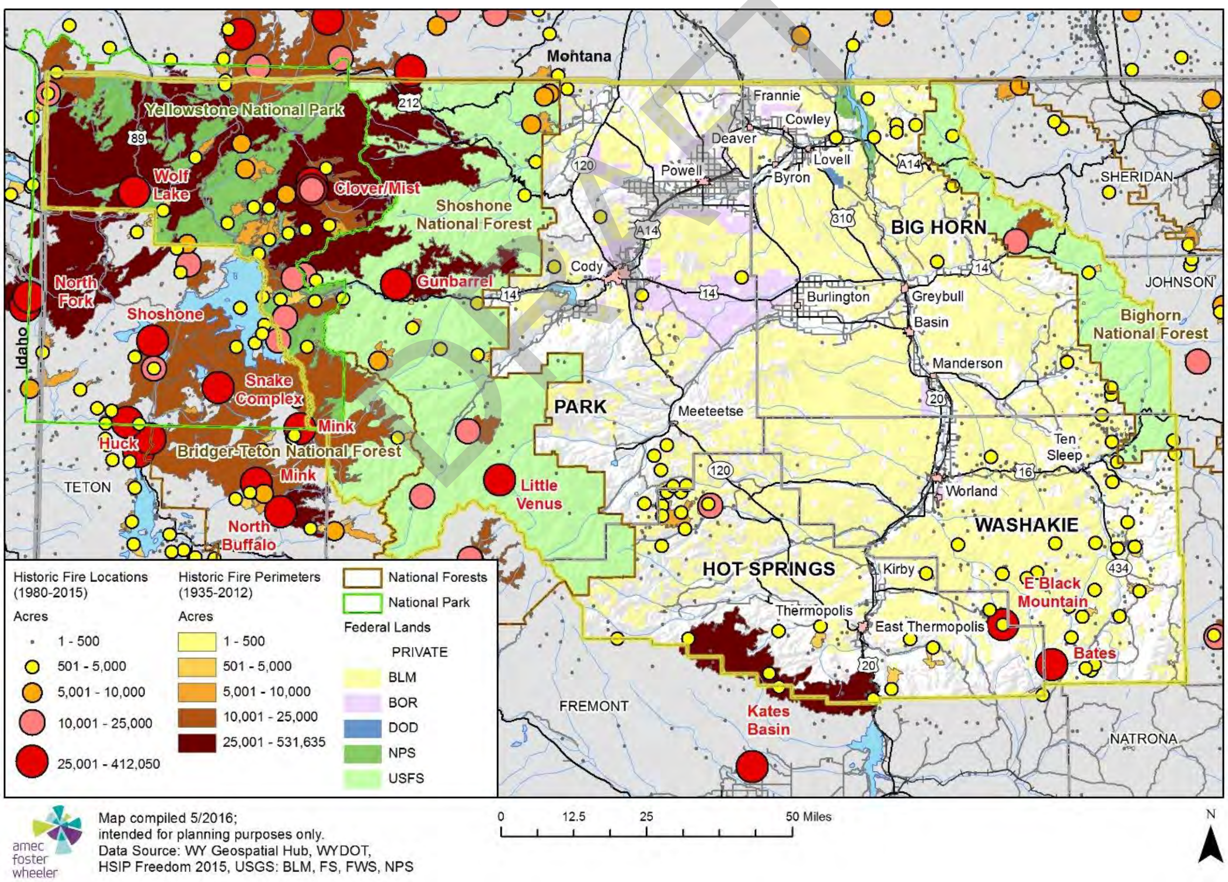
Past Occurrences

The Federal Wildland Occurrence Database was used to analyze fire history in Region 6.

The Federal Wildland Fire Occurrence 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 US Forest Service reports include fires of 10 acres and greater. The database is limited to fires on federal lands. Some fires may be missing altogether or have missing or incorrect attribute data. Some fires may be missing because historical records were lost or damaged, fires were too small for the minimum cutoffs, documentation was inadequate, or fire perimeters have 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.

The following figure shows a map of wildfires that have affected the area based on the Federal Wildland Occurrence Database. Some of the largest recorded fires occurred in the northwest part of the Region. Some of the more significant fires are discussed by county in the following section.

Figure 4.45. Wildland Fire Occurrences in Wyoming 1935 - 2015



Big Horn

Big Horn County has a long history of wildfire, as a significant portion of the county is located in the Big Horn Mountains. One of the earliest recorded large fires was in the summer of 1876 when the Sioux Indians retreated into the Big Horn Mountains, setting fire to the land, burning an estimated 500,000 acres to keep the United States Army, under the command of General Crook, from pursuing them.

Historically, most significant fires in Big Horn County have occurred in the eastern county, in and around the foothills and higher elevations of the Bighorn Mountains. More recently there have been several fires affecting over 1,000 acres, and many smaller fires throughout the county (see Figure 4.45). Lightning starts many wildfires, but a number of structures in Big Horn County have burned as a result of out-of-control irrigation ditch burning to clear vegetation and debris for agricultural field operations (Source: Wyoming Multi-Hazard Mitigation Plan 2014). Additional details on fire history in Big Horn County can be referenced in their County Annex to this plan.

According to the Federal Wildland Occurrence data, a total of 225 fires burned 41,571 acres. Many of these fires were relatively small, burning only a few acres. The largest fire in Big Horn County occurred in 2007. The Bone Creek Fire burned 13,450 acres. Table 4.59 describes Big Horn County wildfires that burned 1,000 or more acres between 1980 and 2015.

Table 4.59. Wildfires over 1,000 acres in Big Horn County: 1980-2015

Name	Year	Acres Burned
Big Fork	2013	1,509
Reservoir	2011	2,200
Bone Creek	2007	13,450
Copper	2003	2,500
Little Mt 2	1997	1,093
Intermission	1988	1,800
Dorn 2	1988	1,514

Hot Springs

The Federal Wildland Occurrence data recorded 157 fires between 1980 and 2015 in Hot Springs County. The total acres burned added up to 99,205 acres.

The Kate's Basin Fire was a wildfire complex which began burning southwest of Thermopolis and north of Riverton in Hot Springs County, Wyoming. The fire complex started as the Kate's Basin and Blondie #2 fires on August 7, 2000 and by August 18, it had burned over 137,600 acres (556.8 km2). The fire started as a result of lightning. During the fighting of the fire a burn over incident resulted in the death of an engine boss.

By the end of July 2000, the Enos Complex fires had burned over 11,000 acres of limber pine, juniper, Douglas fir, sagebrush, and grass on mostly Bureau of Land Management (BLM) administered public lands. The fire was started by lightning.

Table 4.60. Wildfires over 1,000 acres in Hot Springs County: 1980-2010

Name	*Year*	*Acres Burned*
Copper Mountain	2007	3,978
Renner DRA	2001	2,974
Kate's Basin	2000	137,600
Middle Enos	2000	10,005
Muddy Creek	2000	3,840
Enos	2000	2,499
Middle Creek	2000	1,400
Lower Gras	1999	1,832
Lower Gras 2	1999	1,410
Larsen	1998	2,640
E. Black Mountain	1996	48,844
Barbeque	1996	1,400
Black Mountain 2	1996	1,187
Blondie 2	1988	1,000

Park

Fire occurrence often coincides with times of drought which can create especially severe fire seasons. This was well-demonstrated by the Yellowstone Fires in the late 1980s. The Yellowstone National Park fires of 1988 were the largest series of fires in the northern Rockies during the last 50 years. Fifty fires started in the park that year. These fires, along with other natural and human-caused fires that began outside the Park boundaries, eventually burned more than a third of the Park, nearly 800,000 acres. Another 700,000 acres outside the Park also burned. Figure 4.46 displays the burned area extent from the fires. Approximately 25,000 firefighters worked to put out the fires. The costs exceeded $120 million. Roughly half of the national park lies within northwestern Park County.

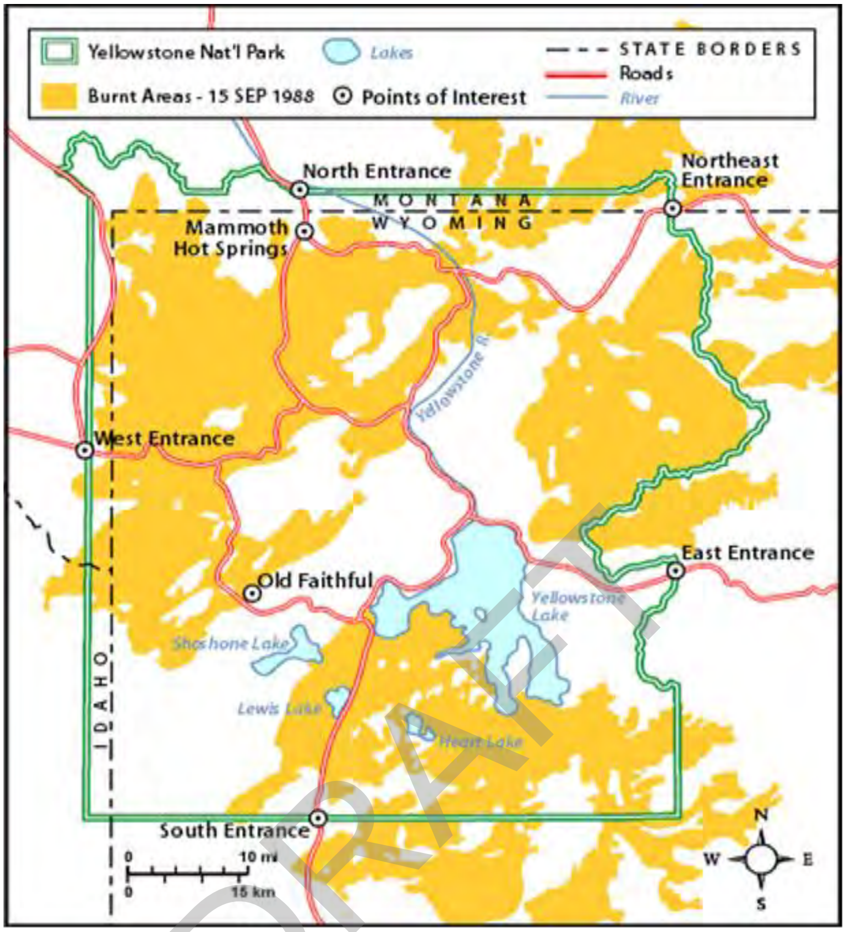
In Yellowstone National Park, the fire season usually lasts from June to early September. In 1988, several factors led to an abnormal fire season. During June of that year, there was little rain and extremely high temperatures and winds. Yellowstone National Park was suffering from severe drought conditions. The drought left Yellowstone more vulnerable to fires than usual. The fires of 1988 led to an intense public debate regarding the National Park Service's fuel management policy. This policy stated that fires started by natural causes should be allowed to burn to their natural conclusion.

Table 4.61. Wildfires over 1,000 acres in Park County: 1980-2010

Name	Year	Acres Burned
Henry Mill	2015	1,259
Swede	2014	1,529
Hardluck	2013	24,515
Alum	2013	7,299
Cygnet	2012	3,540
Butte Creek	2012	1,515
Dewdrop	2012	1,498
Sage Creek	2012	1,122
Hole in the Wall	2011	6,541
Point	2011	2,000
Antelope	2010	5,510
Gunbarrel	2008	68,148
Columbine	2007	18,595
Citadel	2007	1,974
Beaverdam	2007	1,353
Little Venus	2006	34,581
Stinky	2006	1,010
East	2003	18,762
Boulder Basin 2	2003	10,953
Deep Lake	2003	6,980
Norris	2003	5,425
Grizzly	2003	5,000
Blackwater	2003	1,462
Broad	2002	9,140
Sulphur	2001	3,750
Arthur	2001	2,850
Crow	2000	1,418
Renner 2	2000	1,156
Towers	1999	1,944
Rooster	1999	1,540

Name	Year	Acres Burned
Antler	1996	4,902
Coyote PNF	1996	4,283
Coyote	1996	4,263
Dano	1996	1,906
Pelican	1996	1,570
Tern	1994	4,728
Raven	1994	3,000
Line Creek	1991	4,506
Clovermist	1988	412,050
Wolf Lake	1988	93,050
Fan	1988	18,100
Clover	1988	10,700
Shallow	1988	5,946
Fan	1988	3,500
Fern	1988	1,985
Lovely	1988	1,666
Mist	1988	1,527

Figure 4.46. Extent of burn 1988 Yellowstone Fire



Source: Exploring the Environment http://www.cotf.edu/ete/modules/yellowstone/YFsituation.html

Even though most of the damage has been in Yellowstone National Park, Park County has experienced wildfires in many other areas of the county, such as national forests and other forested areas (Table 4.61). On July 16, 2003, a fire was started by dry lightning and gusty winds in the Shoshone National Forest east of Deep Lake in Littlerock Creek Canyon in the Beartooth Mountains, eight miles west of Clark. It burned a total of 6,886 acres and was only 22% contained in the first six days. Fifteen boy scouts had to be rescued via helicopter as the fire approached Deep Lake. Many person-hours, resources, and equipment hours were used to attack this fire, with the estimated cost totaling $1.3 million dollars. There was no loss of life or property.

Washakie

The readily available wildfire history data ranges from 1980-2015. Data for this section was obtained from the Federal Wildland Fire Occurrence database housed with the US Geological Survey. Data from the Federal Wildland Fire Occurrence database is compiled from several federal agencies including the BIA, BLM, FWS, NPS, and USFS. According to this data, a total of 277 fires burned 96,651 acres. Many of these fires were relatively small, burning only a few acres. In fact, the 23 largest fires of 500 acres or more burned 85,099 acres, or nearly 88% of the total burned acreage. 1996 in particular was one of the worst wildfire years for Washakie County. Two of the largest wildland fires occurred in 1996. The Bates Creek Fire and the East Black Mountain Fire burned 38,858 and 48,844 acres, respectively, of sagebrush community. A number of other fires burned in 1996, totaling an additional 18,579 acres. 0 describes Washakie County wildfires that burned 1,000 or more acres between 1980 and 2010.

The readily available wildfire history data in Washakie County ranges from 1980 to 2015. Data from the Federal Wildland Fire Occurrence database is compiled from several federal agencies including the BIA, BLM, FWS, NPS, and USFS. According to this data, a total of 277 fires burned 96,651 acres between 1980 and 2015. Many of these fires were relatively small, burning only a few acres. In fact, the 25 largest fires of 500 acres or more burned 84,499 acres, or nearly 87% of the total burned acreage. 1996 in particular was one of the worst wildfire years for Washakie County. Two of the largest wildland fires occurred in 1996. The Bates Creek Fire and the East Black Mountain Fire burned 38,858 and 48,844 acres, respectively, of sagebrush community. A number of other fires burned in 1996, totaling an additional 18,579 acres. Table 4.62 describes Washakie County wildfires that burned 1,000 or more acres between 1980 and 2015.

Table 4.62. Wildfires over 1,000 acres in Washakie County: 1980-2015

Name	Year	Acres Burned
Upper Bee	2012	3,926
Reservoir	2011	2,200
Blue Bank 2	2007	1,089
Little Canyon Creek	2006	3,017
Nowater Creek	2006	1,082
Devilslide	2005	1,567
Alkali Rim	2001	1,325
Muddy Creek	2000	3,843
Bates	1996	38,858
Willow	1996	4,793
Cedar Ridge	1996	4,525
N. Broken Back	1996	3,741
Buffalo 2	1996	1,466
Eight Mile	1996	1,425
Lake Bed	1996	1,403
Brome	1994	1,665
Goldmine	1988	1,344
Orchard	1983	1,325

Source: USGS, BIA, BLM, FWS, NPS, USFS, Wildland Fire Management Information (WFMI) Database

Frequency/Likelihood of Occurrence

Wildfires are **highly likely** to occur in each county in the Region each year, meaning that there is nearly a 100% chance of a fire happening in any given year. It is important to note that the risk of wildfires occurring may increase during times of drought, especially prolonged droughts such as the statewide Wyoming drought that began between 1999 and 2000 and the 1988 drought in northwestern Wyoming.

Potential Magnitude

Most of the counties ranked the potential magnitude as limited, defined as 10 to 25 percent of property is severely damaged, facilities and services are 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. More specific consequences are discussed by county in the next section. It is important to note that the magnitude of a wildfire can be intensified by drought.

Vulnerability Assessment

Washakie

The principal wildfire mitigation plan for Washakie County is the "Washakie County Community Wildfire Protection Plan" (February, 2005). Wildland fire hazard assessment was conducted on the landscape and community scales. The landscape scale considered the entire county. Thirty-one communities were identified for the community-level assessment. Communities were designated based on common characteristics for wildland fire assessment. The communities are located around the towns of Worland and Ten Sleep, in the Bighorn River corridor, along Cottonwood and Gooseberry Creeks, and in the forested areas in the northeast and southeast corners of the county. The plan is available at the Washakie County Homeland Security Office.

The 2005 Washakie Community Wildfire Protection Plan identified the following communities with either a high or moderate wildfire hazard rating. See that document for additional descriptions of these communities and mitigation recommendations.

- Canyon Creek Country – High
- Bar C Creek – High
- Middle Fork Headwaters – High
- Middle Fork – High
- Deerhaven Lodge – High
- West Rivere Road Lowland – High
- Lower Ten Sleep Canyon – High
- Middle Fork Campground – Moderate
- State Game and Fish Cabin- Moderate
- Nowood – Moderate

- Cherry Creek Road – Moderate
- Meadowlard Resort – Moderate
- State Fish Hatchery- Moderate

Big Horn County

See the Big Horn County Annex for additional details on vulnerability and discussion of local CWPPs.

Park County

The 2008 Park County Community Wildfire Protection Plan (CWPP) outlines potential impacts from wildfires by identifying "communities" most at-risk to wildfire in the WUI areas. The CWPP identified 43 at-risk communities that received a final rating of low, moderate, or high risk based on their community rating, hazard rating, and historical fire occurrence. Rankings of the 43 at-risk communities are captured in Figure 4.47 below.

Figure 4.47. Park County CWPP Communities and Hazard Rankings

WUI	Area	Community Rating	Hazard Rating	Fire Occurrence	Final Rating
2	Lower Clarks Fork	3	3	3	4.0
5	Upper Sunlight Creek	3	3	3	4.0
25	Beartooth	3	3	3	4.0
28	Dead Indian West	3	3	3	4.0
33	Upper North Fork	3	3	3	4.0
34	Lower North Fork	3	3	3	4.0
38	Carter Mountain	3	3	3	4.0
3	Russell Creek	3	3	2	3.7
21	Silver Gate	3	3	2	3.7
26	Lower Sunlight Creek	3	3	2	3.7
41	Upper Wood River	3	3	2	3.7
6	Middle Sunlight Creek	3	2	3	3.3
11	Cody Canyon/Cedar Mtn	3	2	3	3.3
22	Cooke City	3	3	1	3.3
23	Upper Clarks Fork	3	2	3	3.3
24	Crandall	3	2	3	3.3
35	Wapiti	3	2	3	3.3
20	Francs/Timber Creek	3	2	3	3.3
27	Stinkingwater	3	3	1	3.3
4	Switchback Ranch	3	2	2	3.0
8	Clarks Fork Canyon	2	2	3	3.0
9	Rock Creek	3	2	2	3.0
17	Upper Meeteetse Creek	3	2	2	3.0
1	Bennett/Line Creek	2	2	2	2.7
7	Trail Creek	2	2	2	2.7
16	Bald Ridge East	2	2	2	2.7
32	Rattlesnake Creek	1	2	3	2.7
40	Lower Meeteetse Creek	2	2	2	2.7
10	Upper South Fork	2	1	3	2.3
18	Upper Greybull River/Pickett Creek	3	1	2	2.3
37	Lower South Fork	1	2	2	2.3
30	Heart Mountain	2	1	2	2.0
36	Canyon Estates	2	1	2	2.0
42	Lower Wood River	2	1	2	2.0
43	South Meeteetse	2	1	2	2.0
12	Gooseberry Creek	2	1	2	2.0
19	Sunshine Reservior	2	1	2	2.0
39	Lower Greybull River	2	1	2	2.0
13	Little Buffalo Basin	1	1	2	1.7
15	Hoodoo Creek Oil Fields	1	1	2	1.7
14	Coal Mine Gulch	1	1	1	1.3
29	Paint Creek	1	1	1	1.3
31	Two Dot Ranch	1	1	1	1.3

Legend		
(red)	High	3.1 - 4.0
(yellow)	Moderate	2.1 - 3.0
(light blue)	Low	1.0 - 2.0

Hot Springs

The 2011 Hot Spring County Community Wildfire Protection Plan outlines potential impacts from wildfires by identifying "communities" most at-risk to wildfire in the WUI areas. The CWPP identified 31 at-risk communities that received a final rating of low, moderate, or high risk based on their community rating, hazard rating, and historical fire occurrence. The top 10 communities ranked as 'High' include the following, in priority order:

- Upper Cottonwood Creek
- Upper Grass Creek
- Bighorn River North
- Bighorn River South
- Cedar Ridge
- Missouri Floats
- Woods Basin
- North Fork Owl Creek
- South Fork Owl Creek
- Coyote Run

More details can be referenced in the CWPP document. The Hot Springs County HMPC noted that the WUI is not as extensive as other parts of Wyoming as many of the forested areas are not inhabited. The group noted that Cottonwood Ventures subdivision having the highest risk and highest value homes in the WUI. South Thermopolis could have some expansion into areas that could be prone to range fires, but nothing is anticipated in the near future. Range land and grass fires can be a threat both to property and livestock. The railroad has seen impacts from fires. Other impacts include air quality, even from fires hundreds of miles away.

Population

The most exposed population 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, examined in the section below. Other exposed groups include children, the elderly, or those with breathing conditions who may be exposed to high levels of smoke.

Population at-risk estimates were developed by multiplying the average household size from the U.S. Census for each county in the region by the number of residential structures within the Redzone. These results are shown in the table below. 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.

General Property

GIS is a tool that is used to compare, capture, input, output, store, manipulate, analyze, model, 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 value is the value of buildings that can be potentially damaged by wildland fire in an area. The total building exposure value is $211,907,709 according to this analysis. The Redzone analysis also includes a buffer zone to exhibit potential areas at risk within 2 miles of the Redzone. Since wildfires can spread rapidly, it is important to consider areas close to the Redzone boundary. According to the Redzone Buffer analysis, the total building exposure value is $2,929,510,041. The table below summarizes exposure by jurisdiction. Table 4.63 and the following tables include the exposure values within the Redzones in the Region. Details on property type, risk by municipality, and county maps can be referenced in the county annexes.

Table 4.63. Building Exposure within the Redzone by County

County	Building Count	Improved Value	Est. Content Value	Total Exposure	Population
Big Horn	7	$711,701	$541,281	$1,252,982	11
Hot Springs	124	$21,545,279	$15,110,976	$36,656,255	214
Park*	469	$99,197,785	$55,412,151	$154,609,936	1,024
Washakie	75	$12,362,332	$7,026,205	$19,388,537	148
Total	675	$133,817,097	$78,090,612	$211,907,709	1,397

Table 4.64. Building Exposure within the Redzone100 Buffer by County

County	Building Count	Improved Value	Est. Content Value	Total Exposure	Population
Big Horn	240	$32,285,136	$20,502,252	$52,787,388	497
Hot Springs	1,889	$215,326,420	$131,063,067	$346,389,487	3,464
Park	6,760	$1,498,700,395	$913,975,549	$2,412,675,944	14,123
Washakie	423	$70,624,526	$47,032,697	$117,657,223	715
Total	9,312	$1,816,936,477	$1,112,573,564	$2,929,510,041	18,799

*A more specific analysis based on CWPP boundaries can be referenced in the Park County Annex

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.

Big Horn

According to the 2010 Big Horn County Future Land Use (FLU) Plan, Big Horn County contains two of the top 20 locations in Wyoming for seasonal homes. One is Meadow Lark Lake area in the Big Horn Mountains. The second location is the unincorporated town of Hyattville, showing 32% of housing units as seasonal in 2000 Census figures. Inside the county boundaries, 220 cabins in 25 different community groups ranging from just south of the Montana state line to the whole length of the county to the Washakie County line, reside throughout the Big Horn Mountains (Source: Big Horn County Mountain CWPP).

Essential Infrastructure, Facilities, and Other Important Community Assets

These aspects of the region 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 moves into the WUI zone. Communications lines passing through susceptible areas such as forests are more exposed than those located in cities and other more urban areas. The indirect exposure of response capability increases seasonally and with the number of occurrences. Though the populations making up the response capability are not directly exposed to all fire events, the response of some of the personnel to an event lessens the capabilities overall for response 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 4.65. Critical Facilities within Redzone

County	Facility Type	Facility Count
Hot Springs	Bridge	1
	Total	**1**
Park	Air Facility	1
	Bridge	3
	Communications	41
	Fire Station	1
	National Shelter System Facility	1
	Public School	1
	Total	**48**
Washakie	Bridge	2
	Scour Critical Bridge	1
	Total	**3**
	Grand Total	**52**

Table 4.66. Critical Facilities Within Redzone Buffer

County	Facility Type	Facility Count
Big Horn	Bridge	15
	EMS	1
	Fire Station	1
	Total	**17**
Hot Springs	Air Facility	1
	Bridge	12
	Communications	19

County	Facility Type	Facility Count
	Day Care Center	3
	EMS	2
	Fire Station	1
	HAZMAT	1
	Hospital	2
	Law Enforcement	2
	Local EOC	1
	Nursing Home	2
	Private School	1
	Public Health Department	1
	Public School	4
	Total	**52**
Park	Air Facility	3
	Bridge	40
	Communications	57
	Day Care Center	11
	Fire Station	2
	HAZMAT	6
	Hospital	1
	Law Enforcement	6
	Local EOC	1
	Nursing Home	2
	Private School	1
	Public Health Department	1
	Public School	7
	Scour Critical Bridge	1
	Urgent Care Facility	1
	Total	**140**
Washakie	Air Facility	1
	Bridge	23
	Communications	2
	EMS	1
	Fire Station	1
	Public School	1
	Total	**29**
	Grand Total	**238**

Natural, Historic and Cultural Resources

According to GIS mapping, the Big Cedar Ridge Fossil Plant Area in Washakie County is vulnerable to wildfires. This area is home to fossilized prehistoric plant remains. Historic resources such as this provide insight into what Washakie County's environment was like millions of years ago.

A large percentage of Park County includes Yellowstone National Park, which is a crown jewel in the National Park system and contains many natural and cultural resources potentially at risk. Wildfires in Yellowstone also have a regional impact on summer tourism.

The Hot Springs County CWPP notes Areas of Critical Environmental Concern and sage grouse leks on maps. While wildfire is generally beneficial to most wildlife species, negative impacts can occur where significant areas of sagebrush are burned within crucial mule deer winter range and sage-grouse breeding and winter habitats.

Other natural resources and natural areas may actually benefit from wildland fire, as at some level they must also be exposed to wildfire for a healthy ecological development of the area. Historic and cultural resources exhibit a vulnerability rating similar to those in general property, where vulnerability ratings increase the further 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.

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 wildland urban interface than most western states. According to the 2016 Wyoming Hazard Mitigation Plan the areas of highest existing risk from wildfire (number of square miles of the wildland urban interface with homes now) mainly occur within Park, Teton and northern Lincoln Counties. 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 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 apparatus, pumps, and backup generators. Such standards serve to protect residents and property, as well as emergency services personnel.

Summary

Wildfires occur within the region on generally an annual basis. Based on GIS analysis, the Region has over $211 million in building value potentially at risk to wildland fires in the Redzone. This estimate is not including the extended buffer, which would reach over $2 billion in building value potentially at risk. 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. County ratings are noted in the table below.

Table 4.67. Wildfire Hazard Risk Summary

County	Likelihood	Spatial Extent	Potential Magnitude	Significance
Big Horn	Likely	Significant	Limited	High
Hot Springs	Likely	Significant	Limited	High
Park	Likely	Significant	Limited	High
Washakie	Likely	Significant	Limited	High

Municipalities impacted: Ten Sleep, Thermopolis and E Thermopolis (direct and indirect impacts); Cody (direct and indirect impacts);

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 process and mitigation action plan for the Region 6 Hazard Mitigation Plan. It describes how the counties 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 hard work of each county's HMPC led to this mitigation strategy and action plan. Section 5.2 below identifies the goals of this plan 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 has 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 2016 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 2016, the counties reviewed the results of the hazard identification, vulnerability assessment, capability assessment and goals from previous county-level hazard mitigation plans as well as the State of Wyoming Multi-Hazard Mitigation Plan. 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 Hot Spring's county's case) planning goals and to base the development of new or updated mitigation strategies for the counties in the Region.

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. Implementation cost, 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 as means to achieve the goals. Objectives define strategies to attain the goals and are more specific and measurable and are sometimes developed in mitigation planning as an intermediate step between goals and mitigation actions or projects.

The update/development of goals for each county in the region was initiated through a facilitated discussion at the first planning workshops held in 2016 (Risk Assessment and Goals workshop). The HMPC members were provided a PowerPoint presentation that explained goals, objectives and actions and listed examples of each. Existing plan goals and related plan goals were noted in the PowerPoint, including the State of Wyoming Multi-Hazard Mitigation Plan (2016). This review was to ensure that the Regional plan's mitigation goals were aligned and integrated with existing plans and policies. Based on discussion at the HMPC meetings the groups decided that the mission statement from the Wyoming Multi-Hazard Mitigation Plan was applicable as an overall mission statement for the Region as well.

The mission statement of the Region 6 Mitigation Plan is to "*reduce or eliminate risk to human life and property from hazards.*"

Based on this mission statement, the risk assessment review and the goals development/update process, each county identified or updated county-specific goals which provide the direction for reducing future hazard-related losses within the county and regional planning area. During the 2016 Regional Plan development process Hot Springs County developed new goals as this was the first such plan for the County. The County felt the State of Wyoming Multi-Hazard Mitigation Plan goals provided a good baseline, with some modifications. Big Horn County's 2015 Hazard Mitigation Plan was in the process of being adopted, thus the goals of their plan did not change. Park County felt the goals from the 2011 hazard mitigation plan were still valid and did not change. Washakie County modified their goals slightly to add the word 'identified' to underscore that the goals apply to the hazards identified in the plan. The updated goal statements for each county in the Region are noted below.

Hot Springs County Goals

Goal 1: Strengthen Public Infrastructure

Goal 2: Improve Existing Mitigation Capabilities

Goal 3: Reduce Economic Losses due to Hazard Events including costs of Response and Recovery

Park County Goals

Goal 1: Mitigate the effect of hazards through education, ordinances, resolutions, and clear definition and implementation of mitigation projects to enhance life-safety and reduce the loss of property of residents and visitors to Park County.

Goal 2: Coordinate mitigation activities with all entities of Park County to assess the hazards and take various actions to reduce or eliminate the risk factors of those hazards.

Goal 3: Reduce the local economic impact caused by the effects of hazards in the communities

Washakie County Goals

Goal 1: Mitigate the effect of identified hazards through education, ordinances, resolutions, and clear definition and implementation of mitigation projects to reduce the loss of property and enhance life-safety of residents.

Goal 2: Coordinate mitigation activities with all entities of Washakie County to assess the identified 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 identified hazards in the communities.

Big Horn County Goals

Goal 1: Reduce the potential loss of life and property from natural and human-caused disasters in Basin.

Goal 2: Reduce the potential loss of life and property from natural and human-caused disasters in Burlington.

Goal 3: Reduce the potential loss of life and property from natural and human-caused disasters in Byron.

Goal 4: Reduce the potential loss of life and property from natural and human-caused disasters in Cowley.

Goal 5: Reduce the potential loss of life and property from natural and human-caused disasters in Deaver.

Goal 6: Reduce the potential loss of life and property from natural and human-caused disasters in Frannie.

Goal 7: Reduce the potential loss of life and property from natural and human-caused disasters in Greybull.

Goal 8: Reduce the potential loss of life and property from natural and human-caused disasters in Lovell.

Goal 9: Reduce the potential loss of life and property from natural and human-caused disasters in Manderson.

Goal 10: Reduce the potential loss of life and property from natural and human-caused disasters in Big Horn County.

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 2016 Regional Plan development each county's HMPC analyzed viable mitigation options by hazard that supported the identified goals. The HMPC was provided with the following list of categories of mitigation actions, which originate from the Community Rating System:

- **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**: 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.
- **Emergency services**: Actions that protect people and property during and immediately after a disaster or hazard event.
- **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.

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 for 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 distributed. This document lists the common alternatives 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 C 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 a number of new project ideas with the intent of reducing 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 be addressed through additional personnel or a change in procedure or policy.

Based upon the key issues identified in the risk assessment, including the capability 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 so they could be captured in the plan. Final action strategies are discussed in Section 5.4.

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 assist in evaluating the priority of a mitigation action includes:

- 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 'high,' 'medium' and 'low.' 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 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. 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 description of the problem and proposed project, the entity with primary responsibility for implementation, any other alternatives considered, a cost estimate, expected project benefits, potential funding sources, and a schedule for implementation. Development of these project details for each action led to the determination of a high, medium, or low priority for each.

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 plan's goals. 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 Park and Washakie counties. The mitigation actions in these county's plans provided the basis for the updates of mitigation action strategies. As part of the update process these two counties 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 was completed or deferred to the future. Actions that were not completed were discussed for continued relevance and were either continued in the Plan or in some cases recommended for deletion.

The counties and the majority of their participating jurisdictions have been very successful in implementing actions identified in their respective plans' Mitigation Strategy, thus, working 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 Park and Washakie county annexes. These action plans were also shared amongst the regional plan participants to showcase progress and stimulate ideas amongst the respective planning committees in each county. Reasons that some actions have not been completed include low priority, lack of funding, or lack of administrative resources. See the county annexes for more details on progress on implementation.

5.4.2 Continued Compliance with NFIP

Given the significance of the flood hazard in the planning area and as required by the DMA, an emphasis will be placed on continued compliance with the National Flood Insurance Program (NFIP). Counties and jurisdictions that participate in the NFIP will continue to make every effort to remain in good standing with the program. This includes continuing to comply with the NFIP in regards to adopting floodplain maps 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 the 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.

Further, it should be clarified that the actions included in this mitigation strategy are subject to further review and refinement; alternatives analyses; and reprioritization due to 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 as a result of a disaster or other circumstances and reserves 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 noted in the county annexes.

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.

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 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 E, 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: implementation. While this plan contains many worthwhile actions, each County and jurisdiction will need to decide which action(s) to undertake first. 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 and its counties will be responsible for the plan implementation and maintenance. Each county, led by their emergency management agency, will reconvene their HMPC for plan implementation and maintenance. This HMPC will be the same committee (in form and function, if not actual individuals) that developed this HMP and will also be responsible for the next formal update to the plan in five years.

Each county's HMPC 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 Maintenance

Plan maintenance implies an ongoing effort to monitor and evaluate plan implementation and to update the plan as progress, roadblocks, or changing circumstances are recognized.

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 HMPC 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 WYOHS and FEMA for funds to assist with the update. It is recommended to begin seeking funds in 2019 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 WYOHS 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 have failed or are 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.

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 planning efforts
- Other plans, regulations, and practices with a mitigation aspect

The county annexes note, where applicable, the previous versions of the hazard mitigation plan have been incorporated into existing planning mechanisms in the past 5 years.

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 will be held and public comments will be solicited on the plan update draft.