Wyoming Multi-Hazard Mitigation Plan

Comprehensive Update

June 2014

Wyoming Office of Homeland Security
5500 Bishop Boulevard
Cheyenne, WY 82002

Requirement §201.4(c)(6): *The plan **must** be formally adopted by the State prior to submittal to [FEMA] for final review and approval.*

[State of Wyoming Adoption]

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1. Introduction

1.1 Purpose

A major function of this mitigation plan is to identify activities which can reduce or eliminate the risk residents of the state face from natural hazards. The hazard assessment portion of the plan represents extensive data gathering and analysis. This adds credibility to the quality of the hazard assessment and vulnerability analysis. The quality of the work enhances its value for application in future mitigation planning by the State of Wyoming, her counties and local jurisdictions for the purpose of reducing or eliminating long-term risk to human life and property from all hazards. The plan complies with the Disaster Mitigation Act of 2000 and supersedes a previously-approved plan.

Determining the level of risk a community faces depends in large measure on an understanding of what has or could happen. Due to infrequency of significant hazard events in Wyoming, residents are often unaware of the potential for loss of life and damage to property from hazards such as earthquakes, severe blizzards, and flooding. Today, only a small percentage of the state's population is aware of the tremendous impact the Blizzard of 1949 had on Wyoming and its neighboring states. Historical events recorded within this document are based on research of the most comprehensive data available and provide a foundation for the vulnerability analysis portion of the plan. The data and analyses can be useful to elected officials in establishing policy to mitigate hazards for the benefit of ensuing generations.

As defined by the Federal Emergency Management Agency, *mitigation* refers to any sustained action taken to reduce or eliminate long-term risk to people and property from hazards and their effects. Mitigation measures can include structural and nonstructural activities, such as ensuring homes are constructed away from flood plains, engineering bridges to withstand earthquakes, and creating and enforcing effective building codes to protect property from severe storms, earthquakes, floods, and other hazards. These activities can occur before, during, and after a disaster. Involvement of a wide range of participants in the planning process increases the feasibility and likelihood of implementing mitigation projects as resources become available.

1.2 Mitigation Goals

Requirement §201.4(c)(3)(i): *[The State mitigation strategy **shall** include a] description of State goals to guide the selection of activities to mitigate and reduce potential losses.*

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities…

Following a review of the goals incorporated into the last mitigation plan update, the ten goals in the 2011 update have been compressed in this update to reflect changes in priorities, progress in mitigation efforts and changes in development around the state. The following goals outline the state's strategy for improving hazard resistance and community resilience through implementation of mitigation projects around the state:

Goal 1
Continue to strengthen infrastructure and lifelines.

Goal 2
Continue to improve state and local capacity and capability to detect and/or warn of hazards before damage occurs.

Goal 3
Minimize economic losses resulting from impacts of hazards.

Goal 4
Reduce state and local costs of disaster response and recovery.

Goal 5
Reduce or eliminate risk to human life and property.

1.3 Wyoming Profile

Wyoming is located in the Rocky Mountain section of the western United States. Wyoming is bounded on the north by Montana, on the east by South Dakota and Nebraska, on the south by Colorado and Utah, and on the west by Utah, Idaho and Montana. Wyoming is one of three states entirely bounded by straight lines. From the north border to the south border it is 276 miles; from the east to the west border, 375 miles. Wyoming is the tenth (10^{th}) largest state, with an area of 97,814 square miles but with the smallest population (50^{th}) at 563,626, according to the 2010 census. Wyoming has several medium sized cities with concentrated populations and vast areas of extremely low population densities. Overall the population density is just under 6 persons per square mile. Cheyenne, the State Capitol, is located in the southeast corner of the state and is the largest city with an estimated 2011 population of 60,096.

Industry

Wyoming is the leading coal-producing state and a leader in the production of petroleum and natural gas. Wyoming has the world's largest sodium carbonate (natrona) deposits and has the nation's second largest uranium deposits. Tourism ranks second of Wyoming's industries. Wyoming is historically considered a farming and ranching community. These three industries round out the industries Wyoming relies upon. High-tech and manufacturing businesses are being recruited in an effort to diversify the state's economy.

Geology

The Great Plains meet the Rocky Mountains in Wyoming. The state is a great plateau broken by a number of important mountain ranges. The highest point is Gannett Peak at 13, 804 feet and lowest point is the Belle Fourche River at 3,099 feet. The mean elevation of Wyoming is 6,700 feet. Approximately 47% of the state is owned by the Federal Government. The Rocky Mountains are located along the western edge, as are Yellowstone National Park and Grand Teton National Park. The Big Horn Mountains are in the north central part of the state with the Laramie Mountains extending from the central part of the state to the southeast. The Bear Lodge Mountains, which are part of the Black Hills, are located in the northeast part of the state. The south central part of Wyoming includes the Medicine Bow Mountains. There are 10 National Forests including the Thunder Basin National Grasslands, 2 National Parks, 2 National Monuments, 1 National Historic Site, and 1 National Recreation Area.

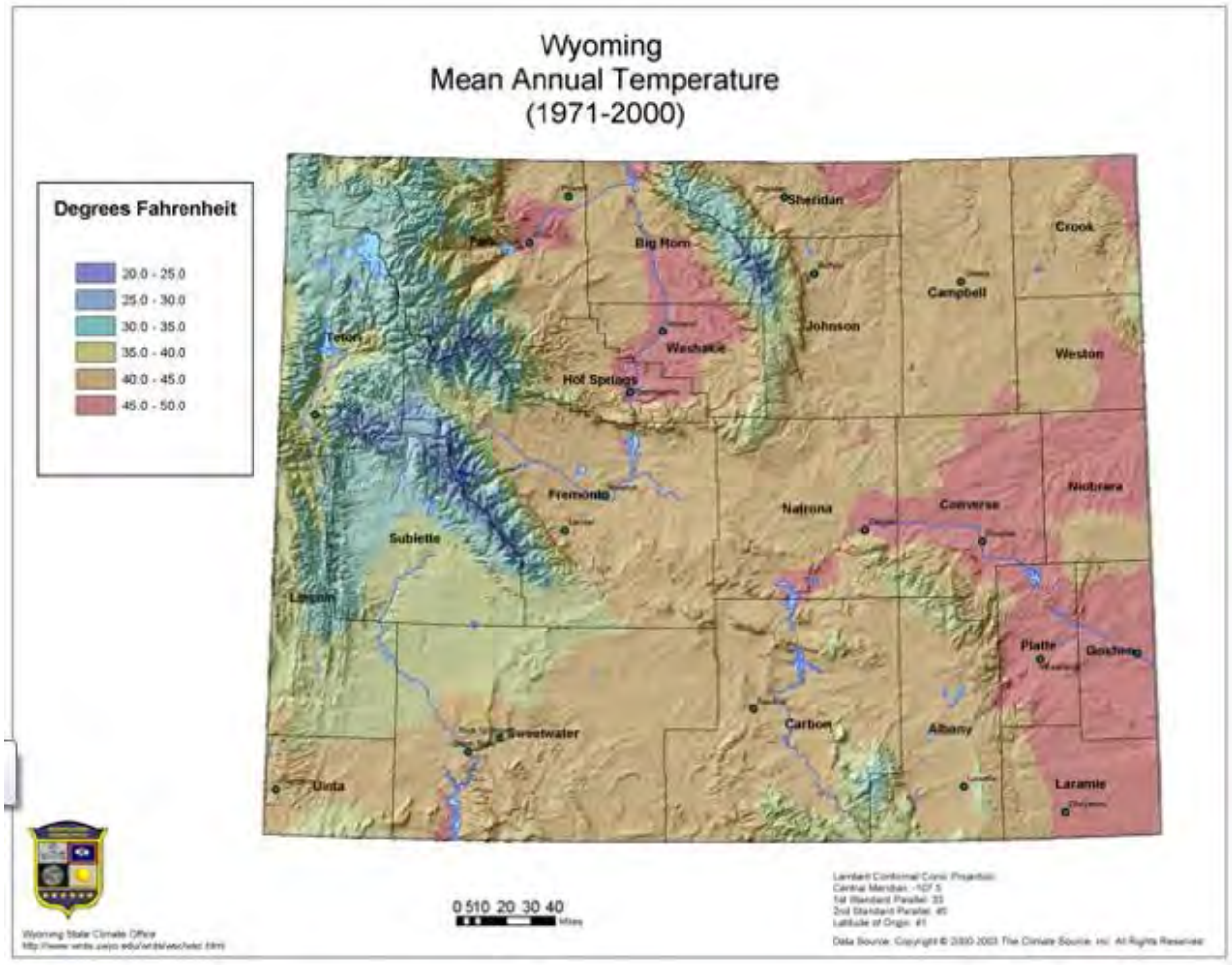
Wyoming's economy is dependent upon mining (coal and trona), natural gas production, agriculture, and tourism. Critical infrastructure includes electrical power generation and transmission and the F.E. Warren Air Force Base, home of the 90th Space Wing. The largest recurring events include the University of Wyoming home football and basketball games, Cheyenne Frontier Days, and the Wyoming State Fair.

Climate

Wyoming's climate is semiarid. Annual precipitation varies throughout the state from as little as five inches to as much as 45 inches a year, some in the form of rain and some in snow. Because of its

elevation, Wyoming has a relatively cool climate; the normal mean temperature is 45° Fahrenheit. However, Wyoming's climate can include extreme temperature highs and lows. Above 6,000 feet temperatures rarely exceed 100° F. The highest recorded temperature of 116° occurred at Bitter Creek in Sweetwater County. For most of the state, the mean maximum July high temperatures range from 85° to 95°. Average July lows range from 50° to 60°. In the summer, parts of the state can experience temperatures above 100° and in the winter, extended temperatures below 0° are common. Wyoming experiences a lot of wind. The average wind speed is 12.9 mph. Heavy snowstorms, blizzards, floods, tornados and wildland fires are naturally-occurring disasters typical for Wyoming.

Map 1.1 – Mean Annual Temperatures-Wyoming



Government

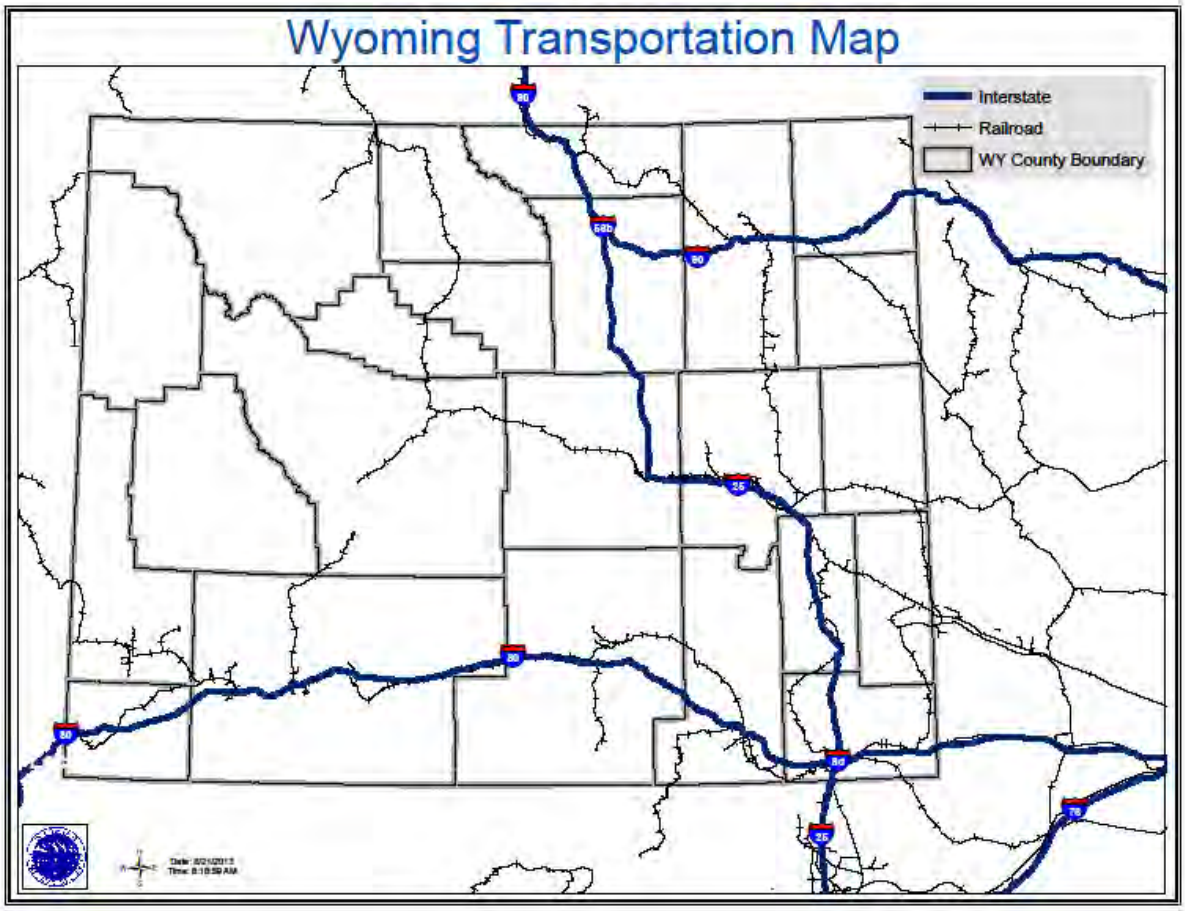
Wyoming is divided into twenty three (23) counties and eight (8) Homeland Security Regional Response areas, with ninety nine (99) incorporated municipalities. There is one Indian Reservation located in the central portion of the state. Public Safety agencies include 23 Sheriff Offices, 56 Police Departments, 134 Fire Departments, 66 Ambulance agencies and 41 Dispatch centers. The State of Wyoming has 11

agencies with public safety roles including law enforcement, corrections, health, livestock, state parks, transportation, forestry, fire marshal, state engineer and homeland security.

Transportation

Three interstate highways transect the state, Interstate 80 along the southern portion of the state, Intestate 25 runs from the southeast to the north central and bisects with Interstate 90 which runs through the northeastern part of the state. The Union Pacific Railroad runs east to west along the southern portion of the state. Burlington Northern Sante Fe Railroad has a northern route across the northeast part of Wyoming and a north south route from the northeast to the southeast, which is shared with the Union Pacific Railroad.

Map 1.2 – Major Wyoming Transportation Routes



Population Growth

The 2010 census data provides the most complete available population data. It was utilized in the last update and is not further updated in this planning cycle. The 2010 Census reveals Wyoming has experienced higher percentage growth greater than experienced over the United States over all.

Wyoming's growth rate over the past ten years exceeded 14% while the national growth rate was only 9.7%. Despite Wyoming's faster paced growth, it remains predominately rural with a population density of not quite 6 persons per square mile and a total population of 563,626.

Table 1.3 – Population Change

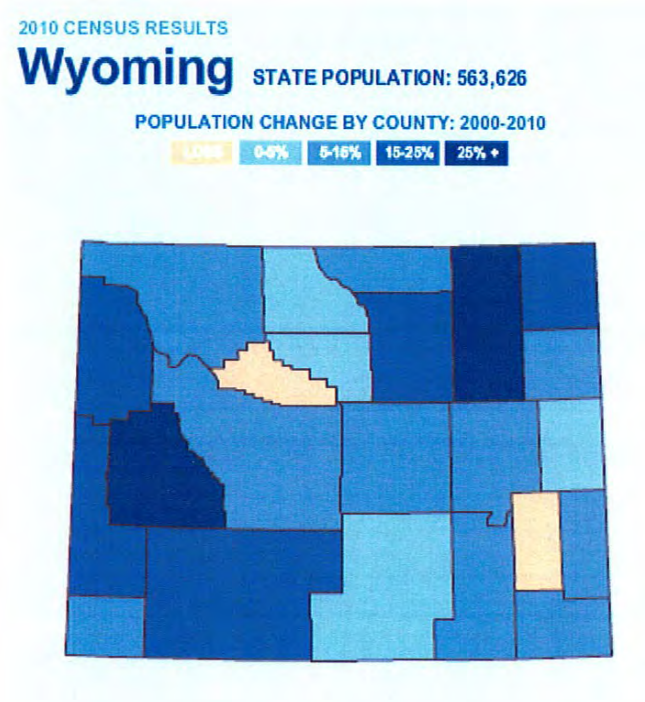
State or Region	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010
Wyoming											
Population	145,965	194,402	225,565	250,742	290,529	330,066	332,416	469,557	453,588	493,782	563,626
Percent Change	57.7%	33.2%	16.0%	11.2%	15.9%	13.6%	0.7%	41.3%	**-3.4%**	8.9%	14.1%
People per sq. mile	1.5	2.0	2.3	2.6	3.0	3.4	3.4	4.8	**4.7**	5.1	5.8
Density Rank	50	50	50	50	50	50	51	51	**51**	51	51

http://2010.census.gov/2010census/data/index.php Accessed 5/3/2011

With a population of 563,626, Wyoming remains the state with the smallest population, as well as the least densely populated state with less than 6 persons per square mile. Laramie County in the southeast corner, and Natrona County, in the center of the state, are the most populated counties, followed by Campbell, Fremont, and Sweetwater Counties.

After twenty years of losing population (1970-1990) or maintaining a fairly steady population (1990-2000), the 2010 Census revealed Wyoming's population overall has increased at a slightly greater rate than the U.S. population overall in the years between 2000 and 2010. Two counties experienced a loss in population; two counties experienced a greater-than 25% increase in population, with the majority of the state's counties increasing in population by between 5%-16%. [See **Appendix A**]

Map 1.4 – Population Change by County



http://www.census.gov/prod/cen2010/briefs/c2010br-01.pdf Accessed 5/3/2011

Employment

There are many industries offering employment opportunities in Wyoming. As the leading coal-producing state and leader in the production of petroleum and natural gas, many Wyoming residents are employed in the mineral-extraction industries. Service industry employment tends to fluctuate in concert with mineral extraction employment trends. Following is a table outlining Wyoming employment trends between 2001 and 2010 which was developed with information from the United States Census Bureau. The number of employees in mineral extraction increased between 2000 and 2010 by 7,342 employees, a 45% increase, while at the same time experiencing a 130% increase in annual salary. This trend, though not a one-to-one relationship, is reflected in service and construction industries. Health Care Employment came in second with an increase of 6,422 employees.

Table 1.5 – Wyoming Business Patterns

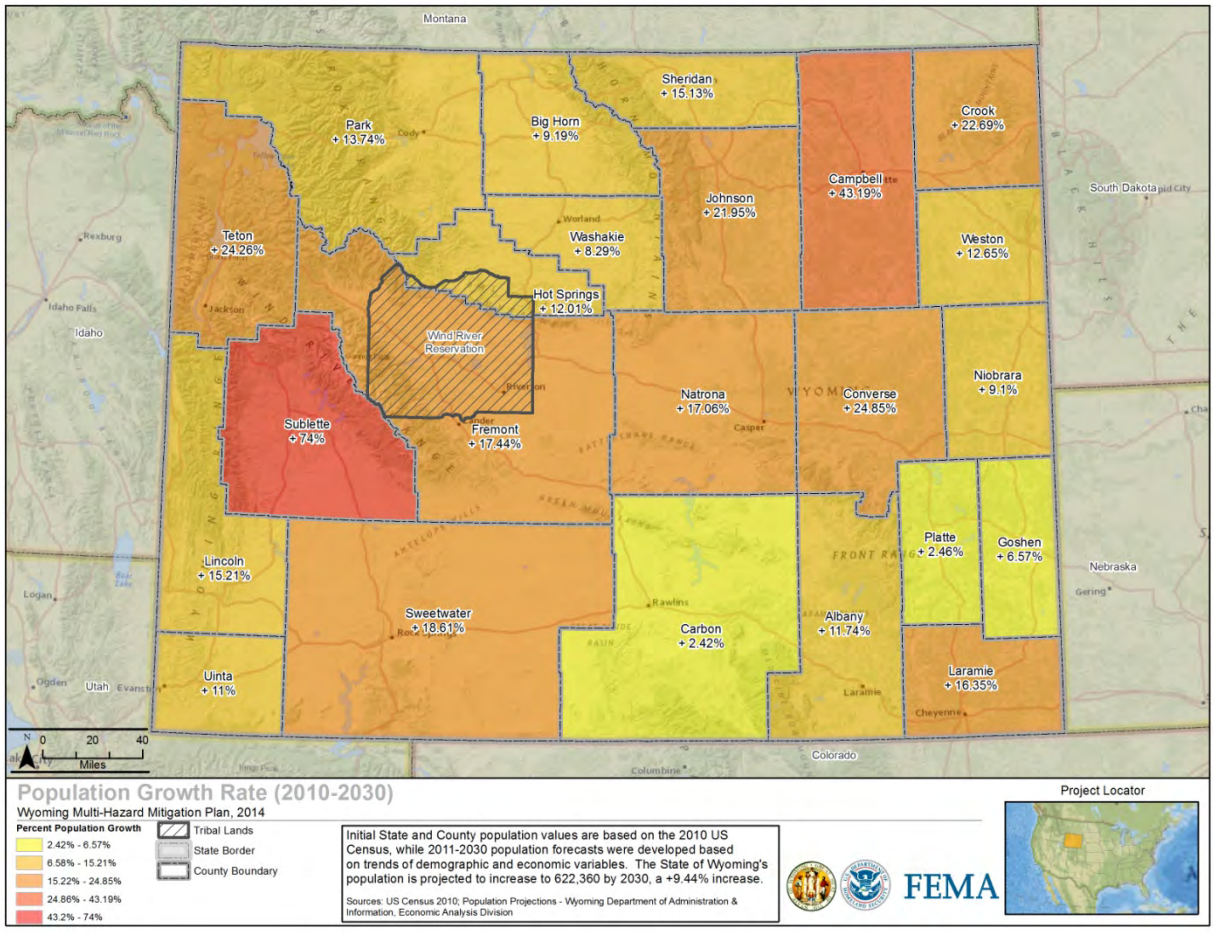
Wyoming Business Patterns 2000 vs 2010								
Industry	**# of Employees 2000**	**# of Employees 2010**	**Annual Payroll 2000 [$1,000]**	**Annual Payroll 2010 [$1,000]**	**Percentage Increase # of Employees**	**Percentage Increase Annual Payroll**	**Annual Average Payroll Per Employee 2000**	**Annual Average Payroll Per Employee 2010**
Mining, Quarrying, Oil & Gas Extraction	16,239	23,581	$447,166	$1,841,948	45.21%	311.92%	$27,537	$78,112
Health Care	25,398	31,820	$640,830	1,301,520	25.29%	3.1%	$25,231	$40,903
Construction	14,930	17,797	$447,166	$821,834	19.20%	83.79%	$29,951	$46,178
Retail Trade	28,285	30,608	$514,508	$750,870	8.21%	45.94%	$18,190	$24,532
Real Estate, Rental & Leasing	2,754	4,293	$50,776	$750,870	55.88%	1378.79%	$18,437	$174,906
Accommodation & Food Services	24,242	26,089	$271,140	$446,298	7.62%	64.60%	$11,185	$17,107

http://censtats.census.gov/cgi-bin/cbpnaic/cbpsect.pl Accessed 7/30/2013
(County-Level Information can be accessed in Appendix B)

Requirement §201.4(d): *Plan must be reviewed and revised to reflect changes in development…*

Development

Map 1.6 – Anticipated Population Growth Rate 2010-2030



Development in Wyoming is driven by employment opportunities. Development also tends to focus within already-existing population centers. The table below shows building permitting over the ten-year period from 2001 through 2010 and documents development throughout the state. Based on building permitting, the counties experiencing the greatest development are Laramie, Natrona, Campbell, and Albany Counties.

The most significant increase in mineral extraction employment between 2000 and 2010 was experienced in Campbell County. Campbell County saw an increase of 3,060 employees in mineral extraction, which represents a 67.83% increase. Campbell County was followed by Uinta (696), Sublette (667), Converse (524) and Fremont Counties (386). Driven by employment increases, Campbell County has seen the most significant increase in development, followed by Laramie and Natrona Counties where the largest population centers are located.

Table 1.7 – Building Permits

Annual County Building Permits in 'Total Units Constructed'												
Source: http://censtats.census.gov/cgi-bin/bldgprmt/bldgsel.pl Accessed 7/31/2013												
County (does not include municipalities)		**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**10-Year Total**
Albany		283	163	271	410	594	329	264	172	132	172	2790
Big Horn		7	11	6	17	8	20	23	37	16	14	159
Campbell		105	144	159	129	273	222	1002	349	349	317	3049
Carbon		37	28	33	60	65	58	96	55	24	18	474
Converse		13	16	54	18	58	34	115	103	38	23	472
Crook		28	30	31	24	21	33	27	10	14	4	222
Fremont		107	45	65	66	85	53	54	43	32	21	571
Goshen		4	2	6	17	11	14	13	8	27	6	108
Hot Springs		1	3	1	5	5	7	8	5	0	1	36
Johnson		25	70	25	15	25	43	47	24	5	12	291
Laramie		319	478	779	876	872	509	316	202	387	238	4976
Lincoln		218	204	180	212	261	200	207	100	62	49	1693
Natrona		140	300	174	284	444	423	429	419	412	807	3832
Niobrara		0	0	1	4	4	3	0	3	3	4	22
Park		118	179	210	242	187	252	244	201	144	118	1895
Platte		12	12	14	42	47	41	32	28	12	19	259
Sheridan		102	112	287	200	175	373	339	230	86	121	2025
Sublette		76	88	95	93	185	238	263	114	44	42	1238
Sweetwater		38	48	63	216	260	268	472	245	351	147	2108
Teton		211	197	292	301	308	291	232	216	89	115	2252
Uinta		58	58	56	63	95	106	328	87	55	45	951
Washakie		2	3	10	7	9	10	25	6	5	1	78
Weston		3	4	2	16	5	10	19	12	7	7	85
Annual Totals		1907	2195	2814	3317	3997	3537	4555	2669	2294	2301	

Projected future growth information was obtained from the Wyoming Administration and Information Economic Analysis Division. Three tables outlining projected growth from 2010 through 2030 are located in **Appendix L**.

2. Authority & Compliance

Requirement §201.4(c)(7): *The plan **must** include assurances that the State will comply with all applicable Federal statutes and regulations in effect with respect to the periods for which it receives grant funding, in compliance with 44 CFR 13.11(c). The State will amend its plan whenever necessary to reflect changes in State or Federal laws and statutes as required in 44 CFR 13.11(d).*

2.1 Authority

Wyoming is committed to working toward the five mitigation goals outlined in Section 5.2. This plan acknowledges agencies throughout the plan who execute mitigation rolls and responsibilities.

The Wyoming Office of Homeland Security has been appointed by the governor as the primary agency responsible for mitigating the effects of a disaster and preparing plans related to mitigation, response, and recovery. [§ 19-13-104(c)(i)] Wyoming Statute § 19-13-101 through § 19-13-414, referred to as 'The Wyoming Homeland Security Act' further details the authority and responsibilities of the Wyoming Office of Homeland Security.

Additionally, this plan has been developed under the authority of and in compliance with the requirements of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, Public Law 93-288, as amended, 42 U.S.C. 5121-5207 and Related Authorities.

Wyoming will continue to comply with all applicable Federal statutes and regulations in effect with respect to the periods for which it receives grant funding, in compliance with 44 CFR 13.11(c). The State will amend its plan whenever necessary to reflect changes in State or Federal laws and statutes as required in 44 CFR 13.11(d) and will submit the amended portions of the plan for approval, if required.

2.2 State Planning Process

Requirement §201.4(c)(1): *[The State plan **must** include a] description of the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how other agencies participated.*

Requirement §201.4(b): *The [State] mitigation planning process **should** include coordination with other State agencies, appropriate Federal agencies, interested groups, and … .*

Requirement §201.4(b): *[The State mitigation planning process **should**] be integrated to the extent possible with other ongoing State planning efforts as well as other FEMA mitigation programs and initiatives.*

The 2014 Wyoming Multi-Hazard Mitigation Plan (Plan) is the product of cooperation among local, state, and federal partners over a period of several years. The Wyoming State Geological Survey (WSGS) generated the original 2005 Wyoming Multi-Hazard Mitigation Plan. The 2005 plan emphasized a thorough multi-hazard assessment which was augmented through the planning process resulting in the 2008 updated plan. The 2011 update was the cumulative result of the previous plans, information acquired from a public survey, and earthquake hazard updates based on a FEMA HAZUS-Earthquake software project, utilized to examine earthquake hazard and risk in Wyoming.

This 2014 update builds on previous years' mitigation plans by utilizing subject matter expertise to correct and update many of the hazard chapters. Hazard occurrences over the past three years have been incorporated into the historical record so all incidents to date are reflected in the plan. Additionally, this update further analyzes two hazards not previously incorporated into the plan: wind and solar weather.

The following process was utilized to update this year's state mitigation plan: 1) When possible, a face-to-face, typically one-on-one, meeting between the State Hazard Mitigation Officer (SHMO) and subject matter expert was pursued and the information gleaned at the meeting was captured. 2) The hazard chapter was updated by the SHMO to incorporate the subject matter expert's suggested changes and to incorporate additions to each hazard's historical record. 3) A second review of the hazard chapter was completed by the subject matter expert and any additional suggested changes incorporated. 4) Finally, each chapter was subjected to peer review internally, to ensure clarity, appropriate English usage and appropriate punctuation. 5) Geographic Information System (GIS) was incorporated throughout the process. 6) As opportunities arose, typically in meetings and classroom settings throughout 2013, the public and emergency management professionals were asked to participate in a hazard ranking survey. 7) Public input will be futher pursued as the draft plan and final, approved plan will be posted on the Wyoming Office of Homeland Security's web site, with opportunities to provide feedback available on the site.

Experts involved throughout the planning update process include:

Melinda Gibson, State Hazard Mitigation Officer, Wyoming Office of Homeland Security

Larry Green, Security Unit Chief, Wyoming Office of Homeland Security

Earthquake Hazard

Martin 'Mort' Larsen, Project Geologist, Wyoming Geological Survey

Seth Wittke, Manager / Geologic Hazards, Wyoming Geological Survey

Dam Failure

Mike Hand, Safety of Dams Engineer, Wyoming State Engineer's Office

Nathan Graves, Safety of Dams Engineer, Wyoming State Engineer's Office

Geographic Information Systems (GIS)

Shelby Hudson, CFM, Mitigation Planner/GIS Specialist, FEMA Region VIII

Jesse Rozelle, Risk Analyst/GIS Coordinator, FEMA Region VIII

Casey Zuzak, Risk Analyst, FEMA Region VIII

Flooding

Ginni Melton, CFM, Wyoming NFIP State Coordinator

State Assets

Mitzi Krois, Risk Analyst, Wyoming A&I – Risk Management

Tammy Hooper, Manager, Wyoming A&I – Risk Management, General Services Division

Wildland Fire

Bill Haagenson, Assistant State Forester – Forest Management, Wyoming Forestry Division

Ron Graham, Forestry Program Analyst, Wyoming Forestry Division

Landslides

Kent Ketterling, State Maintenance Engineer, Wyoming Department of Transportation

Disabled Community

Rick Jansen, Preparedness and Response Coordinator, Wyoming Department of Health

Unable to Self-Evacuate Core Advisory Group (UTSE CAG)

Subsidence

Alan Edwards, Administrator, Abandoned Mine Land Division, Department of Environmental Quality

Bill Locke, Program Manager, Abandoned Mine Land Division, Department of Environmental Quality

Jeff Meena, Project Manager, Abandoned Mine Land Division, Department of Environmental Quality

Marcia Murdock, Project Manager, Abandoned Mine Land Division, Department of Environmental Quality

Space Weather

Scott Ramsay, Radiological Services – WIPP Program Manager

The mitigation planning process is incorporated into the development of the Threat Hazard Identification and Risk Assessment (THIRA), the State Preparedness Report (SPR), the State Operations Plan, the State Recovery Plan, the Wyoming Department of Health's Joint Risk Assessment (JRA), and others. This is accomplished though internal and inter-agency planning meetings and discussions, references to the mitigation plan while in response and recovery operations, and through direct reference within other plans.

2.3 Local Planning Support and Coordination

COORDINATION OF LOCAL MITIGATION PLANNING Local Funding and Technical Assistance

Requirement §201.4(c)(4)(i): *[The section on the Coordination of Local Mitigation Planning* ***must*** *include a] description of the State process to support, through funding and technical assistance, the development of local mitigation plans.*

The Wyoming Office of Homeland Security supports, through funding and technical assistance, the development of local mitigation plans. Every county has received Homeland Security Grant Program (HMGP) and Emergency Management Program Grant (EMPG) funds each year since the last state mitigation plan update. Both of these grant programs promote planning as an eligible activity in their guidance. All Wyoming County Coordinators were notified when Pre-Disaster Mitigation (PDM) and Flood Mitigation Assistance (FMA) grant funding grant application periods opened, giving them an opportunity to pursue mitigation planning and project funding.

The State Hazard Mitigation Officer has facilitated and assisted in local mitigation planning efforts through face-to-face visits with local communities, directing mitigation discussions at local planning meetings, providing training opportunities, responding with written responses to inquiries, and participating in conference calls with local planners and FEMA Region VIII's planning team.

In the years since the 2011 update multiple efforts were pursued to assist local jurisdictions with their mitigation planning process. Of those, the following actions represent the types of actions undertaken to assist local jurisdictions:

- HMGP and FMA funding for plan development was applied for, received, awarded to sub-grantees, and has been tracked utilizing quarterly reporting tools provided by FEMA.
- The Wyoming Office of Homeland Security made technical assistance available to all counties and has provided on-site technical assistance to requesting counties. Technical assistance provided includes face-to-face meetings with at least one tribe, six local jurisdictions, and three counties,
- Mitigation information, mitigation status updates, and mitigation grant application updates were provided to all county coordinators in monthly conference calls.
- Presentations were given at two (2) county coordinators' semi-annual meetings.
- Countless phone calls and e-mails have been exchanged to discuss local mitigation issues, potential mitigation projects, and mitigation planning.
- The State Hazard Mitigation Officer has reviewed nine (9) local multi-jurisdictional, multi-hazard mitigation plans, offered suggestions for improvements, and submitted the local plans to FEMA for their review and approval.
- September 2011—HMGP Applicant Briefings were presented statewide in coordination with FEMA Region VIII following flooding disaster DR-4007.
- January 2012—FEMA L212 Developing Quality Project Application Elements training was held in Casper.
- February 2012—Benefit Cost Analysis training was held in Casper.

- June 2012—Participated in four (4) local Risk Map Meetings sharing mitigation information
- Participated in monthly Risk Map Conference Calls
- January 2013—Attended Mitigation for Emergency Managers training in Casper, discussed local mitigation issues with County Coordinators in attendance at the training
- May 2013—FEMA 154, ATC-20 and ROVER training was provided in May 2013 to assist with earthquake hazard planning activity at the local level.

Local Plan Integration

Requirement §201.4(c)(4)(ii): *[The section on the Coordination of Local Mitigation Planning **must** include a] description of the State process and timeframe by which the local plans will be reviewed, coordinated, and linked to the State Mitigation Plan.*

The Wyoming Office of Homeland Security has committed to compressing the state review of the local mitigation plans into two - three weeks. Generally, local plans have been reviewed over the past three years within three-to-five working days.

The local plans are linked to the State's Mitigation Plan by reference. In addition, information from the local plans is incorporated into the State's Plan, where appropriate. It has been helpful to incorporate locally-proposed mitigation actions into the State Plan, thereby validating the state's mitigation goals.

Prioritizing Local Assistance

Requirement §201.4(c)(4)(iii): *[The section on the Coordination of Local Mitigation Planning **must** include] criteria for prioritizing communities and local jurisdictions that would receive planning and project grants under available funding programs, which **should** include consideration for communities with the highest risks, repetitive loss properties, and most intense development pressures.*

*Further, that for non-planning grants, a principal criterion for prioritizing grants **shall** be the extent to which benefits are maximized according to a cost benefit review of proposed projects and their associated costs.*

All mitigation planning and project grant applications are considered for funding. Suggestions for application improvement are provided. Prior to 2010 Wyoming's Office of Homeland Security's (WOHS) mitigation program had experienced significant turnover in the SHMO position, with five individuals in the role over a six-year period. WOHS has been rebuilding the mitigation program since late in 2010. To date, through the rebuilding process Wyoming has not been over-subscribed. Therefore, since the last update all qualified applications received have been submitted for review at the regional and national levels. It is anticipated this will not continue, and that difficult decisions will have to be made in the future regarding grant applications to forward on to the regional and national levels. Hazard Mitigation Grant Program (HMPG) applications will be forwarded beyond the state level based on the guidelines developed and outlined in the HMGP Administrative Plan. Other FEMA mitigation planning and project grant applications will be forwarded to regional and national competition based on stated national priorities and maximizing benefits to Wyoming residents. Grant application reviews at the state level may also include consideration for communities with highest risk, most intense development pressures and repetitive loss properties.

As of April 2013, seventeen (17) of Wyoming's 23 counties have multi-jurisdictional mitigation plans approved by the Federal Emergency Management Agency (FEMA). One single-jurisdiction plan is approved. One (1) county plan is currently in the review process. Seven (7) counties and two (2) tribes do not have approved plans. **(Table 2.2.1)** This represents an improvement since the last update in 2011, when 11 counties had approved multi-jurisdictional mitigation plans. WOHS will continue to assist local jurisdictions with development of multi–hazard mitigation plans through training facilitation, technical assistance, plan reviews, participation in planning meetings, and other opportunities as they become available.

In the table below, counties without current mitigation plans are highlighted in mauve. Counties whose plans will expire within the next two years have their expiration date highlighted in yellow.

Table 2.2.1 – Local Mitigation Planning Status

Wyoming Hazard Mitigation Plans April 2014				
Jurisdiction	**Expires**	**Last Expiration Date**	**Plan Status**	**Planning Grant Y/N**
State of Wyoming	22-Jun-14	22-Jun-14	Plan Approved - Updating Process Begun	
Counties				
Albany	8-Jul-15	8-Jul-15	Plan Approved	
Big Horn	28-Jan-16	28-Jan-16	Plan Approved	
Campbell	21-Nov-16	21-Nov-16	Plan Approved	
Carbon	21-Jul-14	21-Jul-14	Applied for PDM funding Sept 2013. Selected for further review Jan 2014.	
Converse	28-Feb-17	28-Feb-17	Plan Approved	
Crook	22-Dec-18	22-Dec-18	Plan Approved	
Fremont	13-Jul-17	13-Jul-17	Plan Approved	
Goshen	Expired	9-Jan-12	Expired 1/9/2012	
Hot Springs	No Plan		Plan to submit funding request for plan per e-mail 3/25/2011 (Draft rec'd 4/1/2003..never approved by FEMA) Received NOI- Cnty plans to apply for FY13 PDM	
Johnson	13-Oct-18	13-Oct-18	Plan Approved	
Laramie	26-Feb-18	26-Feb-18	Plan Approved	
Lincoln	Expired	6-Aug-12	Expired 8/6/2012	

Natrona	19-Sep-16	19-Sep-16	Plan Approved	
Niobrara	25-Feb-15	25-Feb-15	Plan Approved	
Park	21-Nov-16	21-Nov-16	Plan Approved	
NWCollege-Powell	Expired	16-May-13	Plan Expired	
Platte	No Plan		Interested in applying for PDM grant funding in next cycle per phone call 3/28/2011	
Sheridan	7-Apr-14	7-Apr-14	Plan Approved thru Apr 14 Mar 20- Updated Plan Approvable Pending Adoption	Jul 8, 2013- Using HSGP funding for update - Nov 4-6- Reviewed Plan Nov 14- Draft Plan forwarded to FEMA
Sublette	Expired	21-Aug-13	Expired 8/21/2013	
Sweetwater	No Plan		Draft Completed 2004-Will pursue completion at later date 3/28/2011	
City of Rock Springs	23-May-18		Plan Approved	
Teton	25-Feb-15	25-Feb-15	Applied for PDM funding Sept 2013. Selected for further review Jan 2014.	
Uinta	30-Sep-16	30-Sep-16	Plan Approved	
Washakie	19-Sep-16	19-Sep-16	Plan Approved	
Weston	No Plan		Cnty Coordinator inquired on benefits of mitigation plan via e-mail October 2011. Responded with benefits 10/7.	
Tribes				
Eastern Shoshone			Vernon Submitted 03 Draft 8/10 & FEMA Commented directly to the tribe- Tribe working directly with FEMA on plan status Met w/ tribes & FEMA @ Ft. Washakie 9/20/2011 to discuss plan.	
Northern Arapaho				

3. Hazards

3.1 Introduction

Requirement §201.4(c)(2): *[The State plan must include a risk assessment] that provides the factual basis for activities proposed in the strategy portion of the mitigation plan. Statewide risk assessments must characterize and analyze natural hazards and risks to provide a statewide overview. This overview will allow the State to compare potential losses throughout the State and to determine their priorities for implementing mitigation measures under the strategy, and to prioritize jurisdictions for receiving technical and financial support in developing more detailed local risk and vulnerability assessments.*

Requirement §201.4(c)(2)(i): *[The State risk assessment **shall** include an] overview of the type … of all natural hazards that can affect the State … .*

Requirement §201.4(c)(2)(i): *[The State risk assessment **shall** include an overview of the] location of all natural hazards that can affect the State, including information on previous occurrences of hazard events, as well as the probability of future hazard events, using maps where appropriate… .*

Requirement §201.4(c)(2)(ii): *[The State risk assessment **shall** include an] overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments as well as the State risk assessment. The State **shall** describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events. State owned critical or operated facilities located in the identified hazard areas shall also be addressed … .*

Requirement §201.4(c)(2)(iii): *[The State risk assessment **shall** include an] overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment. The State **shall** estimate the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.*

Requirement §201.4(c)(2)(iii): *[The State risk assessment **shall** include an] overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment. The State **shall** estimate the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.*

Hazard Identification

Wyoming hazards identified for analysis in the 2014 Mitigation Plan update include twenty-two (22) hazards. The 2014 update includes two additional hazards not previously considered. Those hazards are wind and space weather.

Wind is considered part of daily living in Wyoming and is dealt with in that manner—daily—and rarely thought of as a hazard. Upon further consideration of natural hazards, however, it would be remiss to fail to include wind in our analysis.

Space weather has a limited daily impact. However, it has the potential to severely impact communications and the electrical grid. Should space weather restrict communications during a disaster of another type, the results could be catastrophic. Therefore, space weather is considered in this update.

While 22 hazards have been identified and listed, not all are analyzed in this mitigation plan. Hazards analyzed in detail are those that have recurrence intervals less than 10,000 years and those not related specifically to health issues.

Table 3.1.1 Wyoming's Identified Hazards

Dam Failure	Lightning	** Water Quality
Drought	Liquefaction	Wildland Fire
Earthquake	Meteor Impact	Wind
Expansive Soil	Mine Subsidence	Windblown Deposits
Flood	Snow Avalanche	Winter Storm - Blizzard
Hail	Space Weather	** Yellowstone Volcano
Human Caused	Tornado	
Landslides	** Toxic Elements-Natural Occurrence	** Not Analyzed

Hazards analyzed in detail are those that have recurrence intervals less than 10,000 years and those not related specifically to health issues. The hazards analyzed are dam failure, drought, earthquakes, expansive soils, floods, hail, hazardous materials and waste, landslides, lightning, liquefaction, mine subsidence, space weather, snow avalanches, tornadoes, wildland fire, wind, windblown deposits, winter storms and blizzards. The Hazards and Vulnerability Research Institute at the University of South Carolina hazard event data was used to enhance the quality of this plan. Their information is housed in the Spatial Hazard Events and Losses Database for the United States (SHELDUS). Hazard event data obtained from SHELDUS is listed below and can be found at the following web site: (http://webra.cas.sc.edu/hvriapps/sheldus_setup/sheldus_login.aspx).

SHELDUS Hazards

Avalanche*

Flood*

Fog

Hail*

Lightning*

Landslide*

Severe Thunderstorm

Severe Wind*

Tornado*

Wildfire*

Winter Weather& Blizzard*

*Hazard Identified in Risk Assessment

The SHELDUS data has been organized into tables. The first presents an overview of hazard events in the state and in each county (**Table 3.1.2**) and the second summarizes the number of events by event type (**Table 3.1.3**). SHELDUS data is incorporated throughout this plan and can be found in hazard-specific descriptions which follow.

Historical losses provide us a picture of potential future losses, informing estimated future losses to structures, infrastructure and critical facilities. Historical losses also inform mitigation actions, allowing strategic focus of mitigation funding where it will do the greatest good.

Table 3.1.2 - SHELDUS Events by County and Statewide Totals (1960-2012)

County	*Total Events*	*Total Injuries*	*Total Fatalities*	*Total Property Damage*	*Total Crop Damage*	*Total Damage*
Albany	151	45	8	$ 3,753,839	$ 393,982	$ 4,147,821
Big Horn	121	6	1	$ 7,319,008	$ 1,127,271	$ 8,446,278
Campbell	169	25	5	$ 79,777,407	$ 16,565	$ 79,793,972
Carbon	129	45	14	$ 1,700,446	$ 74,760	$ 1,775,206
Converse	137	23	6	$ 5,588,000	$ 40,994	$ 5,628,995
Crook	141	10	1	$ 11,238,148	$ 17,660	$11,255,808
Fremont	236	103	10	$ 21,730,945	$ 1,071,329	$ 22,802,274

County	*Total Events*	*Total Injuries*	*Total Fatalities*	*Total Property Damage*	*Total Crop Damage*	*Total Damage*
Goshen	170	8	3	$ 7,898,708	$ 1,740,832	$ 9,639,540
Hot Springs	79	16	2	$ 5,157,985	$ 67,854	$ 5,225,839
Johnson	117	45	2	$ 6,141,224	$ 353,704	$ 6,494,928
Laramie	319	181	17	$ 129,401,344	$ 6,678,198	$ 136,079,542
Lincoln	116	39	7	$ 4,658,383	$ 425,813	$ 5,084,196
Natrona	191	63	2	$ 18,313,678	$ 74,413	$ 18,388,090
Niobrara	134	25	1	$ 6,018,256	$ 22,944	$ 6,041,200
Park	166	47	7	$ 9,017,887	$ 298,863	$ 9,316,749
Platte	181	27	1	$ 4,217,531	$ 290,948	$ 4,508,479
Sheridan	93	3	1	$ 5,927,415	$ 573,704	$ 6,501,119
Sublette	101	36	8	$ 4,102,076	$ 42,313	$ 4,144,389
Sweetwater	112	43	5	$ 2,576,305	$ 14,050	$ 2,590,355
Teton	144	95	18	$ 5,953,606	$ 5,979	$ 5,959,585
Uinta	54	1	1	$ 349,768	$ -	$ 349,768
Washakie	89	2	2	$ 6,467,998	$ 209,271	$ 6,677,268
Weston	125	6	0	$ 9,322,207	$ 5,960	$ 9,328,167
Statewide	**3,275**	**897**	**122**	**$ 356,632,165**	**$ 13,547,405**	**$ 370,179,571**

Table 3.1.3 - Statewide SHELDUS Summary by Hazard (1960-2012)

Hazard	*Number of Events*	*Injuries*	*Fatalities*	*Property Damage*	*Crop Damage*	*Total Damage*
Avalanche*	128	23	24	$ 15,000	$ -	$ 15,000
Flooding*	202	78	20	$ 100,962,400	$ 1,887,505	$ 102,849,905
Fog	4	5	-	$ 46,000	$ -	$ 46,000
Hail*	309	15	-	$ 133,172,017	$ 3,473,400	$ 136,645,417
Landslide*	18	-	-	$ 1,238,000	$ -	$ 1,238,000
Lightning*	208	137	28	$ 2,795,750	$ 102,500	$ 2,898,250
Severe Wind *	1,067	163	6	$ 12,315,316	$ 638,450	$ 12,953,766
Severe Thunderstorms	343	12	4	$ 8,099,000	$ 6,168,050	$ 14,267,050
Tornado*	168	78	3	$ 14,162,650	$ 169,500	$ 14,332,150
Wildfire*	30	11	1	$ 8,351,000	$ -	$ 8,351,000
Winter Weather & Blizzard*	798	374	36	$ 75,475,033	$ 1,108,000	$ 76,583,033
Totals	**3,275**	**897**	**122**	**$ 356,632,165**	**$ 13,547,405**	**$ 370,179,571**

*Hazard Identified in Risk Assessment

In the two pie charts below, (**Chart 3.1.4** and **Chart 3.1.5**) it is interesting to compare the percentage of events to the monetary losses experienced. Though hail ranks 4th in number of events at nine percent (9%), it ranks first in losses, exceeding all other hazards. Severe wind, though it ranks first in number of events, represents only three percent of total losses, ahead of only three other hazards: wildfire, lightning, and landslide. Given these statistics, one might conclude Wyoming residents have successfully mitigated many of the impacts from severe wind. Further, it appears there is room for improvement in mitigating the impact from hail events. The bar graph below further analyzes injuries and fatalities resulting from Wyoming natural hazards. **(Chart 3.1.6)**

Chart 3.1.4 - Statewide Loss Causing Events - SHELDUS

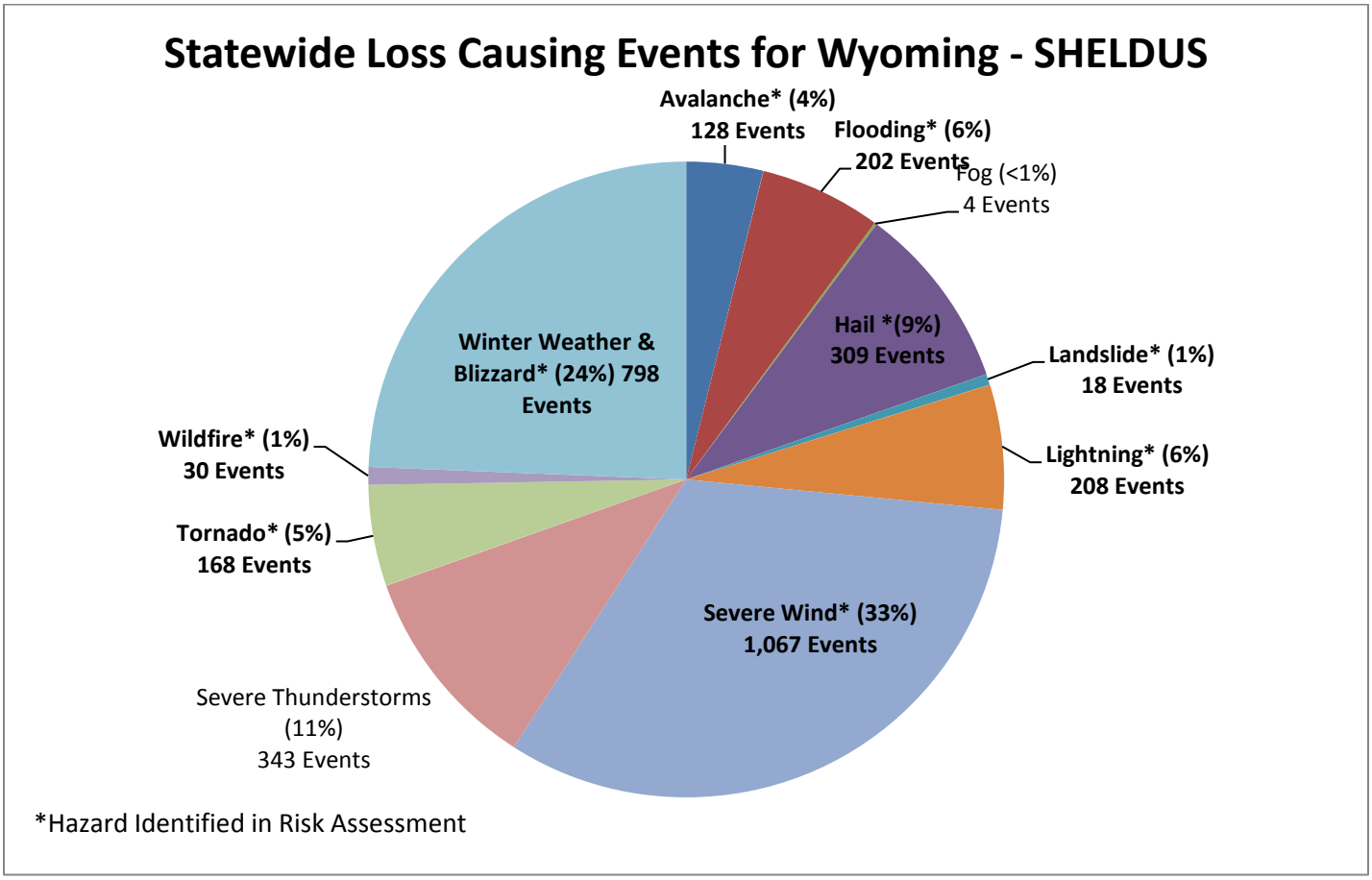


Chart 3.1.5 - Statewide Total Losses – SHELDUS

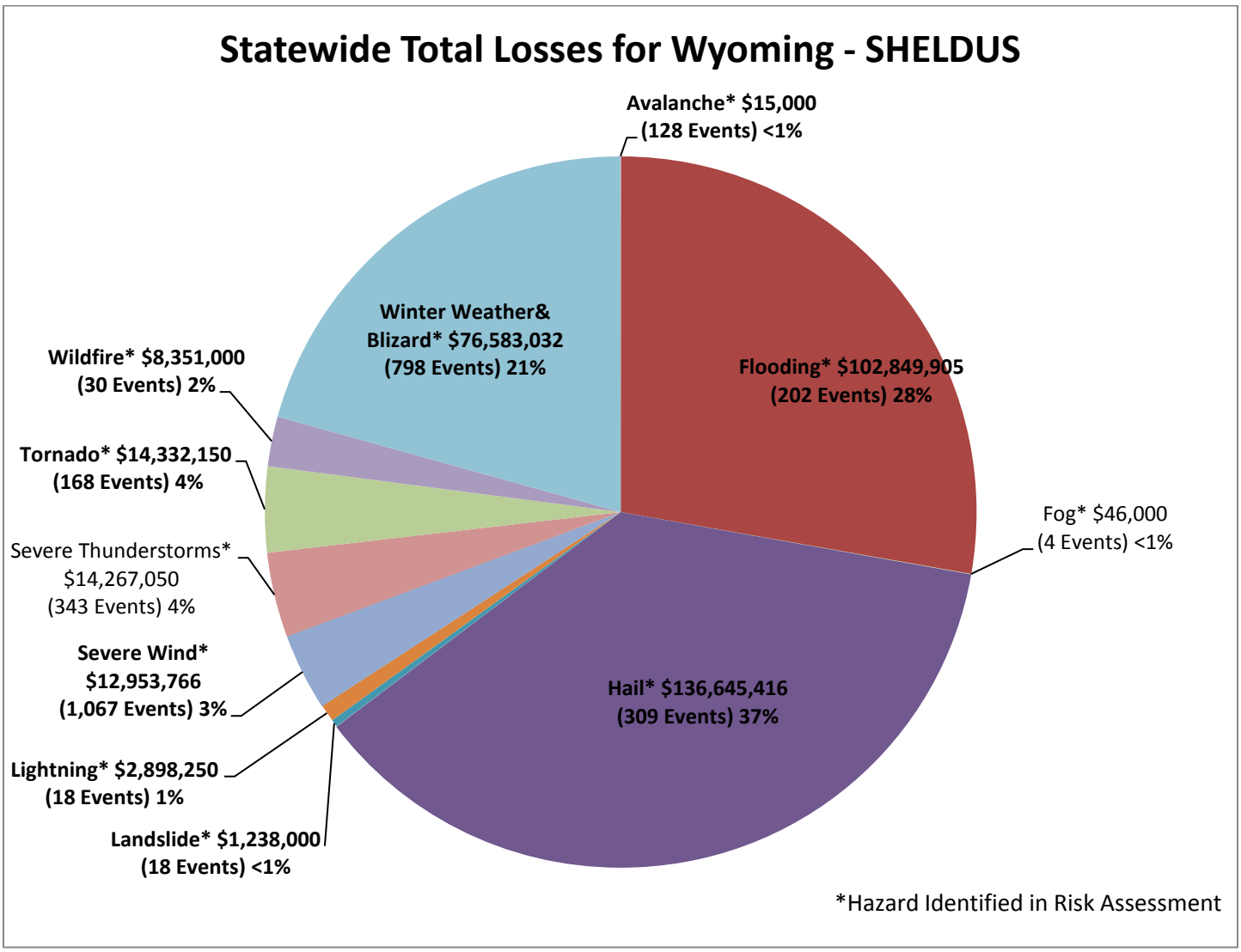
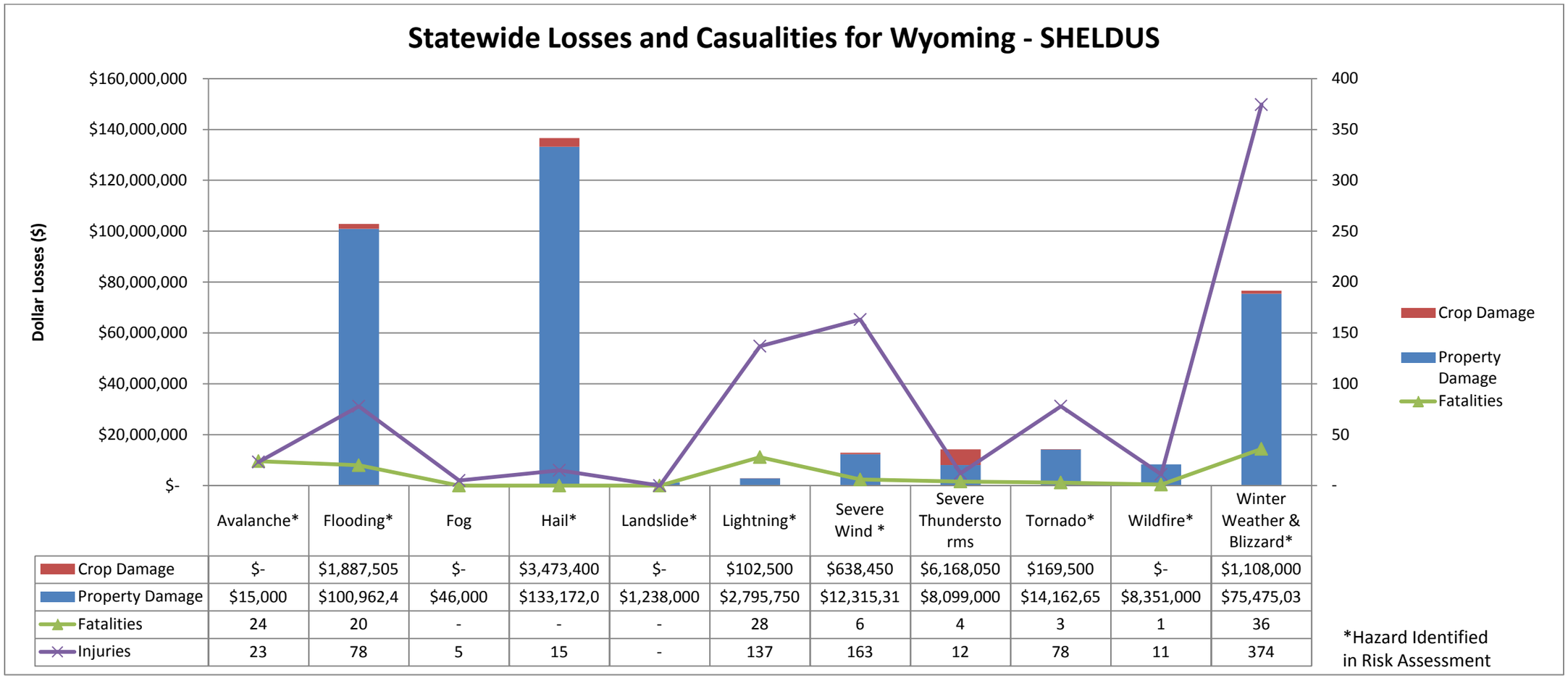


Chart 3.1.6 - Statewide Losses and Casualties- SHELDUS



	Avalanche*	Flooding*	Fog	Hail*	Landslide*	Lightning*	Severe Wind *	Severe Thunderstorms	Tornado*	Wildfire*	Winter Weather & Blizzard*
Crop Damage	$-	$1,887,505	$-	$3,473,400	$-	$102,500	$638,450	$6,168,050	$169,500	$-	$1,108,000
Property Damage	$15,000	$100,962,4	$46,000	$133,172,0	$1,238,000	$2,795,750	$12,315,31	$8,099,000	$14,162,65	$8,351,000	$75,475,03
Fatalities	24	20	-	-	-	28	6	4	3	1	36
Injuries	23	78	5	15	-	137	163	12	78	11	374

*Hazard Identified in Risk Assessment

Following identification of hazards to be evaluated in the 2014 plan update, the hazards were then ranked based on a Risk Factor approach. Wyoming hazards were ranked using a risk factor approach which combines historical data, local knowledge, and consensus opinions to produce numerical values allowing identified hazards to be ranked against one another.

Risk factor values were obtained by assigning varying degrees of risk to five categories for each hazard: probability, impact, spatial extent, warning time, and duration. Each degree of risk is assigned a value ranging from 1 to 4 and a weighing factor for each category was determined. Based upon unique concerns for Wyoming, the planning team may also adjust the risk factor weighting scheme. To calculate the risk factor value for a given hazard, the assigned risk value for each category is multiplied by the weighting factor. According to the weighting scheme applied, the highest possible risk factor value is 4.0. The sum of all five categories equals the final value, as demonstrated in the example equation below:

Risk Factor Value = [(Probability x .30) + (Impact x .30) + (Spatial Extent x .20) + (Warning Time x .10) + (Duration x .10)]

Probability is based on the likelihood of a hazard event occurring in a given year. This calculation is obtained by dividing the number of recorded occurrences by the number of recorded years. A numerical value from 1 to 4 was assigned based on the probability an event would occur. Following is a table outlining the criteria used to determine probability:

Table 3.1.7 - Probability Calculation

Probability: What is the likelihood of a hazard event occurring in a given year? [value: 30%]		
Degree of Risk Level	**Criteria**	**Value**
Unlikely	Less than 1% Annual Probability	1
Occasional	Between 1 & 10% Annual Probability	2
Likely	Between 10 & 90% Annual Probability	3
Highly Likely	Greater than 90% Annual Probability	4

The other risk factor values [impact, spatial extent, warning time, and duration] were assigned a value by individuals experienced with Wyoming hazards and by members of the public. During the planning process County Coordinators, Wyoming Office of Homeland

Security staff, public health staff, members of the Unable to Self Evacuate Core Advisory Group, members of the public and others with knowledge of Wyoming hazards were asked to evaluate hazards using the risk factor system. The values for Impact, Spatial Extent, Warning Time, and Duration were obtained using this method. A copy of the completed risk factor scoring sheets used to calculate each hazard's risk factor values can be found in **Appendix C**.

To further focus on the list of identified hazards for this plan, **Table 3.1.8** presents a list of all presidentially-declared disaster and emergency declarations occurring in Wyoming since 1963. The list further defines the hazards posing the greatest risk to property, residents and visitors in the State of Wyoming. Wyoming has experienced 26 presidentially-declared disasters or emergency declarations since 1963.

Table 3.1.8 - Disaster and Emergency Declarations

Major Disaster Declarations

Number	Date	State/Tribal Government	Incident Description
4007	07/22/2011	Wyoming	Severe Storms, Flooding, And Landslides
1923	07/14/2010	Wyoming	Flooding
1599	08/22/2005	Wyoming	Tornado
1351	12/13/2000	Wyoming	Winter Storm
1268	02/17/1999	Wyoming	Severe Winter Storm
740	08/07/1985	Wyoming	Severe Storms, Hail, Flooding
591	07/19/1979	Wyoming	SEVERE STORMS, TORNADOES
557	05/29/1978	Wyoming	SEVERE STORMS, FLOODING, MUDSLIDES
155	07/04/1963	Wyoming	Heavy Rains, Flooding

Emergency Declarations

Number	Date	State/Tribal Government	Incident Description
3092	09/04/1987	Wyoming	Methane Gas Seepage
3043	06/15/1977	Wyoming	Drought

Fire Management Assistance Declarations

Number	Date	State/Tribal Government	Incident Description
5014	09/09/2012	Wyoming	Sheep Herder Hill Fire
2995	07/03/2012	Wyoming	Oil Creek Fire
2993	07/02/2012	Wyoming	Squirrel Creek Fire
2992	06/29/2012	Wyoming	Arapahoe Fire
2719	08/12/2007	Wyoming	Little Goose Fire
2665	08/14/2006	Wyoming	Jackson Canyon Fire
2654	07/14/2006	Wyoming	Thorn Divide Fire Complex
2512	11/20/2003	Wyoming	Tongue River Fire
2460	08/31/2002	Wyoming	Commissary Ridge Fire
2436	07/01/2002	Wyoming	Reese Mountain Fire
2427	06/18/2002	Wyoming	Hensel Fire
2382	09/06/2001	Wyoming	McFarland Divide Fire
2370	08/01/2001	Wyoming	Elk Mountain #2 Fire

Fire Management Assistance Declarations			
Number	Date	State/Tribal Government	Incident Description
2367	07/26/2001	Wyoming	Green Knoll Fire
2315	07/31/2000	Wyoming	Dead Horse Fire

http://www.fema.gov/disasters/grid/state-tribal-government/74?field_disaster_type_term_tid_1=All
Accessed August 13, 2013

The majority of Wyoming's counties have completed their own multi-hazard mitigation plan, with hazards addressed at the local level. Hazards presented in the local plans were reviewed and information mined from them is presented in this state-level multi-hazard mitigation plan. Not all hazards identified by the State Plan are hazards addressed within the individual counties' plans. The level of perceived risk varies hazard-to-hazard and county-to-county.

§201.4(c)(3) [To be effective the plan must include a] Mitigation Strategy that provides the State's blueprint for reducing the losses identified in the risk assessment.

3.2 Dam Failure

Photo from Wyoming State Engineer's Office Web Site
https://sites.google.com/a/wyo.gov/seo/surface-water Accessed 8/14/2013

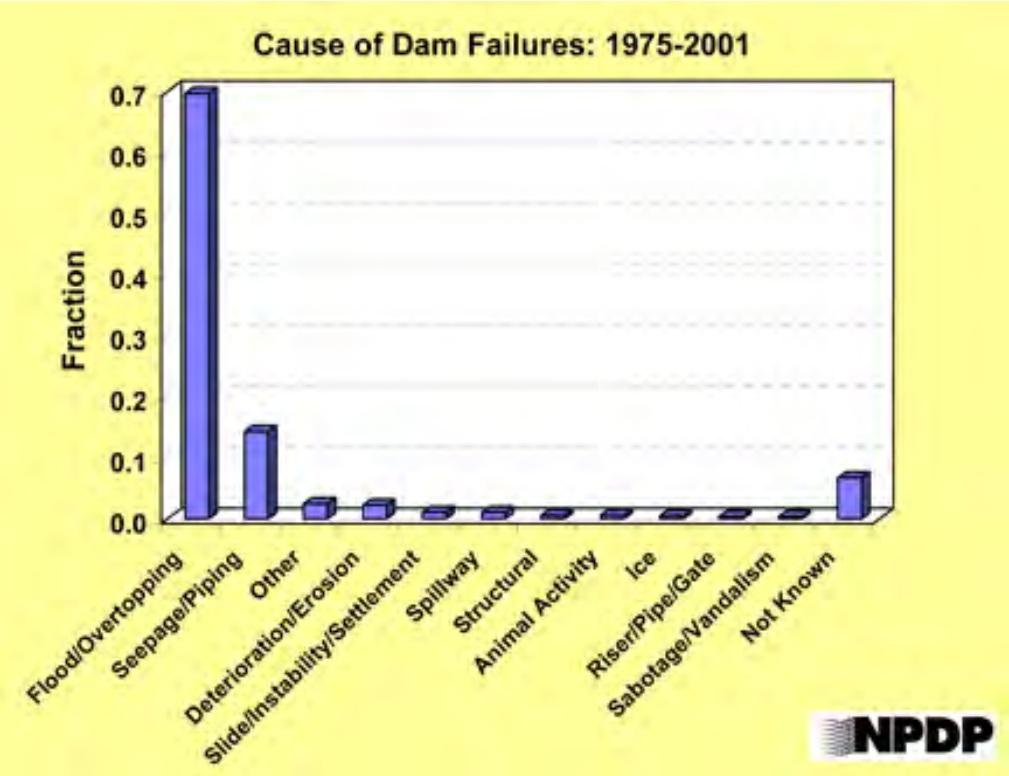
Wyoming has over 30,000 dams and reservoirs, ranging in size from over one million acre-feet in Pathfinder and Seminoe reservoirs above Casper to small coalbed methane and stock reservoirs scattered throughout the state. Of these dams, only 1,518 rise to the 'Safety of Dam' (SOD) size which is defined, generally, as either greater than 20 feet tall or holding more than 50 acre feet of water. The dams and reservoirs serve an important role for Wyoming residents and industry.

Dams rarely fail, either completely or partially, but when they do they may be a life and safety hazard for those downstream. Wyoming State Statutes 41-3-307 through 41-3-317 legislate the safety of dams and the role the state plays in ensuring their safety.

Overtopping failures result from uncontrolled flow of water over, around, and adjacent to the dam. Approximately 70% of failures are from floods and overtopping. Older dams are most susceptible to overtopping failure. Foundation and structural failures are usually tied to

seepage through the foundation of the main structure of the dam. Seepage or piping accounts for about 12% of dam failure. Deformation of the foundation or settling of the embankment can also result in dam failure. Below is a chart of dam failure causes provided by the Association of State Dam Safety Officials.

Chart 3.2.1 Dam Failure Causes



http://www.damsafety.org/news/?p=412f29c8-3fd8-4529-b5c9-8d47364c1f3e#FailureCauses Accessed September 4, 2013

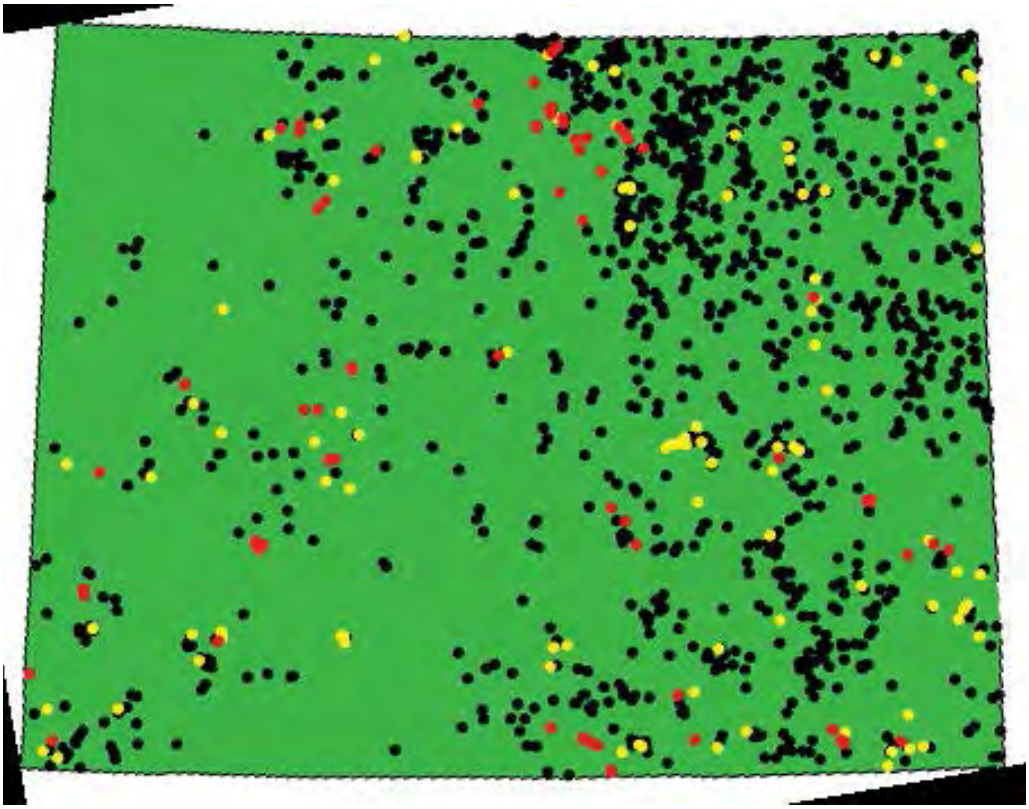
The Wyoming State Engineer's Office (WSEO) regulates dams over 20 feet high or with a storage capacity of 50 acre-feet or more, although smaller dams are also regulated if the potential for failure indicates a need. According to the WSEO web site (http://www.damsafety.org/map/state.aspx?s=51, accessed 8/13/2013), as of 2011 the WSEO regulates 1,518 dams. As a part of the regulatory process the WSEO inspects these dams once every five years. Of these dams, 81 are rated high hazard, 109 are rated significant hazard, and 1,328 are rated low hazard. **Map 3.2.2** shows the general locations of dams inspected by the WSEO.

The U.S. Army Corps of Engineers completed inspections of nonfederal dams in 1981. The four-year project included compiling an inventory of about 50,000 dams nationally, and conducting a review of each state's capabilities, practices, and regulations regarding design,

construction, operation, and maintenance of dams. Evaluation of each dam and assigning a hazard potential based on the downstream effects should one of the dams fail was also part of the inventorying process.

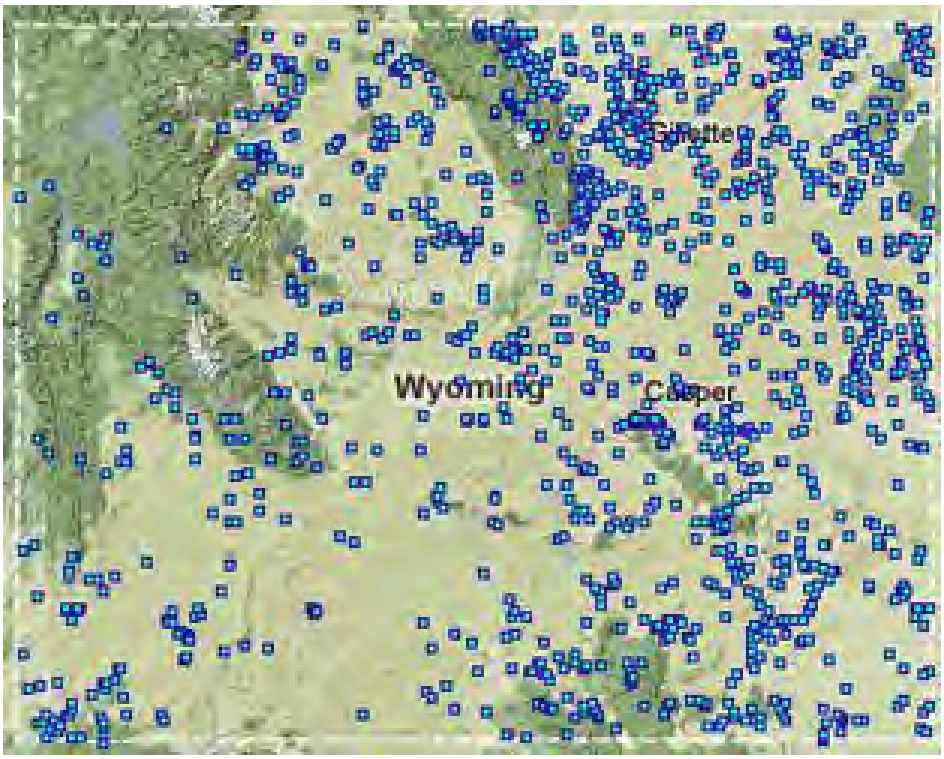
Dams are classified based upon hazard potential. This classification is based on the consequences if a dam were to fail, not on the potential of failure, or the existing condition of the dam. The dams were rated (1) high, (2) significant, and (3) low hazard. The Corps of Engineers based the hazard potential designation on such items as acre-feet capacity of the dam, distance from nearest community downstream, population density of the downstream community, and age of the dam. High hazard dams would, in case of dam failure, likely cause loss of life. Significant hazard dams would, in case of failure, likely cause significant property damage, but no loss of life. Failure of a low hazard dam would likely cause only minimal property damage. Hazard potential classification is no guarantee of safety. **(See map 3.2.2)**

Map 3.2.2 – Dam Hazard Potential



Red: High-Hazard Potential Dam
Yellow: Significant-Hazard potential Dam
Black: Low-Hazard Potential Dam
http://www.damsafety.org/media/Documents/STATE_INFO/State%20Performance%20Data/Performance%20Reports/Wyoming%20Dam%20Safety%20Report.pdf **Accessed 5/23/2011**

Map 3.2.3—Dams Inspected 2009



http://www.damsafety.org/map/state.aspx?s=51, **Accessed 5/23/2011**

Dam Failure History

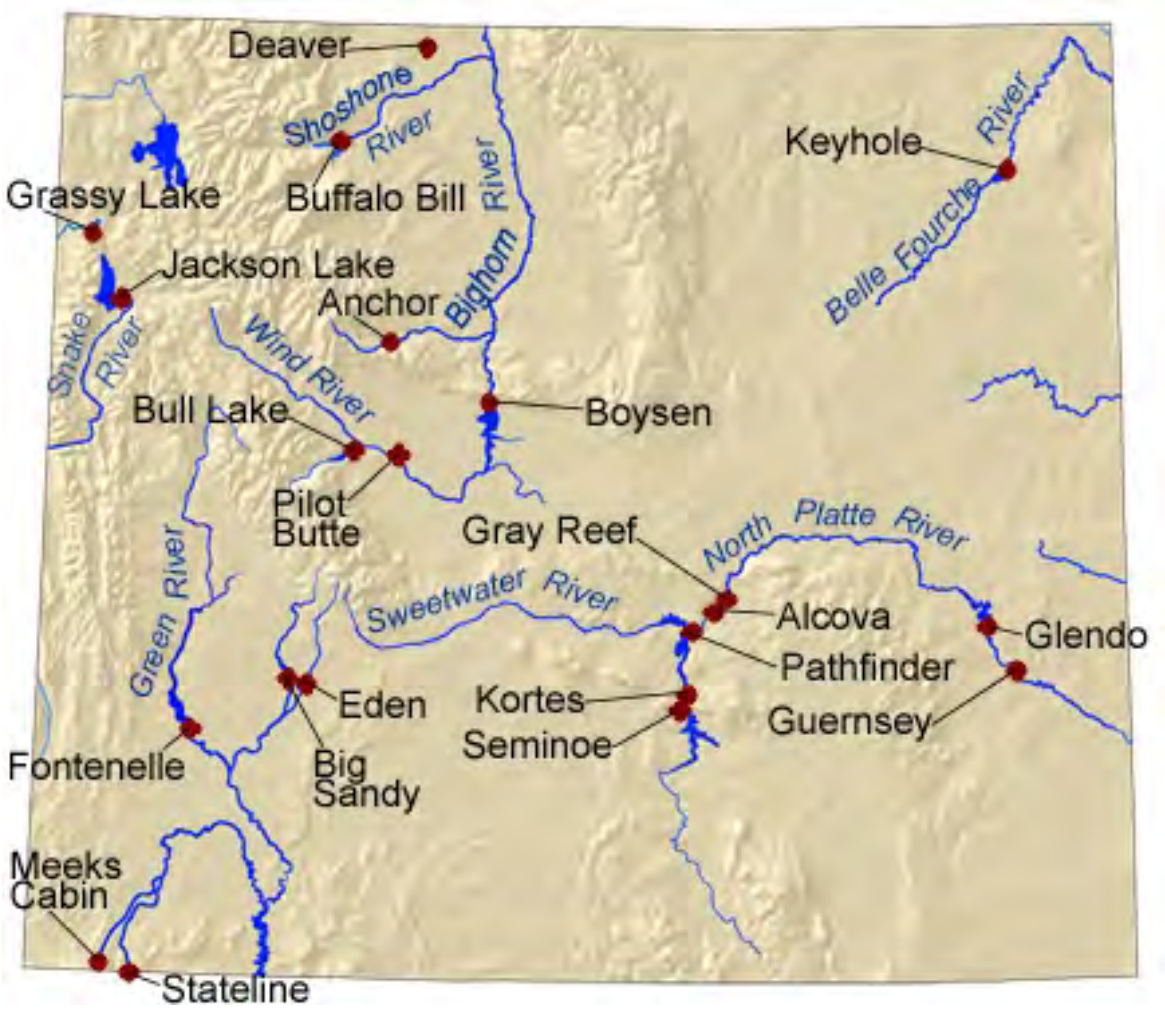
There have been a small number of dam failures in Wyoming, some of which have caused loss of life and damage to property (**Appendix H**). The most significant dam failures in terms of loss of life were in 1906 and 1927. On March 1, 1906, flooding along the North Platte River near Casper resulting from snow/ice melt caused a diversion dam to fail. A stream returned to its natural channel with a culvert too small to handle the flood, causing the water to rise against a railroad embankment. The embankment failed. Twelve were killed in a train wreck when the railroad bridge was damaged.

> *Probably the most infamous flash flood in Teton County's recorded history is the Kelly Flood. On June 23, 1925, part of the northern face of Sheep Mountain became unstable after weeks of heavy rain and slid into the Gros Ventre River. The 50 million cubic yards of sedimentary rock formed a natural dam 200 feet high and 400 yards wide that created Lower Slide Lake. On May 18th, 1927, a portion of the natural dam broke causing a flash flood to rush down the Gros Ventre River. The flood was at least 6 feet*

deep for at least 25 miles downstream, and wiped out the town of Kelly 6 miles downstream. Six people died, and many others lost everything they owned.

Fifteen miles downstream in Wilson, Wyoming 6 feet of water inundated the town and hundreds of farm animals died. In narrower sections of the Snake River near Hoback, flood waters rose as much as 50 feet. The next day the waters reached Idaho Falls,ID and covered lowland sections there. When all was said and done, damages totaled $500,000 which would be over $27 million in today's dollars. You can still see the bald rock on the north face of Sheep Mountain (Sleeping Indian) as a reminder of this tragic event. [http://www.tetonwyo.org/em/topics/flash-flood/201706 Accessed 10/1/2013]

Map 3.2.4 - Wyoming Dams Managed by U.S. Bureau of Reclamation



http://www.usbr.gov/projects/FacilitiesByState.jsp?StateID=WY **Accessed 8/14/2013**

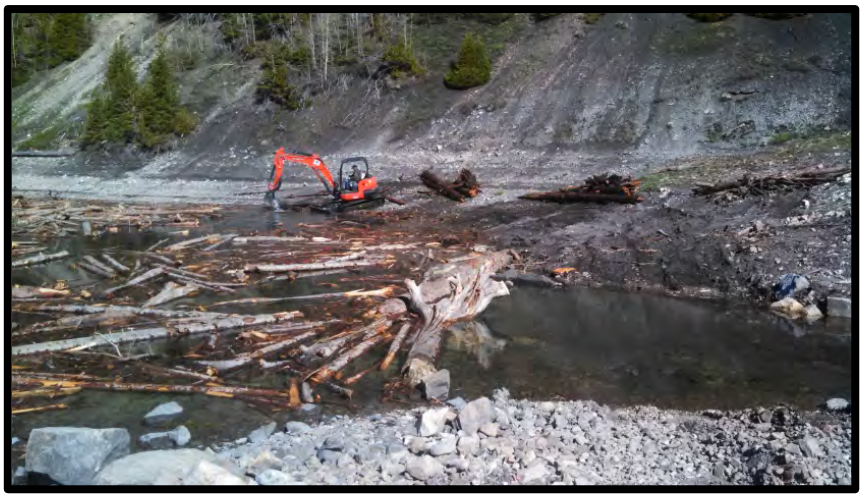
The most costly dam failure in Wyoming occurred on May 14, 1984. High runoff from melting snow in the mountains of southern Wyoming and northern Colorado resulted in the failure of the Highline Dam near Baggs. A 4-foot wall of water poured down a canyon. There was an estimated $5 million in damage to the area, including damage to a water treatment plant, crops, fences, irrigation systems, and structures. Four hundred people were forced to evacuate. Twenty-six homes and trailers were damaged. Recovery response was from the Small Business Administration, Civil Defense, Red Cross, and the Army Corps of Engineers.

To date there have been no Presidential Emergency Declarations in Wyoming as the result of a dam failure. Additionally, there have been no state-level emergency declarations in Wyoming as the result of a dam failure.

The Wyoming State Engineer's Office (WSEO) was contacted August 14, 2013. The WSEO indicates no dam failures have occurred in Wyoming since the mitigation plan was last updated, which puts the most recent Wyoming dam failure in 2010. There was a small incident in Sublette County in the summer of 2013, when an avalanche introduced logs to the Middle Piney Lake. The logs blocked the outlet, causing the water to rise.

Water remains a critical resource throughout the state. Water conservation is accomplished in part through the utilization of dams. Dams control flooding and conserve water for summer months when rainfall is limited. The use of dams is significant to Wyoming's water management. Most counties have multiple dams located within their borders, each of which represent both a hazard to property and residents, as well as a benefit to the community.

Photo 3.2.6 - Middle Piney Lake June 10, 2013 Wyoming State Engineers Office



Dam Failure Impacts

From 1906 to present, there have been $6.8 million in reported damages and 18 deaths caused by dam failures in Wyoming.

Probability of Future Dam Failures

The U.S. Bureau of Reclamation controls most of the larger dams in the state. The dams and reservoirs have inundation maps maintained by the U.S. Bureau of Reclamation in preparation for potential dam failure. Because of security concerns, inundation data is not available to the public, making the study and analysis of inundation areas for the purposes of publication within this plan unproductive.

The failure of large dams could be expected to lead to hundreds of millions of dollars in damage and loss of life. As documented in the maps earlier in this chapter, dam inspections and mitigation efforts are ongoing throughout Wyoming by the agencies responsible for dam safety.

Past experience outlined in **Appendix H** reflects 24 dam failures in the past 107 years, out of nearly 1,400 dams statewide, with only two of those leading to $1 million or more damage.

Dam Failure Probability

Likely = Value 3
24 dam failures ÷ 107 years = 1 dam failure every five (5) years or a 22.4% annual probability of dam failure

Dam Failure Risk Factor

Dam Failure Risk Factor Value = 2.74 [(Probability Likely: 3 x .30) + (Impact Limited: 2.6 x .30) + (Spatial Extent Small: 2.6 x .20) + (Warning Time: 12-24 hours 2.9 x .10) + (Duration Less than 24 hours: 2.6 x .10)]

State Capacity Related to Dam Safety

A summary of Wyoming Dam Safety Law is included as **Appendix D**.

Local Mitigation Plan Risk Assessments

Local mitigation plans ranked the risk of dam failure within their borders based on probability of occurrence and the expected impact from a dam failure. Data available through the Wyoming Multi-Hazard Mitigation Plan was made available to Wyoming Counties. Dam failure data most frequently used by local jurisdictions in the development of their plans is incident and frequency information.

Below is a table outlining local risk determinations related to dam failure. The table shows probability of occurrence within county borders and the risk dam failure represents locally.

Table 3.2.7- Local Risk Determination – Dam Failure

COUNTY	Plan Y/N	Year Approved	Included in Plan	Probability-High, Medium, Low	Impact-High, Medium, Low
ALBANY	Y	2010	Y	Low	Medium
BIG HORN	Y	2011	Y	Low	High
CAMPBELL	Y	2011	Y (in Flood Chapter)	High (Flooding)	Medium
CARBON	Y	2009	Y	Medium	Medium
CONVERSE	Y	2012	Y	Low	Low
CROOK	Update Under Review	2013	Y	Medium	Low-Medium
FREMONT	Y	2012	Y	Low	High
GOSHEN	Expired	2007	Y	Low	High
HOT SPRINGS	N				
JOHNSON	Update Under Review	2013	Y (in Flood Chapter)	High (Flooding)	High
LARAMIE	Y	2013	Y	Low	Medium
LINCOLN	Expired	2007	Y	Low	High
NATRONA	Y	2011	N		
NIOBRARA	Y	2010	Y	Low	Low
PARK	Y	2011	Y	Low	Low
PLATTE	Expired	2004	Y	Low	Medium
SHERIDAN	Y	2009	Y	Low	High
SUBLETTE	Expired	2008	Y	Low	Low-Medium
SWEETWATER	N				
TETON	Y	2010	Y	Low	Medium
UINTA	Y	2011	Y	Low	Medium
WASHAKIE	Y	2011	Y	Low	Medium
WESTON	N				
NORTHERN ARAPAHO TRIBE	N				
EASTERN SHOSHONE TRIBE	N				

Dam Failure Mitigation Projects

The majority of Wyoming dams are privately owned and mitigation activity it not always welcomed by private owners. The State Engineer's Office has the power to require dams be drained, if it is perceived to be necessary. However, private owners may view mitigation inquiries or opportunities as an intrusion.

Dam hazard mitigation can be accomplished only if the owner is willing to pursue it. Wyoming also has barriers in place regarding expenditure of public funds. Public funds may be used only to benefit the public, and may not benefit a private property owner.

The following dam hazard mitigation projects were listed in the last update, and were reviewed in a one-on-one meeting with staff from the State Engineers Office, Division of Dam Safety on September 4, 2013. Mitigation projects and actions were updated for current status, prioritization and current applicability. Many of Wyoming's dams are private facilities, limiting the state's authority to accomplish mitigation. Authority to mitigate privately-owned dams rests with private owners. Under state statute the Wyoming State Engineers Office is authorized to enforce dam safety by requiring owners to drain a dam which has been determined unsafe, posing a risk to life and property. [§41-3-313 and §41-3-314]

Table 3.2.8 Mitigation Strategy – Dam Failure

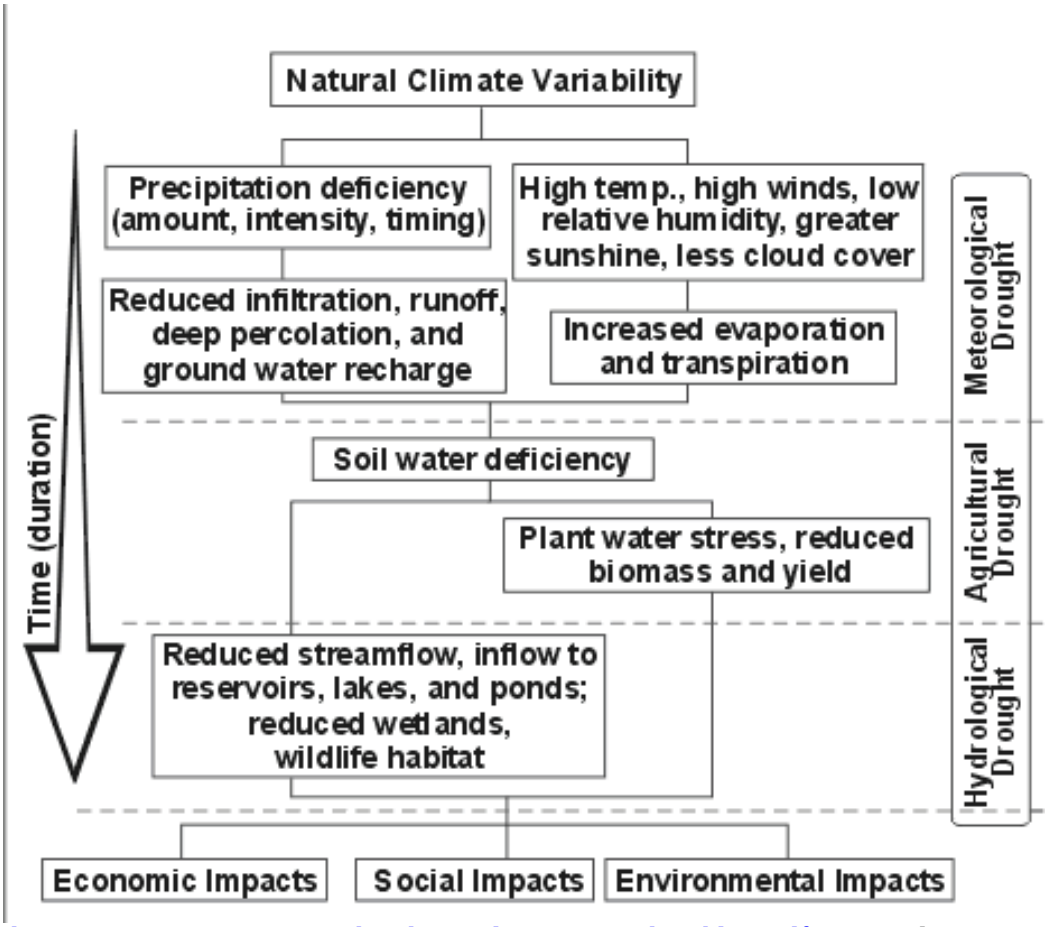
Refine computer models to determine potential damage to dams from earthquakes.	Not started. VERY low priority.
Drill test cores on older hydraulic fill dams in western Wyoming to determine liquefaction or piping potential of the dam.	Not started. VERY low priority. Unlikely to be pursued.
Identify homes built in inundation areas of dam failures.	Progress has been made and is ongoing for high and significant hazard dams.
Update hazard rating of all dams statewide.	Continuous, ongoing project.
Develop and train a team to respond to landslide dams to prevent failure.	Not started. Low priority. Limited mitigation value. Determined to be response, rather than mitigation.
Increase height of dams to compensate for sediment behind dams.	Removed from the list. Sediment may be removed as necessary. Increased dam height is rarely considered.
Spillway modifications to reflect current analysis on design storms.	Ongoing.
Provide all-hazards weather radios to all residences in Wyoming.	Removed from the list.
Identify and inspect shelters in hazard prone areas.	American Red Cross is working with WOHS and VOAD to develop and maintain a current list of identified shelters. Shelters have been identified and validated (3-deep) in all counties. The list is re-validated at least annually.

Provide hazards info to shelters, emergency facilities in public buildings, campgrounds, and phone books.	Removed from the list.
Develop reseeding plans for losses due to all hazard events.	Removed from the list.
GIS training for local jurisdictions with emphasis on hazards recognition and analysis for application to mitigation planning.	Local GIS capability is encouraged. Training is accomplished at the local level, as needed and as funding is available.
Investigate opportunities for developing or improving warning systems as a means to reduce loss of life, damage to property, and economic losses.	Removed from the list. This is an ongoing, response planning activity, and not a mitigation activity.
Education programs encompassing multi-hazard insurance for business, resident and government application.	Ongoing mitigation activity. Annual workshop series and tabletop exercises are conducted each year.
Education programs encompassing multi-hazard mitigation for business, resident and government application.	Ongoing mitigation activity. Annual workshop series and tabletop exercises are conducted each year.
Planning studies regarding transportation of essential and/or key personnel during all hazard events.	Removed from the list. This is a response planning activity and not a dam hazard mitigation activity.
Continue outreach to counties on identifying cost effective and feasible mitigation projects.	Ongoing. Outreach accomplished through County Coordinators.
Promote Continuity of Operations and Continuity of Government, statewide.	Continuity of Operations is an ongoing activity.
Maintain and continue to expand hazards databases that were generated for the State Hazard Mitigation Plan. Seek new sources of information.	Removed from the dam safety mitigation list. Not a dam hazard mitigation activity.
Identify, document, and advertise all volunteer agency's locations and contact information.	Removed from the list. This is a response and recovery planning activity and is not a dam hazard mitigation activity.

3.3 Drought

Unlike other disasters that quickly come and go, drought's long-term unrelenting destruction has been responsible for mass migrations and lost civilizations. 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.

Chart 3.3.1 - Drought Flow Chart



http://www.nws.noaa.gov/os/brochures/climate/DroughtPublic2.pdf Accessed 9/3/2013

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. This criterion can be misleading if all the precipitation falls in a very short time period resulting in floods. Additionally, winter precipitation is usually two to six times less than summer precipitation and these so-called seasonal droughts are normal in our semiarid climate. Conditions are often made worse with high temperatures, high winds, low humidity, and greater sunshine; all of these factors contribute to

increased evaporation and transpiration and result in reduced soil infiltration, runoff, deep percolation, and groundwater recharge.

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 in strong winds (blowing dust).

Drought conditions can vary considerably from region to region and location to location within Wyoming. There are multiple factors impacting moisture levels throughout the state, two of which are Wyoming's widely-varied topography and the size of the state. Wyoming lays claim to terrain consisting of mountains, rolling hills and plains, and Wyoming is ranked 10th among the states for its size with 97,818 square miles. Wyoming ranges in height from a mere 3,099 feet above sea level at the Belle Fourche River to 13,804 feet above sea level at Gannett Peak in the Wind River Mountain Range, with the continental divide running from north to south through the state. (http://www.netstate.com/states/geography/wy_geography.htm) Moisture content varies significantly across the state due to the interaction of Wyoming's terrain with moisture content traveling across the state in weather systems. Weather systems containing rain and snow tend to interact significantly with Wyoming's terrain, and this of course, results in varied moisture from one side of the state to the other. Drought does seem to be cyclical in nature throughout Wyoming's history, though it can be expected to vary region to region within each drought cycle. Drought is addressed in an overall, state-level perspective throughout this chapter, rather than through the lens of a regional perspective. There is however, attention made to each local county's perspective of the drought hazard through review of local multi-hazard mitigation plans and extrapolation of data from them. It can be noted, all counties within Wyoming recognize drought as a local hazard, though the perceived intensity of its risk is varied.

Drought Measurement

There are several methods for determining drought. One of the most popular is known as the Palmer Drought Severity Index (PDSI). Wayne Palmer developed this index in the 1960s; temperature and rainfall information are used in a formula to determine dryness. It has become the semi-official drought index. However, in the west much of the surface water is derived from mountain snowpack [i.e., the snow-water equivalent (SWE) as measured at a number of SNOTEL sites].

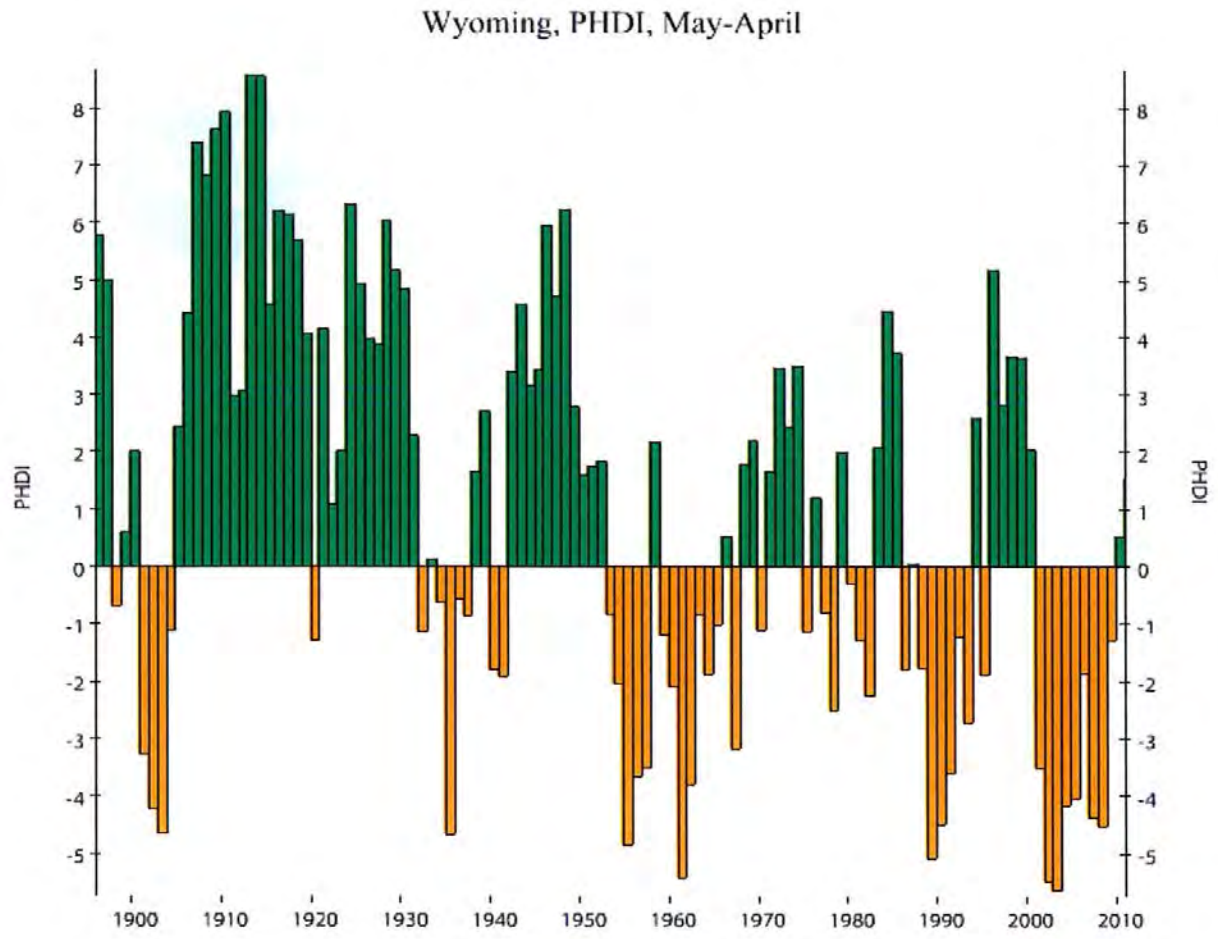
The PDSI is a "meteorological drought" index that responds to weather conditions that have been abnormally dry or abnormally wet. The index is calculated based on precipitation, temperature, and

available water content (AWC) of the soil. The Palmer Index varies from +6.0 to -6.0 with a classification scale indicating relative meteorological and hydrological development cycles. **Table 3.3.2** reflects the range and extent of the PDSI classification system. There are concerns about the number of data points used to calculate the index as well as the accuracy of the data used.

Table 3.3.2 - Palmer Drought Severity Index Classification System

4.00 to 6.00	Extremely wet
3.00 to 3.99	Very wet
2.00 to 2.99	Moderately wet
1.00 to 1.99	Slightly wet
0.50 to 0.99	Incipient wet spell
0.49 to -0.49	Near normal
-0.50 to -0.99	Incipient dry spell
-1.00 to 1.99	Mild drought
-2.00 to -2.99	Moderate drought
-3.00 to 3.99	Severe drought
-4.00 to -6.00	Extreme drought

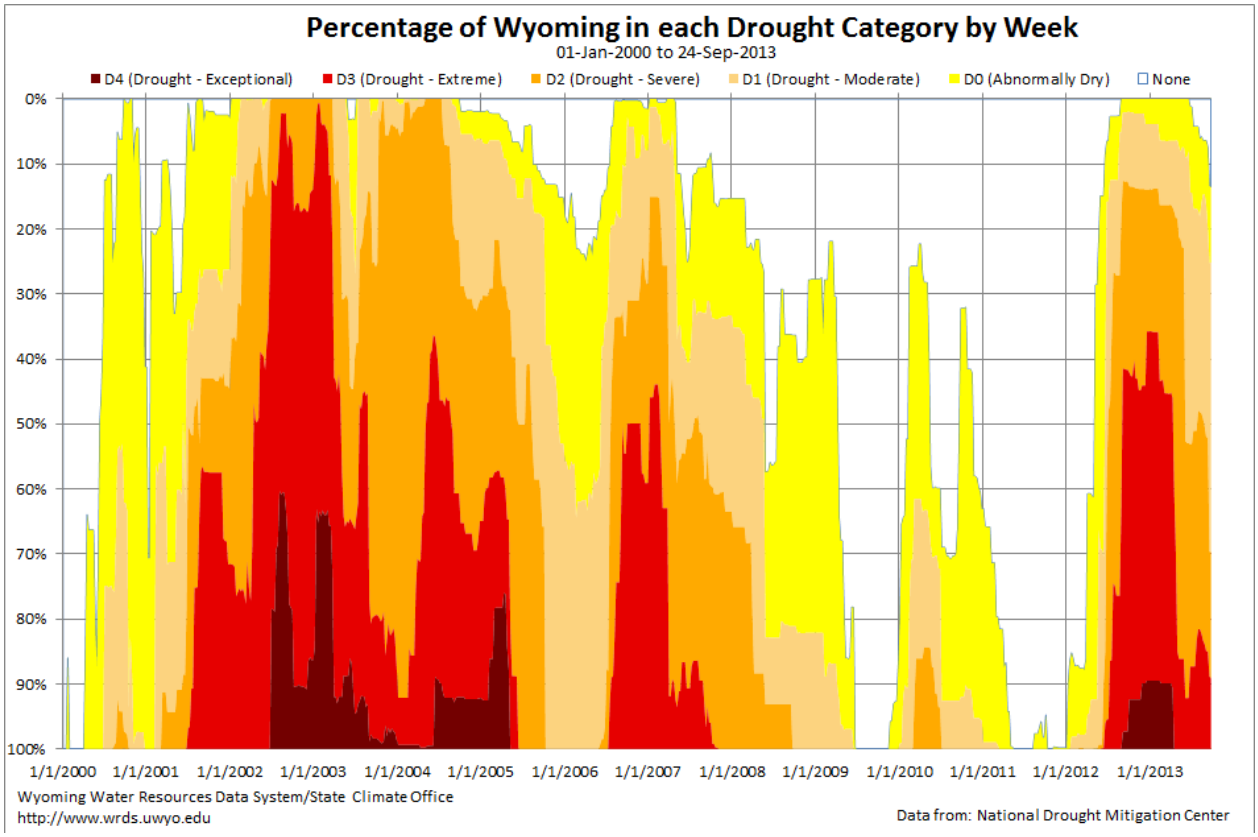
Graph 3.3.3 - Palmer Hydrological Drought Index (PHDI) 1896-2011



The initial estimates are not considered as accurate as later updates. In Wyoming, the Palmer Index should be used with caution since much of surface water is derived from mountain snow pack and the PDSI does not use this as an input to the index. Additionally, the values selected for quantifying the intensity of drought and for determining a start and end of a drought were selected based on Palmer's study of central Iowa and western Kansas.

Another popular index used to determine drought is the Standardized Precipitation Index (SPI). This index measures the precipitation departure using the 1971 through 2000 average monthly totals. At this time the SPI is available for Wyoming, but there are concerns about the number of data points used to calculate the index as well as the accuracy of the data used. At this time the SPI is of limited use in Wyoming and should be used with caution.

Graph 3.3.4 – Percentage in Drought Category by Week



Source: http://www.wrds.uwyo.edu/sco/drought/droughttimeline.html Accessed 10/1/2013

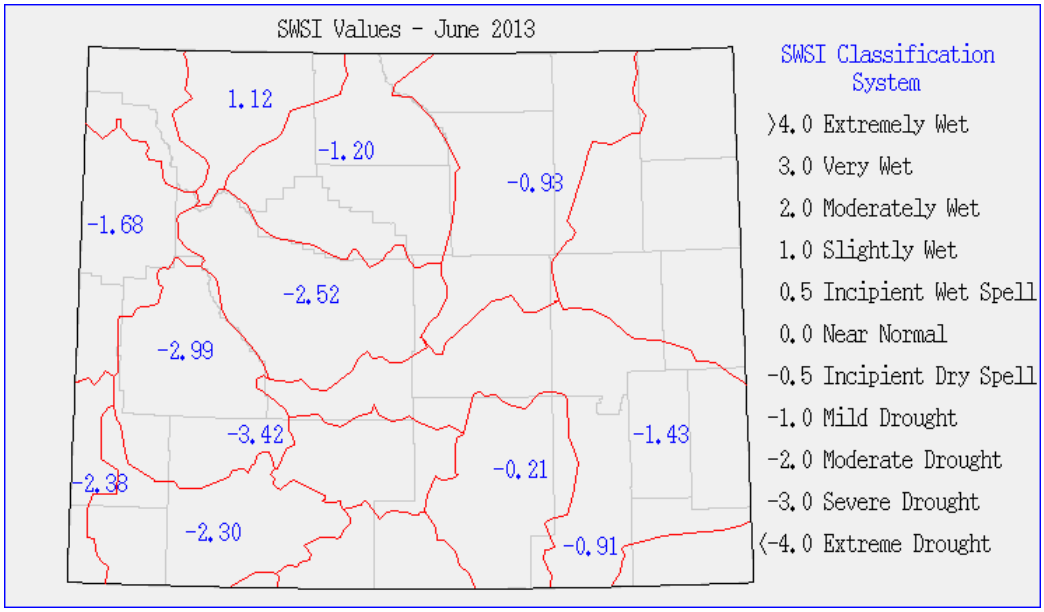
The Surface Water Supply Index (SWSI) was developed to complement the Palmer Index. The objective of the SWSI is to incorporate both hydrological and climatological features into a single index, and is intended to be an indicator of surface water conditions where mountain snowpack is a major component.

Four inputs are required for the SWSI: snow pack, stream flow, precipitation, and reservoir storage. Because it is dependent on the season, the SWSI is computed with only snow pack, precipitation, and reservoir in the winter months; stream flow replaces snow pack in the equation during the summer months. Like the Palmer Index, the SWSI is centered on zero and ranges from +4.2 to - 4.2, as shown in **Table 3.3.5** and in the map following.

Table 3.3.5 Surface Water Supply Index Classification System

Range	Scale
+3.0 to +4.0+	Extremely wet
+2.0 to +3.0	Moderately wet
+1.0 to +2.0	Slightly wet
-1.0 to +1.0	Near average
-2.0 to -1.0	Slightly dry
-3.0 to -2.0	Moderately dry
-3.0 to -4.0-	Extremely dry

Map 3.3.6 Wyoming Surface Water Supply Index June 2013

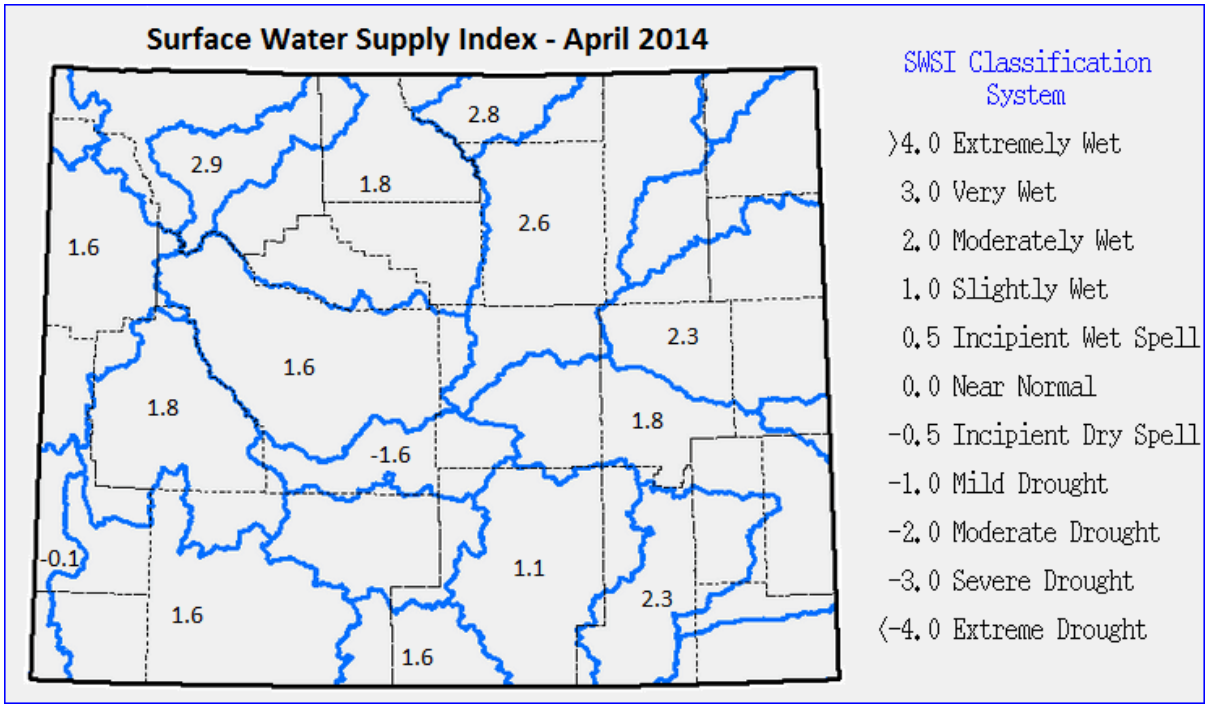


http://www.wrds.uwyo.edu/wrds/nrcs/swsimap/swsimap.html Accessed 8/29/2013

The Surface Water Supply Index (SWSI) is computed using only surface water supplies for the drainage. **(See maps 3.3.6 & 3.3.7)** The computation includes reservoir storage, if applicable, plus the forecast runoff. The index is purposely created to resemble the Palmer Drought Index, with normal conditions centered near zero. Adequate and excessive supply has a positive number and

deficit water supply has a negative values. Soil moisture and forecast precipitation are not considered as such, but the forecast runoff may consider these values. When comparing **Map 3.3.6** to **Map 3.3.7** you can see that one year can make a significant difference in surface water supply in Wyoming.

Map 3.3.7 - Wyoming Surface Water Supply Index April 2014



http://www.wrds.uwyo.edu/wrds/nrcs/swsimap/swsimap.html Accessed 4/16/2014

Another index used to measure drought involves soil moisture. This is a highly complex element that is difficult to accurately determine because there are few weather stations that directly measure surface and subsurface moisture and because precipitation and soil type are highly variable over a given region. Additionally, accuracy of direct measurement deteriorates when the soil temperature is below freezing. However, remote sensing from satellites can indicate the health of vegetation by measures of greenness, which can be used to indirectly determine soil moisture.

The final ingredients for determining drought are past accumulation and the amount of precipitation forecasted. In Wyoming, the April and May precipitation is critical for adequate prairie grassland growth. If the rains are late, the summer heat will reduce or completely eliminate any yield. Since rangeland is not normally irrigated, the short-term, spring weather forecast must be accurate to ensure the most effective management of these lands. Farmers who depend on irrigation will know if drought can be expected if the April 1 snow pack is below normal and if the reservoirs are below 80% of their long term average levels. Percent of capacity of reservoirs is not a good standard to use because every reservoir's water level varies widely from one another throughout the year due to different management practices and environmental conditions. For example, water quality and endangered species protection requires managers to maintain minimum downstream outflow. There are also large

inactive conservation reserves and dead water allocations in reservoirs that are part of total capacity but cannot be used in any way.

History

According to the Wyoming State Climate Office, Water Resources Data System Wyoming is the 5th driest state in the Union, and drought is a constant threat in our region. Since 1999, much of Wyoming has been gripped by moderate to severe drought. The intensity of this drought event has varied from year to year, and counties or regions within the state have experienced varying levels of drought impacts. However, this drought has been a significant event by any measure, and we will continue to feel its effects for years to come. Conditions have eased somewhat beginning in mid-2008, but a near decade with warm temperatures and relatively little precipitation has left us very vulnerable. [http://www.wrds.uwyo.edu/sco/drought/drought.html , Accessed August 30, 2013]

Longtime residents indicate they remember streams drying up in the 1930s and 1950s. According to instrument records, there have been only seven multi-year (three years or longer) statewide droughts since 1895 (**Table 3.3.8**), although single wet years like 1957 (and probably 2005) have broken longer periods of drought (1952-1964 and 1999-present) into two separate events by this definition, making quantification of impacts difficult. Based on statewide average annual precipitation each of the drought periods is ranked as follows:

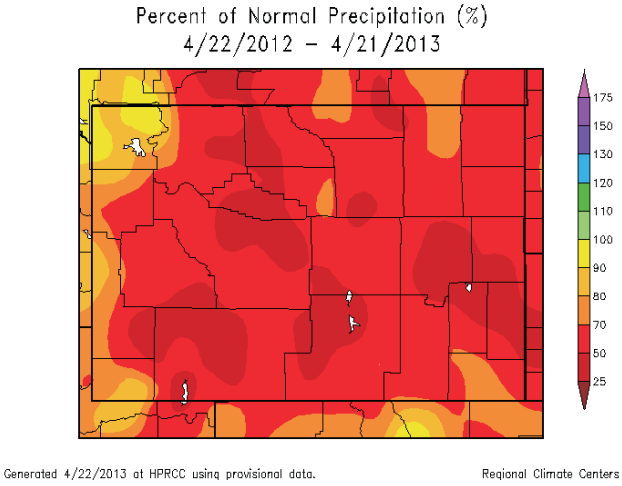
Table 3.3.8 – Recent Worst Multi-Year Statewide Drought

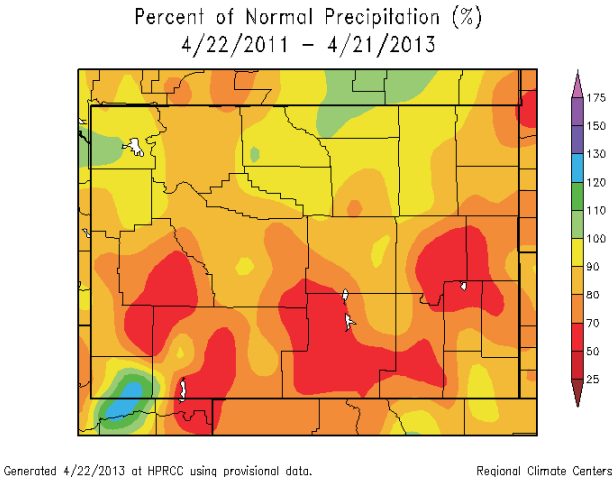
Drought Period	Average Annual Precipitation (Inches)	Percent of 1895-2006 Average Annual Precipitation (13.04")
1952-1956	10.65	81.69%
1900-1903	10.76	82.52%
1999-2004	11.07	84.89%
1987-1990	11.12	85.28%
1958-1964	11.67	89.49%
1974-1977	11.77	90.26%
1931-1936	11.79	90.41%

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

Below are two precipitation maps developed by the Wyoming Water Resources Data System [http://www.wrds.uwyo.edu] . The map on the left depicts precipitation received in the past 12

months as compared to normal levels of precipitation. As you can see, in the 12 months prior to April 2013 Wyoming received significantly less than normal moisture. The second map records the past 24 months' precipitation beginning in 2011 and compares them to normal levels. Wyoming moisture precipitation levels overall have significantly decreased over the 12 months prior to April 2013.





Pre-settlement Drought

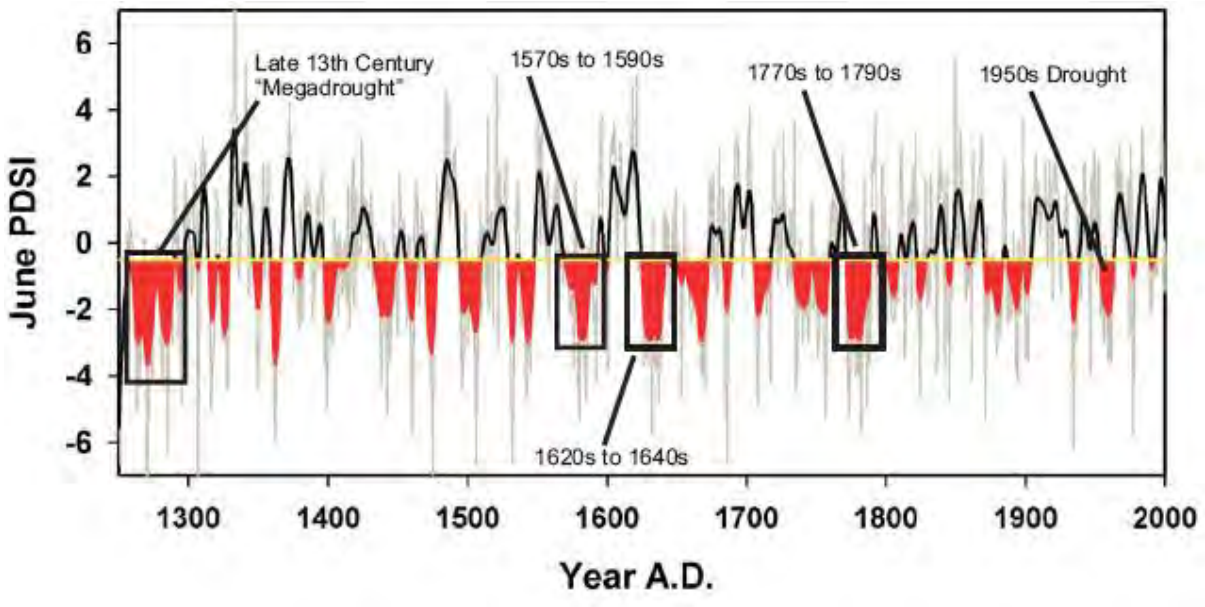
Numerous studies from throughout the world demonstrate that instrumental weather records are insufficient for capturing the full range of climate that the people in any region should expect and plan for. This is particularly true for understanding extreme events like droughts. The length of these instrumental records rarely exceeds 100 years and, therefore, provides only a small sample of single- and multi-year drought events. Furthermore, instrumental records cannot effectively be used to examine long-term (>50-year) trends and cycles that may underlie year-to-year precipitation variability.

Most trees in the western U.S. produce a single layer of growth called a "tree-ring" for each year of their lives. During years of favorable climate, trees will produce wide rings compared to the narrower rings formed in years of unfavorable climate. Tree-rings, therefore, provide a means for developing long-duration climate records that can overcome most of the limitations inherent to instrumental observations. Tree-rings yield continuous, exact-dated proxies of climate that are highly replicated. When properly analyzed, tree-rings provide records of seasonal to annual climate, and can be used to assess climate variability on time scales of decades to millennia.

While tree-rings have commonly been used to reconstruct the climate of the southwestern U.S., the systematic use of these dendrochronological (literally the "science of tree time") techniques to understand Wyoming's climate is relatively new. One recent study from the Bighorn Basin shows the promise of such methods for understanding drought in Wyoming. In this study, wood samples were collected from 95 Douglas fir, ponderosa pine, and limber pine trees at five sites in the Bighorn, Pryor, and Absaroka mountains (**Figure 3.3.9**). Samples from these trees were used to develop a record of annual precipitation spanning 1260 to 1998 A.D. Results from this study show that single-year dry events before the instrumental period (1895 to present) tended to be more severe than those

after 1900 (**Figure 3.3.9**). In general, multi-year dry events were longer and more severe prior to 1900. Dry events in the late-13th to mid-18th centuries surpass both the magnitude and duration of any droughts seen in the Bighorn Basin after 1900. The 14th, 15th, and 16th centuries are also notable for large numbers of droughts having greater magnitude and duration than any events in the instrumental period.

Figure 3.3.9 - Reconstructed annual precipitation (in centimeters) for the Bighorn Basin region.

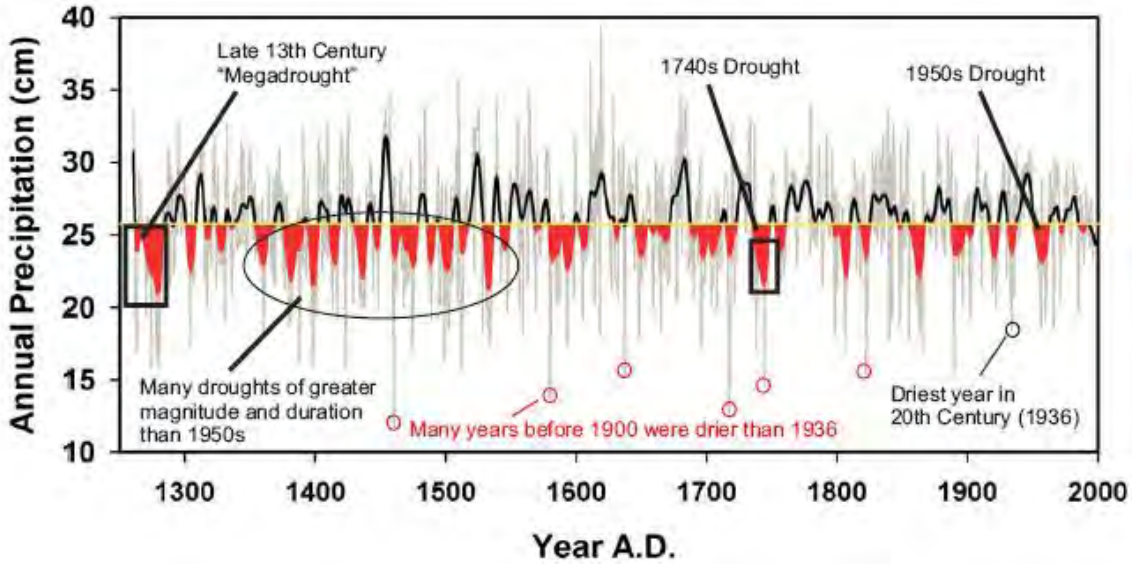


Annual values are shown in gray. The 10-year running average of precipitation is plotted against the long-term mean (yellow line) with multi-year droughts shown in red.

The 10-year running average of PDSI is plotted against the long term-mean (yellow line) with multi-year droughts shown in red.

Trees from the foothills of the northern Uinta Mountains and the southern Salt Range provide insights on drought variability in southwestern Wyoming. **Figure 3.3.10** shows reconstructed PDSI values for the Green River Basin region from 1250 to 2000 A.D. High PDSI values indicate wet conditions while negative values represent droughts. Estimates for PDSI values prior to the instrumental period (1895 to present) were derived from the measurement of limber pine and pinion pine tree-rings at four sites surrounding the basin. Samples from 102 trees (both living and dead) are included in the reconstruction.

Figure 3.3.10—Reconstructed (June) PDSI values for the Green River Basin region.



While the 20th Century dry-events recorded in these trees were quite severe, several droughts prior to instrumental period (*e.g.*, 1576 to 1590, 1620 to 1637, and 1773 to 1786) likely equaled or exceeded their duration. A number of pre-instrumental droughts, particularly those in the 1500s through mid 1600s, were of greater magnitude or severity than any dry events after the early 1900s. The late-13th Century is particularly notable for the occurrence of a severe 50-year drought.

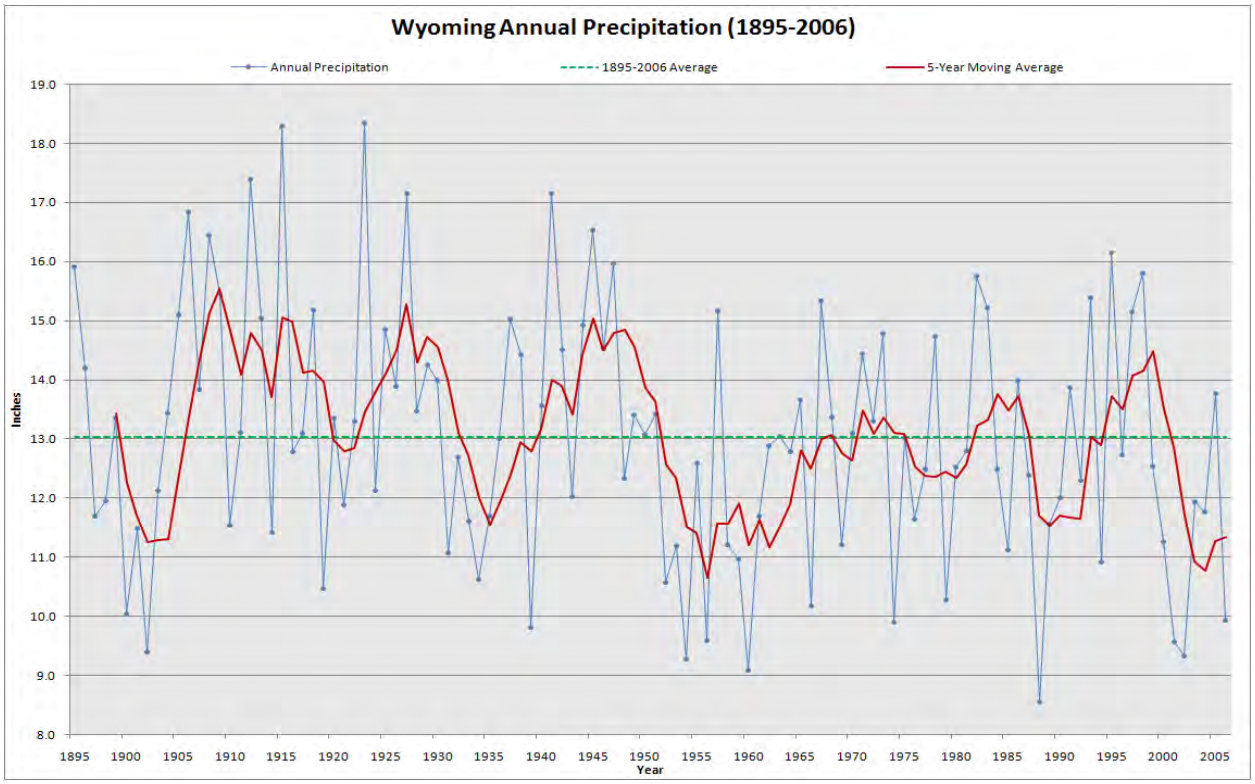
These and other tree-ring studies from throughout the region suggest that severe, long-duration (>10-year) droughts are a common feature of Wyoming's climate and the climate of the Rocky Mountain West at large. While the droughts of the 1930s and 1950s were extreme events in terms of their social and economic impacts on Wyoming, the tree-ring record shows that the climate system is capable of producing longer and stronger droughts. Moreover, in some areas (*i.e.*, southwest Wyoming), parts of the 20th Century were marked by wetter than average conditions. This means that predictions of future water availability based on stream gauge and instrumental weather observations during these years may be biased by abnormally high precipitation.

Overall, long dry spells are a normal part of life in Wyoming. This knowledge should, in turn, affect how we plan for Wyoming's economic and agricultural development. We must also incorporate this fact into our management of natural resources and include severe, sustained droughts in our plans for timber production, wildland and prescribed fires, non-native plant invasions, and water resources. Planning efforts should consider a wide range of climate scenarios, including droughts of different lengths, magnitudes, and intensities. Such scenarios may be derived from long-term proxies of climate variability such as those provided by tree-rings, but might also be obtained from model simulations of past and future climates. In any case, we must consider severe, sustained droughts to be an inevitable part of Wyoming's future.

Instrumentation Record

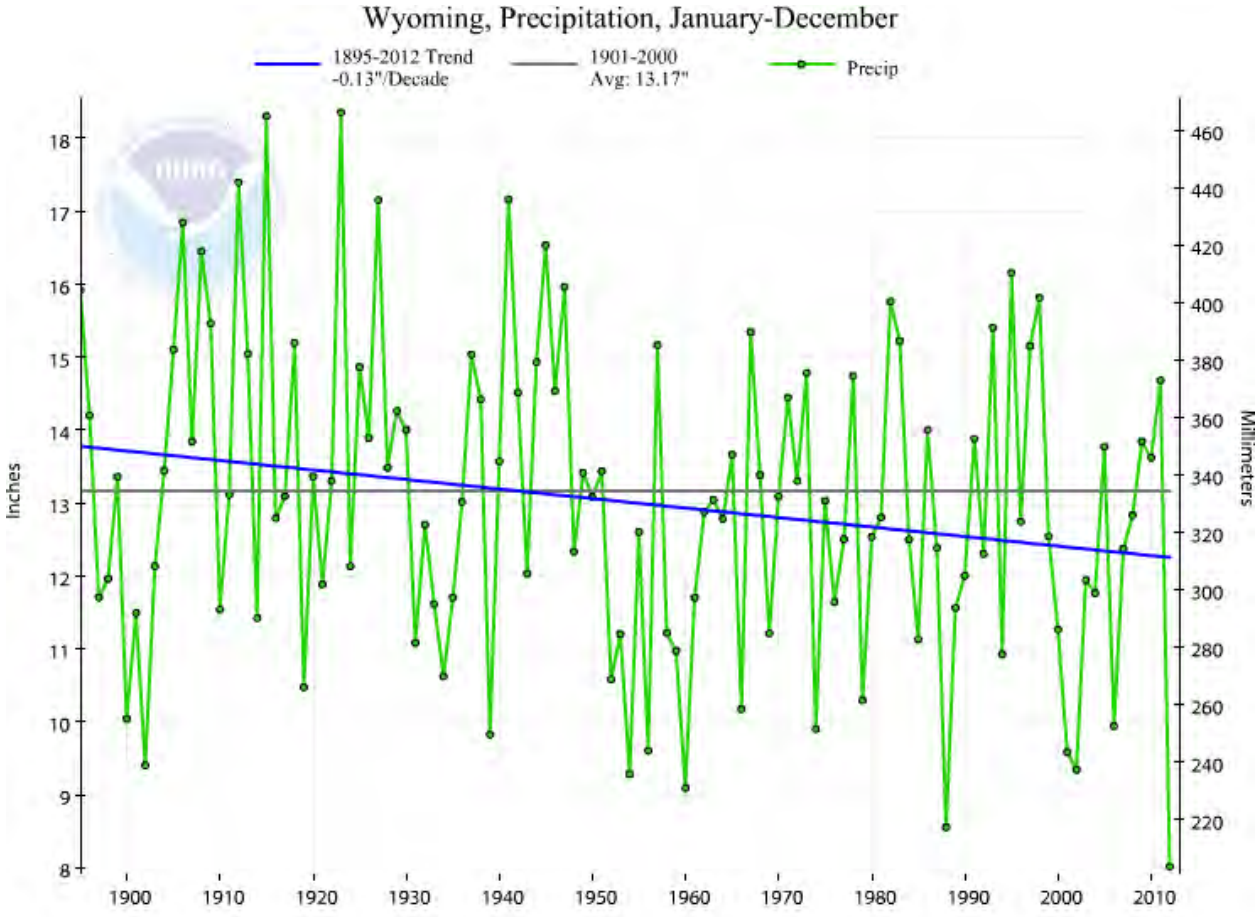
As a whole, Wyoming's precipitation record from 1895 to 2006 reveals that, for the first half of the 20th Century (except for the Dust Bowl years of the 1930s), there was generally a surplus of moisture. During the second half of the century there was a trend of increased periods of drought (**Figures 3.3.11 and 3.3.12**).

Figure 3.3.11 - Wyoming annual precipitation (1895 through 2006)



Data Source: National Climatic Data Center

Figure 3.3.12 – Wyoming Precipitation 1895 thru 2012

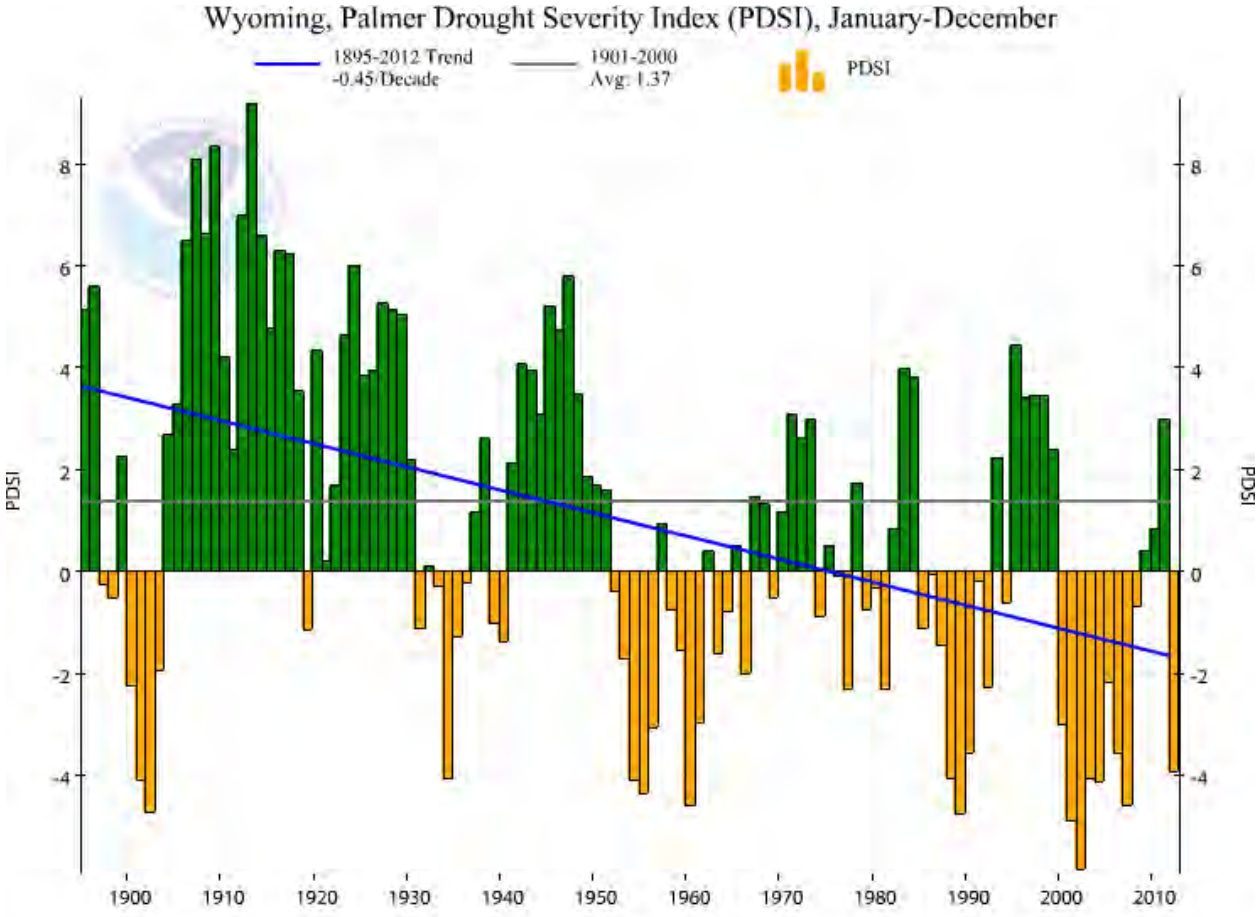


http://www.ncdc.noaa.gov/cag/time-series/us Accessed 8/30/2013

Impacts

Based upon **Figures 3.3.11** and **3.3.12**, the drought of 1999 to 2009 is as significant, if not more significant than any other drought in the last 100 years. **Table 3.3.8**, from the *Wyoming State Climate Office*, indicates that the most significant droughts in the last century, in terms of annual statewide precipitation averages, were in 1952 to 1956, 1900 to 1903, and 1999 to 2004. In order to determine which drought period had the most significant impact on Wyoming, crop production and livestock inventory data for the 1952 to 1956 and 1999 to 2004 periods were compared. 1957 and 2005 were wetter years, with annual statewide precipitation totals above the 1895-2006 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, for the most recent drought impacts were also calculated for 2005 and 2006, and are included in summary tables.

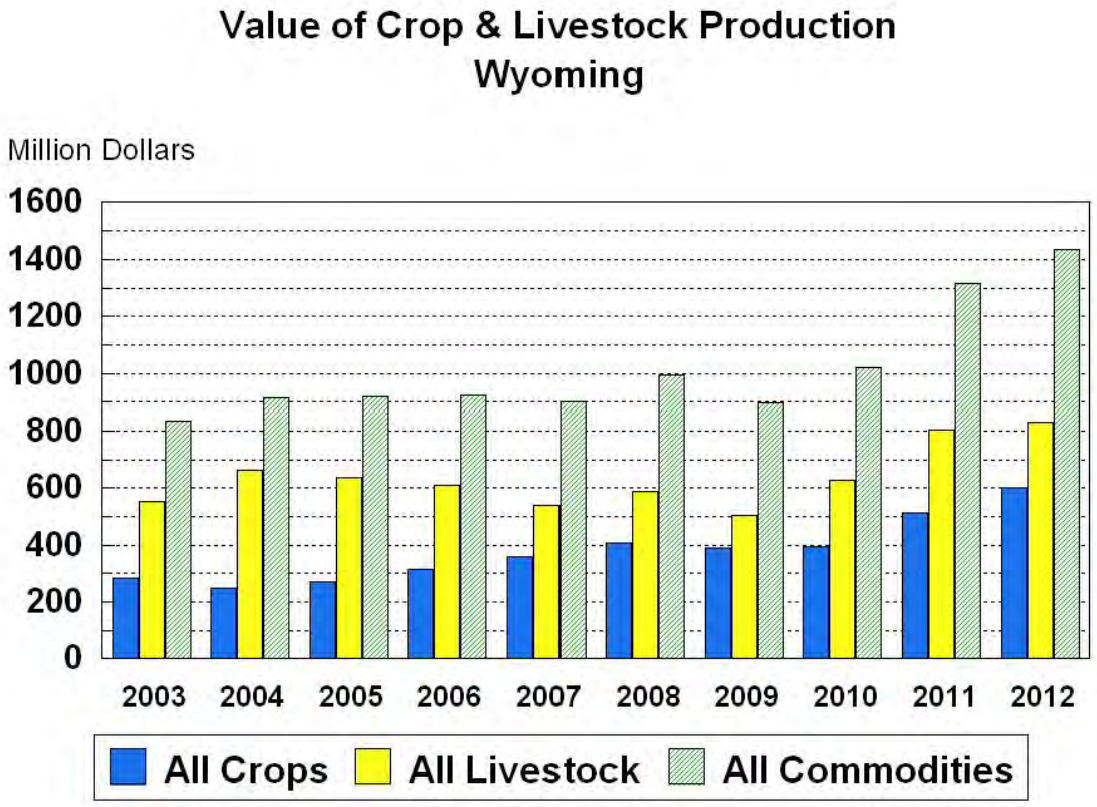
Graph 3.3.12 – Palmer Drought Severity Index 1985 through 2013



http://www.ncdc.noaa.gov/cag Accessed 8/30/2013

Since the last update to the plan, precipitation improved briefly (**Graph 3.3.13**). The improvement in precipitation was immediately reflected in the value of Wyoming's crop and livestock production (bar graph below).

Graph 3.3.13 – Crop & Livestock Value



http://www.nass.usda.gov/Statistics_by_State/Wyoming/Publications/Farm_Numbers_and_Economic_Data/bull-29.pdf Accessed August 30, 2013

Probability of Drought

Likely = 3
50 Drought Years Reported ÷ 117 years = 43 % annual probability of drought

Drought Risk Factor

Drought Risk Factor Value = 2.66 [(Probability Likely: 3 x .30) + (Limited Impact: 2 x .30) + (Large Spatial Extent: 4 x .20) + (More than 24 hrs Warning Time: 1 x .10) + (More than 1 Week Duration: 4 x .10)]

Local Mitigation Plan Risk Assessments

A review of local mitigation plans reflects they recognize the hazard drought represents within their borders. Most of Wyoming's local multi-hazard mitigation plans reflect much of the information contained in the state plan. It can be noted those counties with a greater agricultural economic base have a greater recognition of the economic impact drought has on their communities. Additionally, they have ranked drought risk within their borders based on the population impacted, probability of occurrence within their borders and the property impacted.

Below is a table outlining information mined from the local plans' drought hazard sections. The table shows previous historical incidents of drought within each county's borders as outlined in their plans and extrapolates, based on population impacted, probability of occurrence within their borders, and property impacted, the risk perceived by each county relative to dam failure hazards. You will note all but four counties consider drought to rank as a 'high' hazard within their borders. This may also be because of the frequency drought is experienced within Wyoming counties and the rural, agricultural nature of many of Wyoming's counties.

Table 3.3.14 – Local Risk Determination – Drought

COUNTY	Plan Y/N	Year Approved	Included in Plan	Rank-High, Medium, Low	Loss Potential	Previous Incident(s)
ALBANY	Y	2010	Y	High	$769.6 million	Y/Multiple
BIG HORN	Y	2011	Y	High	Agricultural-Insurance Cov'd	Y/Multiple
CAMPBELL	Y	2011	Y	Medium	$27.7 million-quoted from State Plan	Y/Multiple
CARBON	Y	2009	Y	High	$45.8 million	Y/Multiple
CONVERSE	Y	2012	Y	High		Y/Multiple
CROOK	Update Under Review	2013	Y	High	State-level Info from State Plan	Y/Multiple

COUNTY	Plan Y/N	Year Approved	Included in Plan	Rank-High, Medium, Low	Loss Potential	Previous Incident(s)
FREMONT	Y	2012	Y	High	State-level Info from State Plan	Y/Multiple
GOSHEN	Expired	2007	Y	High	$13 million	Y/Multiple
HOT SPRINGS	N					
JOHNSON	Update Under Review	2013	Y	Medium		Y/Multiple
LARAMIE	Y	2013	Y	High	$11.75 million	Y/Multiple
LINCOLN	Expired	2007	Y	High	$23 million	Y/Multiple
NATRONA	Y	2011	Y	Medium-Low	Low	Frequent
NIOBRARA	Y	2010	Y	High	historic-$1.9 million	Y/Multiple
PARK	Y	2011	Y	High	$63.25 million	Y/Multiple
PLATTE	Expired	2004	Y	Medium-Low	Incomplete Information	Y/Multiple
SHERIDAN	Y	2009	Y	High	$14.7 million	Y/Multiple
SUBLETTE	Expired	2008	Y	High	$28.27 million	Y/Multiple
SWEETWATER	N					
TETON	Y	2010	Y	High	$23.7 million	Y/Multiple
UINTA	Y	2011	Y		Not Stated	Y/Multiple
WASHAKIE	Y	2011	Y	High	$20.78 million	Y/Multiple
WESTON	N					
NORTHERN ARAPAHO TRIBE	N					
EASTERN SHOSHONE TRIBE	N					

Table 3.3.14 – State Mitigation Strategy: Drought

Educate residents on water saving techniques & encourage water-saving techniques as a lifestyle	Ongoing activity
Maintain drought emergency plan	Ongoing activity. State drought plan is in place.
Monitor water supply	Ongoing local & state-level activity
Encourage drought tolerant landscaping	Ongoing activity
Educate agricultural community on crop insurance and education programs encompassing	Ongoing activity

multi-hazard insurance for business, resident and government application	
Develop reseeding plans for losses due to all hazard events.	Removed. Recovery activity.
Seek additional opportunities for water storage	Remains on the list.
Improve monitoring of drought conditions	Ongoing activity through NOAA, local weather reporting, and Snowtel locations around the state
Deployment of solar powered well pumps in drought ridden areas.	Low priority activity
Water conservation projects	Ongoing activity
Weather mitigation modification (cloud seeding expanded research)	Removed.
Education programs encompassing multi-hazard mitigation for business, resident and government application	Ongoing activity

3.4 Earthquake

The American Heritage Dictionary defines an earthquake as "a sudden movement of the earth's crust caused by the release of stress accumulated along geologic faults or by volcanic activity." [http://www.thefreedictionary.com/earthquake Accessed 10/25/2013] 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.

Earthquakes are common in Wyoming and are likely to continue to occur in Wyoming into the future. Official earthquake records have been kept for only the past 140 years. In that time some 47,000 earthquakes have been recorded in Wyoming. Only a small percentage of those have been felt by people. Historically, earthquakes have occurred in every county in Wyoming (**Map 3.4.6** shows those 5.0 magnitude or greater). Most Wyoming earthquakes occur in the western third of the state.

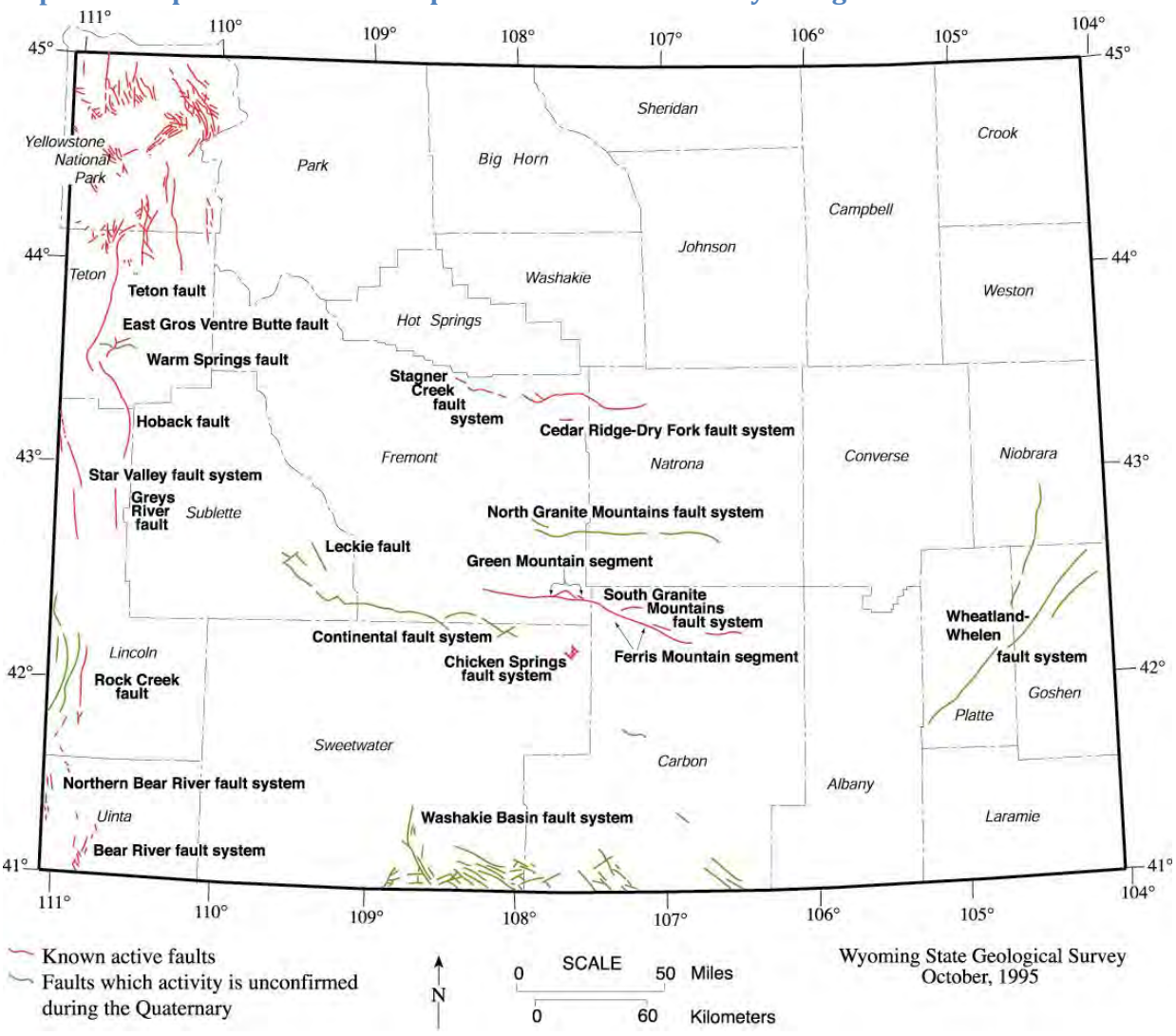
The first reported earthquake occurred in Yellowstone National Park in July of 1871 (Case and Green, 2000). The first earthquake known to originate in Wyoming occurred on June 25, 1894, near Casper. The 1894 earthquake near Casper caused dishes to fall to the floor and a number of people were thrown from their beds (http://earthquake.usgs.gov/earthquakes/states/wyoming/history.php, accessed 10/8/2013). The largest earthquake recorded to date in Wyoming happened on August 18th, 1959 in Yellowstone National Park. It registered as a magnitude 6.5 temblor and is considered to be an aftershock of the Ms 7.5 Hegben Lake, Montana Earthquake (Stover, 1993). Yellowstone National Park is one of the more seismically active areas in the United States, and the vast majority of earthquakes in Wyoming occur there.

Wyoming's Earthquake Sources

Most Wyoming earthquakes outside of Yellowstone National Park occur as a result of movement on faults. If the fault has moved within the Quaternary Period, or last 1.6 million years, the fault is considered to have a greater potential to be the source of future large earthquakes (Machette, 2004). Quaternary faults that show movement over the past 10,000 years are considered to be "active." Of the approximately 80 Quaternary faults in Wyoming (**Map 3.4.1**), 26 are considered to be "active." The best known "active" fault in Wyoming is the Teton fault near Jackson.

Active faults can be exposed at the surface (**Map 3.4.1**) or deeply buried with no significant surface expression. Historically, no Wyoming earthquakes have been associated with exposed active faults. In general, the exposed active faults, however, have the potential to generate the largest earthquakes. As a result it is important to understand both exposed and buried active faults in order to generate a realistic seismological characterization of the state.

Map 3.4.1 - Exposed Known or Suspected Active Faults in Wyoming



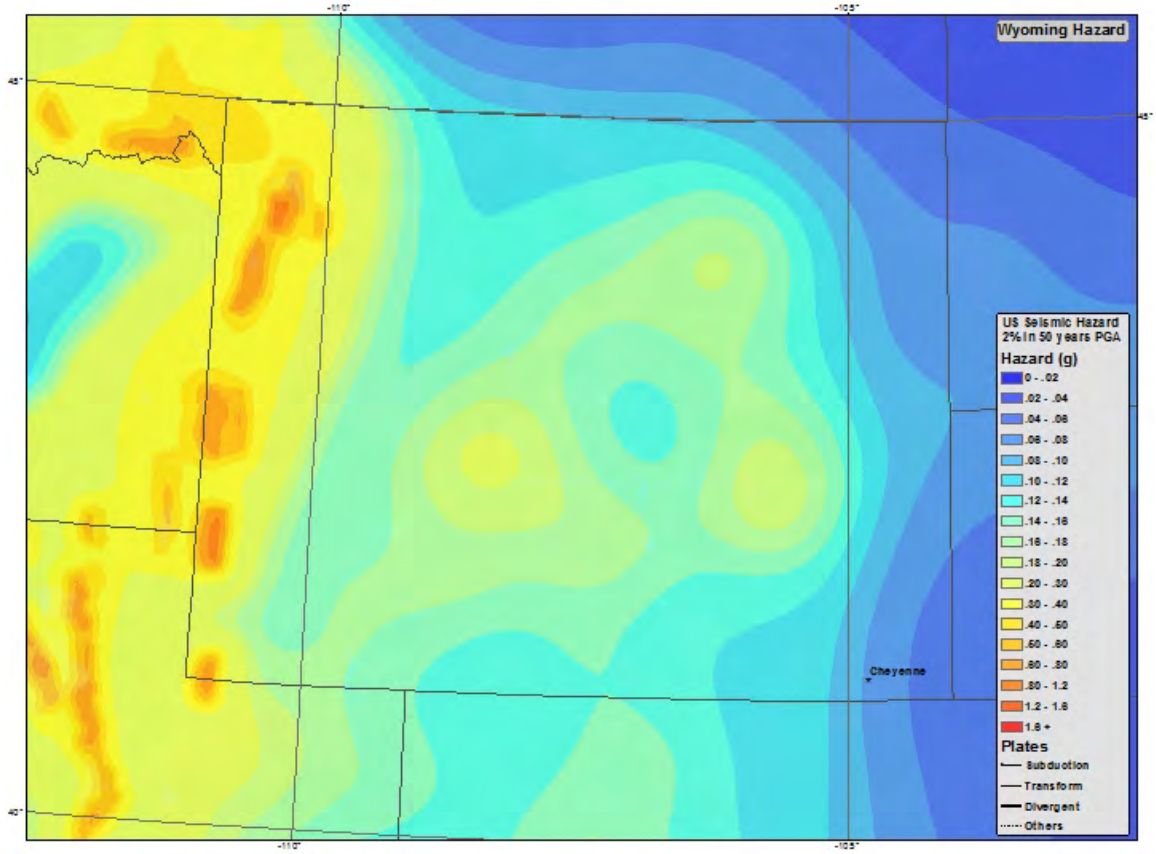
Many of the exposed active faults, including the Teton fault, Star Valley fault, Greys River fault, Rock Creek fault, and the Bear River fault system in western Wyoming are capable of generating magnitude 7.0 to 7.5 earthquakes, and are considered to be overdue for reactivation.

In central Wyoming, the Stagner Creek fault system near Boysen Reservoir and the South Granite Mountain fault system near Jeffrey City, are both capable of generating magnitude 6.5 to 6.75 earthquakes. The Cedar Ridge-Dry Fork fault system near Lysite has limited evidence indicating it may be active, and may be capable of a magnitude 6.7 to 7.1 earthquake. The Chicken Springs fault system near Bairoil is capable of generating magnitude 6.5 to 6.7 earthquakes.

Historically, Wyoming's earthquakes are tied to faults that are buried. Buried faults that have never broken the surface, are generally considered to be capable of generating up to magnitude 6.5 earthquakes. Since the distribution of the buried faults is not well known, it is assumed that

earthquakes up to magnitude 6.5 can occur anywhere in the state. The probability of such an earthquake is lowest in the southeast and northeast corners of the state, although a magnitude 6.2 to 6.6 earthquake did occur in 1882 between Laramie and Estes Park, Colorado.

Map 3.4.2—2500-Year Probabilistic Acceleration Map of Wyoming



http://earthquake.usgs.gov/earthquakes/states/wyoming/hazards.php Accessed 10/14/2013

Earthquakes in Wyoming have also been associated with mine-related activities. In the early to mid-1900s, there were seismic events associated with coal mines beneath Rock Springs and Reliance in Sweetwater County. In many cases there was uncertainty as to whether a mine collapse generated a seismic event or whether an earthquake caused a mine collapse. In 1995, the collapse of a part of the Solvay trona mine near Green River generated a magnitude 5.3 earthquake. There have been numerous other mine-related events in Sweetwater County that have generated small earthquakes.

A dynamic magma chamber beneath Yellowstone National Park, combined with regional tectonic forces, results in significant seismic activity. Many of the earthquakes are associated with movement of hydrothermal fluids in the subsurface. Some deeper earthquakes may be related to fluids within or around the magma chamber. Earthquakes which may be related to active faults also occur in the park. Yellowstone is a super-volcano, and it has explosively erupted 0.64 million, 1.3 million, and 2.1

million years ago. The explosive eruptions led to the formation of three giant calderas, the collapse of which led to the formation of faults. In addition, after major eruptions, resurgent domes formed within the calderas. The doming process led to the formation of other faults. As a result, many of the faults in Yellowstone are not considered major threats. There are other faults, however, that are easily capable of generating magnitude 6.5+ earthquakes.

The August 17,1959 Hebgen Lake-Red Canyon earthquake sequence, (magnitude 7.5, intensity X) occurred just west of Yellowstone National Park, near Hebgen Lake, Montana and was the largest ewarthquake in the U.S. intermountain region in historic time.. That earthquake is a model for the type of earthquakes that can occur in western Wyoming. Even though Wyoming has not experienced a magnitude 7.5 earthquake within its borders in the last 140 years, the potential does exist.

Wyoming has experienced two significant earthquake swarms in Yellowstone Park in recent years. The first occurred between December 2008 and January 2009. (http://volcanoes.usgs.gov/volcanoes/yellowstone/yellowstone_monitoring_53.html, accessed 10/8/2013) 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. (http://volcanoes.usgs.gov/yvo/publications/2010/10swarm.php, accessed 10/8/2013) 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.

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. (http://earthquake.usgs.gov/earthquakes/eventpage/usb000jx4l#dyfi, accessed 10/8/2013)

Earthquake Loss Estimates Scenarios – January 2011

Earthquake activity in Wyoming has prompted the Wyoming State Geological Survey to undertake a study modeling loss estimations for 16 earthquake scenarios. 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.

The Wyoming Geological Survey also included 12 fault-based scenarios in their study, based on the information in the table below:

Table- 3.4.3 Fault Based Earthquake Scenarios

Quaternary fault	*Scenario magnitude*
Bear River fault system	6.9
Chicken Springs fault system	6.5
Eagle Bay fault system	6.8
East Mount Sheridan fault system	6.4
Grand Valley fault system	7.1
Greys River fault	7.1
Hoback fault	6.6
Rock Creek fault	7.0
South Granite fault system	6.8
Stagner Creek fault system	6.8
Teton fault	7.2
Upper Yellowstone fault system	6.5

The fault-based scenarios were run using two methods. Three of the fault based scenarios, the South Granite Mountain fault system, the Stagner Creek fault system, and the Chicken Springs fault system, used WSGS soil maps and default HAZUS-MH® models to provide loss estimates. The remaining nine faults were run with the help of the U. S. Geological Survey (USGS). The USGS provided shakemaps, which model ground shaking parameters on the basis of complex attenuation functions.

The random event scenarios are based on historic events, and although the data provided is beneficial, the odds of an earthquake happening in the exact location of each scenario are extremely low. On the other hand the fault based scenarios are based on faults that have been deemed potential sources of earthquakes. It is impossible to say when an earthquake can occur, but fault sources point to where large destructive earthquakes would happen. This study is not all-inclusive, but does provide valuable information for planning purposes. Scenario regions cover only those areas that would experience potentially damaging modeled ground motions (> 3.5%g). Areas outside the region boundaries would undoubtedly experience shaking from the earthquake; but structural damage would not be expected. [Wyoming Geological Survey, "Wyoming Earthquake Hazard and Risk Analysis: HAZUS-MH Loss Estimations for 16 Earthquake Scenarios", p. 4-5]

The HAZUS-MH, scenario-based study has been published and is available to emergency managers around the state and to the public by accessing a web site hosted by the Wyoming Geological Survey (http://ims.wsgs.uwyo.edu/hazus/Default.aspx, (Confirmed 10/14/2013). The report is incorporated into this plan through reference.

The Wyoming Earthquake Hazard and Risk Analysis: HAZUS-MH Loss Estimations for 16 Earthquake Scenarios includes 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 information provided in the report allows for more informed exercising of responses and more complete, concrete information for proposed earthquake mitigation projects undertaken both locally and statewide.

The map below (**Map 3.4.4**) 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. The attached table shows losses by scenario and by county. This helps compare scenario impacts at the State level and highlight the relative severity of each of these across the state.

The map is followed by a **Table 3.4.5** which summarizes county economic losses in the scenarios.

Map 3.4.4 – Earthquake Scenario Epicenters

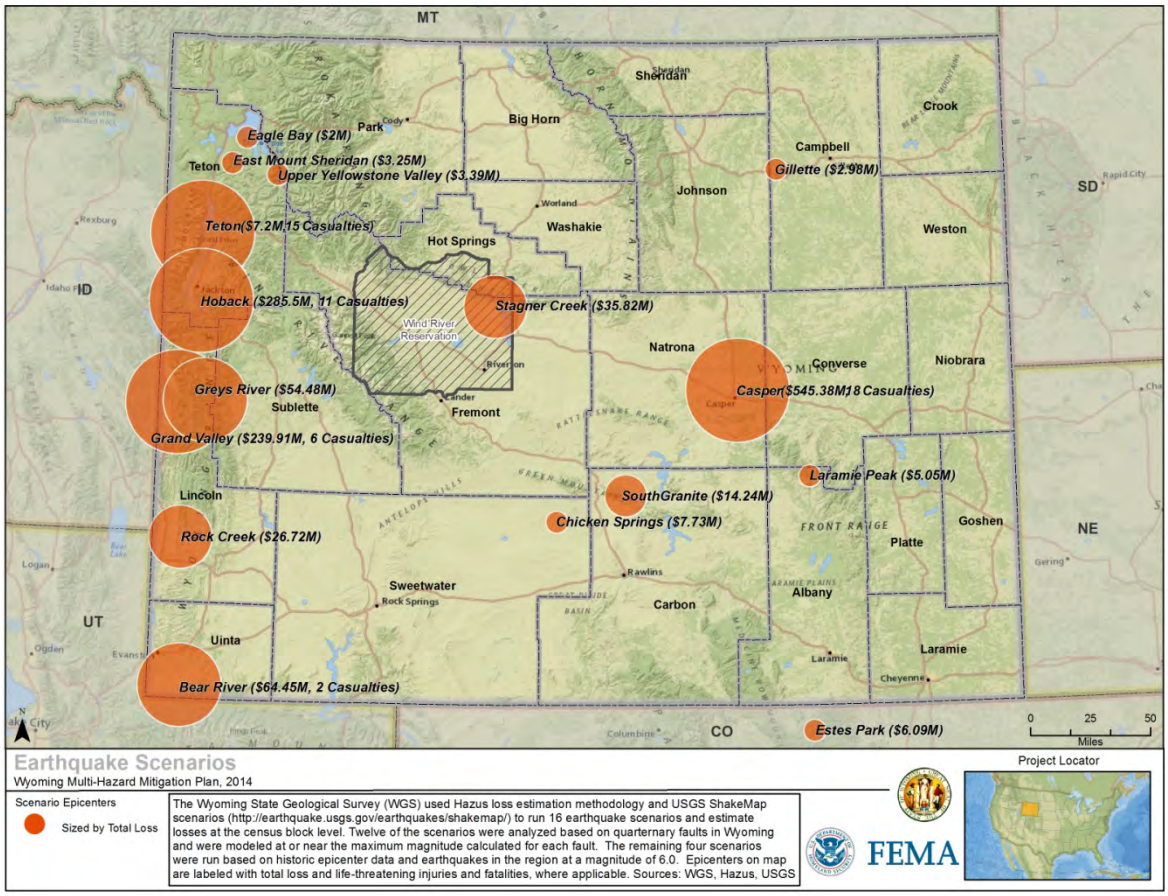


Table 3.4.5 - WGS Earthquake Scenario Summary (values in thousands)

	Bear River	Casper	Chicken Springs	Eagle Bay	East Mt. Sheridan	Estes Park	Gillette	Grand Valley*	Greys River*	Hoback	Laramie Peak	Rock Creek	South Granite	Stagner Creek	Teton	Upper Yellowstone Valley	County Totals
Teton				$1,743	$3,216				$545	$284,123					$370,007	$3,304	$662,938
Natrona		$544,446	$85				$ 1				$2,255		$2,992				$549,779
Lincoln	$$64,447							$239,910	$52,846	$ 1,085		$26,706			$304		$385,298
Fremont			$771		$ 12								$ 115	$16,805	$709	$ 5	$ 18,417
Hot Springs														$17,195			$ 17,195
Carbon		$ 6	$3,320			$ 9					$ 33		$ 8,520				$ 11,888
Sweetwater	$ 1		$3,561									$ 1	$2,618				$ 6,181
Albany		$1				$4,985					$ 357						$ 5,343
Converse		$ 909					$2				$2,258						$ 3,169
Campbell		$3					$2,347										$ 2,350
Washakie														$1,812			$ 1,812
Sublette									$ 1,090	$ 291		$ 6			$230		$ 1,617
Laramie						$1,092											$ 1,092
Park				$261	$ 29									$ 6	$1	$87	$ 384
Johnson		$ 13					$265										$ 278

	Bear River	Casper	Chicken Springs	Eagle Bay	East Mt. Sheridan	Estes Park	Gillette	Grand Valley*	Greys River*	Hoback	Laramie Peak	Rock Creek	South Granite	Stagner Creek	Teton	Upper Yellowstone Valley	County Totals
Platte						$ 1					$ 151						$ 152
Sheridan							$ 54										$ 54
Uinta												$ 8					$ 8
Big Horn																	$ -
Crook																	$ -
Goshen																	$ -
Niobrara																	$ -
Weston																	$ -
Totals	$64,448	$545,378	$7,737	$2,004	$3,257	$6,087	$2,669	$239,910	$54,481	$285,499	$5,054	$26,721	$14,245	$35,818	$371,251	$3,396	

*'Direct Economic Losses for Buildings' report was not available for Grand Valley and Greys River scenarios. Total scenario loss estimate was therefore attributed to counties based on percent of buildings

Earthquakes have many attributes, with magnitudes and intensities being the most common. Magnitudes are instrumentally determined measures of the amount of energy released during an earthquake. Each step increase in magnitude is roughly equivalent to a release of 32 times more energy. Intensities are a subjective measure of how an earthquake was felt. As a result, an earthquake with a single magnitude can have variable intensity associated with it, depending on the distance an observer is from the earthquake source and the response of surficial features. An abbreviated intensity scale is presented in **Table 3.4.6**.

Table 3.4.6 Abridged Modified Mercalli Intensity Scale

Intensity	Intensity description
I	Not felt except by a very few under especially favorable circumstances.
II	Felt only by a few persons at rest on upper floors of buildings. Delicately suspended objects may swing.
III	Felt noticeably indoors, especially on upper floors. Standing automobiles rock slightly. Vibration like passing truck.
IV	During the day felt indoors by many, outdoors by few. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing automobiles rocked noticeably.
V	Felt by nearly everyone, many awakened. Some dishes and windows broken; cracked plaster in a few places; unstable objects overturned. Pendulum clocks may stop.
VI	Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster and damaged chimneys. Damage slight.
VII	Everybody runs outdoors. Damage minor in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built structures; some chimneys broken. Noticed by persons driving cars.
VIII	Damage slight in specially designed structures; considerable in ordinary buildings with partial collapse; great in poorly built structures. Chimneys and walls fall. Heavy furniture overturned. Well water changes. Persons driving cars disturbed.
IX	Damage considerable in specially designed structures; frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud.
XI	Few (masonry) structures remain. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
XII	Damage total. Waves seen on ground surface. Lines of sight and level distorted. Objects thrown into the air.

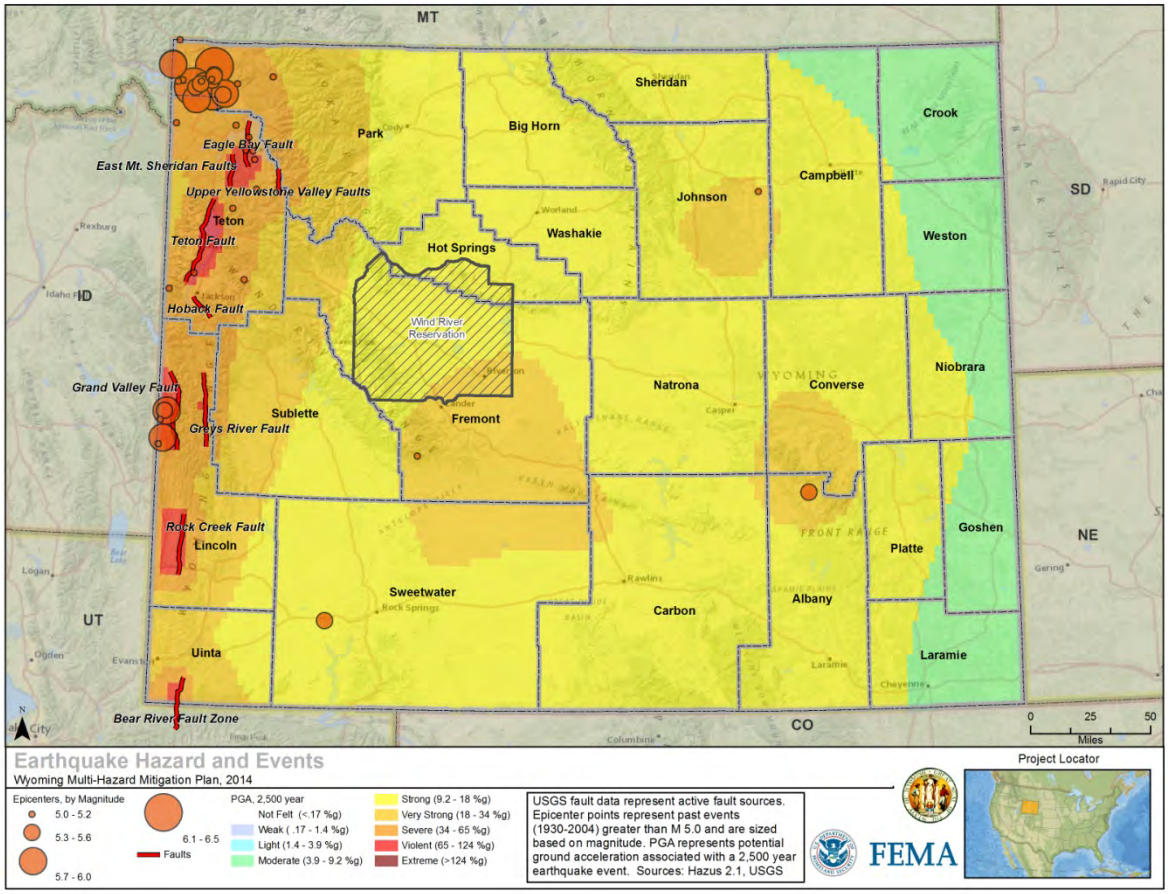
Minor structural damage or damage to objects on walls or shelves does not typically occur until intensity V is reached. It is more difficult to determine at what magnitude damage may occur, as the orientation of a fault plane, the depth of the rupture on the fault, the bedrock, and surficial sediments all affect the transmission and attenuation of seismic waves.

History

A detailed description of Wyoming's seismological characterizations by county can be found on a website at http://www.wrds.uwyo.edu/wrds/wsgs/hazards/quakes/seischar/seischar.html (confirmed 10/8/2013). The earthquake history of Wyoming is only 140 years, with earthquakes recorded only beginning in 1882. Within the 130-year record, there are gaps for the late 19th Century and first half of the 20th Century. After the Hebgen Lake earthquake in 1959, however, monitoring in Wyoming started to improve. Prior to the 1950s, most earthquakes were detected and located by personal reports. Since the 1950s, earthquakes are more commonly located by seismometers.

Every county in Wyoming has experienced an earthquake. Those of magnitude 5.0 or greater are reflected on **Map 3.4.7** below.

Map 3.4.7 - Wyoming Seismicity 1930 – 2004, Magnitude 5.0 and Greater



An attenuated seismic history of Wyoming, including earthquakes with intensities of V or greater, magnitudes of 5.0 or greater, or earthquakes with smaller assigned intensities or magnitudes that did cause some type of damage is presented in **Appendix I**.

Probability of Earthquake

Likely = Value 3
91 earthquakes ÷ 131 years = 1 earthquake (Magnitude 5 or greater) every 1.44 years or a 69.4% annual probability of a damaging earthquake

Earthquake Risk Factor

Earthquake Risk Factor Value = 2.89 [(Probability: Likely 3 x .30) + (Impact: 3 x .30) + (Spatial Extent: 3 x .20) + (Warning Time: 4 x .10) + (Duration: 2 x .10)]

Earthquake Potential

The earthquake history referenced above does not give a complete picture of the earthquake potential in Wyoming. As mentioned previously, the history incorporates only 140 years, and cannot reflect all possible earthquakes or earthquake sources in Wyoming. The exposed active faults mentioned above have all been modeled to determine what effects they may have on the areas around them if they reactivate. A detailed analysis of the potential effects of the faults can be obtained at http://www.wrds.uwyo.edu/wrds/wsgs/hazards/quakes/seischar/seischar.html (confirmed 10/16/2013).

One of the primary tools used in modeling the effects of earthquakes on regions or states are probabilistic acceleration maps generated by the U.S. Geological Survey (USGS). The USGS publishes probabilistic acceleration maps for 500-, 1000-, and 2500-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. This example is similar in principle to a 500 year flood.

The USGS recently generated new probabilistic acceleration maps for Wyoming. The maps are for 500-year (10% probability of exceedance in 50 years), 1000-year (5% probability of exceedance in 50 years), and 2500-year (2% probability of exceedance in 50 years) periods. Until recently, the 500-year map was often used for planning purposes for average structures, and was the basis of the most current Uniform Building Code. The International Building Code uses a 2500-year map as the basis for building design. The 2500-year map was updated in 2008 and is shown in **Map 3.4.2**. The 2500-year map below reflects current perceptions on seismicity in Wyoming. The USGS is updating seismic hazard maps for the conterminous U.S. which are expected to be released in early 2014. In many areas of Wyoming, ground accelerations shown on the USGS maps may be increased due to local soil composition. 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. Intensity values can be found in **Table 3.4.6**.

A comparison between the 2500-year probabilistic acceleration map (**Map 3.4.2**) and the intensity chart (**Table 3.4.6**) indicates the largest intensity earthquake expected in Wyoming could be Intensity IX. The Jackson area, Star Valley and parts of Uinta County could experience an Intensity VIII to IX earthquake. Portions of central Wyoming could have earthquakes with intensities as great as VII.

2500-yr Probabilistic Earthquake Scenario

HAZUS 2.1 was used to develop losses associated with a 2,500 year probabilistic earthquake scenario for 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. Total losses include building, contents, inventory, and income-related losses. Attached is the scenario Global Summary Report PDF that describes WY building and lifeline inventory, earthquake scenario parameters, and estimated damages and impacts.

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 2am, 2pm, and 5pm 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.

Table 3.4.8 – 2500-year Probabilistic Earthquake Scenario Losses

				Casualties			
Rank	**County**	**Total Loss ($M)**	**Loss Ratio**	*Level 1*	*Level 2*	*Level 3*	*Level 4*
1	Teton	$641.1	27%	150-300	40-90	0-20	10-30
2	Lincoln	$517.4	63%	190-220	50-60	0-20	10-20
3	Natrona	$262.4	11%	50-60	10	0	0
4	Uinta	$241.9	18%	90-120	20-30	0-10	0-10
5	Sweetwater	$177.7	19%	50	10	0	0
6	Fremont	$112.3	25%	20	0	0	0
7	Laramie	$103.1	4%	20	0	0	0
8	Sheridan	$82.7	9%	20	0	0	0

				Casualties			
Rank	**County**	**Total Loss ($M)**	**Loss Ratio**	*Level 1*	*Level 2*	*Level 3*	*Level 4*
9	Albany	$79.1	21%	20	0	0	0
10	Campbell	$77.0	14%	20	0	0	0
11	Park	$77.0	1%	10-20	0	0	0
12	Sublette	$72.3	6%	20	0-10	0	0
13	Carbon	$63.2	1%	10	0	0	0
14	Converse	$49.2	28%	10	0	0	0
15	Washakie	$27.5	1%	10	0	0	0
16	Big Horn	$25.9	4%	0-10	0	0	0
17	Johnson	$24.9	1%	0-10	0	0	0
18	Platte	$19.8	3%	0	0	0	0
19	Hot Springs	$19.6	1%	0	0	0	0
20	Goshen	$10.6	1%	0	0	0	0
21	Weston	$6.4	0%	0	0	0	0
22	Crook	$4.6	1%	0	0	0	0
23	Niobrara	$4.0	1%	0	0	0	0
		$2,700					

The tables below (**Tables 3.4.9**) show local critical facilities most at risk to the 2500-yr probabilistic earthquake scenario in the following categories: schools, care facilities, police stations, and fire stations. HAZUS determines critical facility damage states on a site-specific basis (i.e., ground motion parameters are computed at the location of the facility) and the purpose is to estimate the expected loss of functionality for each facility. Top 25 facilities at risk for each critical facility type were pulled from HAZUS results based on lowest percentage of functionality on day 1 after the modeled earthquake. Each list includes the name, address, county and the percentages of functionality on days 1 and 14 after the earthquake.

Tables 3.4.9 - Top 25 at Risk to 2,500-yr Earthquake Scenario

Schools (Sorted by lowest to highest functionality on day 1 after earthquake)

					% of Functionality	
Name	**Address**	**City**	**County**	**Number of Students**	**On Day 1**	**On Day 14**
SWIFT CREEK LEARNING CENTER	222 EAST 4TH AVENUE	AFTON	Lincoln	772	2%	8%
OSMOND ELEMENTARY	3120 STATE HIGHWAY 241	AFTON	Lincoln	287	2%	8%
STAR VALLEY HIGH SCHOOL	445 WEST SWIFT CREEK LANE	AFTON	Lincoln	704	2%	8%
STAR VALLEY MIDDLE SCHOOL	999 WARRIOR WAY	AFTON	Lincoln	366	2%	8%
AFTON ELEMENTARY	175 EAST 4TH AVENUE	AFTON	Lincoln	396	2%	8%
C-BAR-V RANCH	3850 NORTH WILDERNESS DRIVE	WILSON	Teton	125	4%	17%
REGION V BOCES	3850 NORTH WILDERNESS DRIVE	WILSON	Teton	25	4%	17%
COKEVILLE HIGH SCHOOL	300 PINE	COKEVILLE	Lincoln	90	4%	12%
COKEVILLE ELEMENTARY	250 NORTH SAGE	COKEVILLE	Lincoln	122	4%	12%
HOLDAWAY ELEMENTARY	250 VAN NOY PARKWAY	THAYNE	Lincoln	327	4%	13%
KELLY ELEMENTARY	FOURTH STREET	KELLY	Teton	446	5%	20%
JACKSON ELEMENTARY	155 NORTH JEAN STREET	JACKSON	Teton	420	5%	23%
JOURNEYS SCHOOL OF THE TETON SCIENCE SCHOOL			Teton	151	6%	23%
METCALF ELEMENTARY	US HIGHWAY 89	ETNA	Lincoln	259	6%	16%
WILSON ELEMENTARY	5200 HHR RANCH ROAD	WILSON	Teton	227	9%	31%
BONDURANT ELEMENTARY	14224 SOUTH US HIGHWAY 189/191	BONDURANT	Sublette	379	11%	26%

Name	Address	City	County	Number of Students	% of Functionality On Day 1	% of Functionality On Day 14
COLTER ELEMENTARY	1855 HIGH SCHOOL ROAD	JACKSON	Teton	344	11%	35%
JACKSON HOLE HIGH SCHOOL	1910 WEST HIGH SCHOOL ROAD	JACKSON	Teton	637	11%	35%
JACKSON HOLE MIDDLE SCHOOL	1230 SOUTH PARK LOOP ROAD	JACKSON	Teton	493	11%	35%
SUMMIT HIGH SCHOOL	100 MIDDLE SCHOOL ROAD	JACKSON	Teton	50	11%	35%
JACKSON HOLE CHRISTIAN ACADEMY		JACKSON	Teton	190	11%	35%
DAVIS MIDDLE SCHOOL	837 NO NAME STREET	EVANSTON	Uinta	337	11%	27%
EVANSTON HIGH SCHOOL	701 WEST CHEYENNE DRIVE	EVANSTON	Uinta	847	11%	27%
CLARK ELEMENTARY	600 13TH STREET	EVANSTON	Uinta	209	11%	27%
UINTA MEADOWS ELEMENTARY	90 CHEYENNE DRIVE	EVANSTON	Uinta	446	11%	27%

Care Facilities (Sorted by lowest to highest functionality on day 1 after earthquake)

Name	Address	City	County	Number of Beds	% of Functionality On Day 1	% of Functionality On Day 14
STAR VALLEY MEDICAL CENTER	901 ADAMS STREET	AFTON	Lincoln	15	3%	16%
SAINT JOHNS HOSPITAL	625 EAST BROADWAY	JACKSON	Teton	42	7%	35%
TETON YOUTH AND FAMILY SERVICES VAN VECK	510 SOUTH CACHE DRIVE	JACKSON	Teton	0	14%	48%

					% of Functionality	
Name	**Address**	**City**	**County**	**Number of Beds**	**On Day 1**	**On Day 14**
EVANSTON REGIONAL HOSPITAL	190 ARROWHEAD DRIVE	EVANSTON	Uinta	42	15%	46%
SOUTH LINCOLN MEDICAL CENTER	711 ONYX STREET	KEMMERER	Lincoln	116	17%	50%
MEMORIAL HOSPITAL - SWEETWATER	1200 COLLEGE DRIVE	ROCK SPRINGS	Sweetwater	99	54%	87%
MEMORIAL HOSPITAL OF CARBON COUNTY	2221 WEST ELM STREET	RAWLINS	Carbon	35	61%	90%
HOT SPRINGS COUNTY MEMORIAL HOSPITAL	150 EAST ARAPAHOE STREET	THERMOPOLIS	Hot Springs	49	63%	91%
MOUNTAIN VIEW REGIONAL HOSPITAL	6550 EAST SECOND STREET	CASPER	Natrona	0	64%	92%
CENTRAL WYOMING COUNSELING CENTER - NEW	837 EAST C STREET	CASPER	Natrona	0	65%	92%
CENTRAL WYOMING COUNSELING CENTER - NEW	1514 EAST 12TH STREET	CASPER	Natrona	0	65%	92%
WYOMING MEDICAL CENTER	1233 EAST 2ND STREET	CASPER	Natrona	201	65%	92%
MEMORIAL HOSPITAL OF CONVERSE COUNTY	111 SOUTH 5TH STREET	DOUGLAS	Converse	34	67%	93%
WASHAKIE MEDICAL CENTER	400 SOUTH 15TH STREET	WORLAND	Washakie	30	67%	93%
JOHNSON COUNTY HEALTHCARE CENTER	497 WEST LOTT STREET	BUFFALO	Johnson	25	69%	94%
LANDER REGIONAL HOSPITAL	1320 BISHOP RANDALL DRIVE	LANDER	Fremont	81	72%	94%

					% of Functionality	
Name	**Address**	**City**	**County**	**Number of Beds**	**On Day 1**	**On Day 14**
RIVERTON MEMORIAL HOSPITAL	2100 WEST SUNSET DRIVE	RIVERTON	Fremont	70	73%	94%
SOUTH BIG HORN COUNTY HOSPITAL	388 UNITED STATES HIGHWAY 20 SOUTH	BASIN	Big Horn	0	73%	95%
CATHEDRAL HOME FOR CHILDREN	4989 NORTH 3RD STREET	LARAMIE	Albany	0	74%	95%
CAMPBELL COUNTY MEMORIAL HOSPITAL	501 SOUTH BURMA AVENUE	GILLETTE	Campbell	90	75%	96%
IVINSON MEMORIAL HOSPITAL	255 NORTH 30TH STREET	LARAMIE	Albany	99	75%	96%
WEST PARK HOSPITAL	707 SHERIDAN AVENUE	CODY	Park	46	75%	94%
NORTH BIG HORN HOSPITAL DISTRICT	1115 LANE 12	LOVELL	Big Horn	15	75%	96%
PLATTE COUNTY MEMORIAL HOSPITAL	201 14TH STREET	WHEATLAND	Platte	43	76%	96%
SHERIDAN MEMORIAL HOSPITAL	1401 WEST 5TH STREET	SHERIDAN	Sheridan	88	76%	96%

Police Station (Sorted by lowest to highest functionality on day 1 after earthquake)

				% of Functionality	
Name	**Address**	**City**	**County**	**On Day 1**	**On Day 14**
AFTON POLICE DEPARTMENT	416 SOUTH WASHINGTON STREET	AFTON	Lincoln	1%	11%
LINCOLN COUNTY SHERIFFS OFFICE - AFTON	421 JEFFERSON STREET	AFTON	Lincoln	1%	12%
COKEVILLE POLICE DEPARTMENT	110 PINE STREET	COKEVILLE	Lincoln	3%	21%
THAYNE POLICE DEPARTMENT	115 PETERSEN PARKWAY	THAYNE	Lincoln	5%	27%

				% of Functionality	
Name	**Address**	**City**	**County**	**On Day 1**	**On Day 14**
ALPINE POLICE DEPARTMENT	121 UNITED STATES HIGHWAY 89	ETNA	Lincoln	23%	59%
NATIONAL PARK SERVICE - BRIDGER-TETON NA	25 ROSECRANS DRIVE	JACKSON	Teton	24%	65%
NATIONAL PARK SERVICE - BRIDGER-TETON NA	340 NORTH CACHE DRIVE	JACKSON	Teton	24%	65%
TETON COUNTY SHERIFFS OFFICE	180 SOUTH KING STREET	JACKSON	Teton	24%	65%
JACKSON POLICE DEPARTMENT	150 EAST PEARL AVENUE	JACKSON	Teton	24%	65%
WYOMING GAME AND FISH DEPARTMENT - JACKS	420 NORTH CACHE DRIVE	JACKSON	Teton	24%	65%
WYOMING HIGHWAY PATROL - JACKSON	1040 EAST EVANS ROAD	JACKSON	Teton	33%	74%
UINTA COUNTY SHERIFFS OFFICE / UINTA COU	77 COUNTY ROAD 109	EVANSTON	Uinta	36%	73%
EVANSTON POLICE DEPARTMENT	1148 FRONT STREET	EVANSTON	Uinta	37%	74%
NATIONAL PARK SERVICE - BRIDGER-TETON NA	20255 UNITED STATES HIGHWAY 287	MORAN	Teton	40%	79%
KEMMERER POLICE DEPARTMENT	222 STATE HIGHWAY 233	KEMMERER	Lincoln	43%	78%
UNITED STATES FOREST SERVICE - KEMMERER	308 UNITED STATES HIGHWAY 189	KEMMERER	Lincoln	43%	78%
LINCOLN COUNTY SHERIFFS OFFICE / LINCOLN	1032 BEECH AVENUE	KEMMERER	Lincoln	43%	78%
DIAMONDVILLE POLICE DEPARTMENT	20 UNITED STATES HIGHWAY 30	KEMMERER	Lincoln	46%	80%
LA BARGE POLICE DEPARTMENT	222 LA BARGE STREET	LA BARGE	Lincoln	56%	86%
WYOMING HIGHWAY PATROL - PINEDALE	1551 WEST PINE STREET	PINEDALE	Sublette	60%	88%
MOUNTAIN VIEW POLICE DEPARTMENT	405 STATE HIGHWAY 414	MOUNTAIN VIEW	Uinta	62%	89%

				% of Functionality	
Name	**Address**	**City**	**County**	**On Day 1**	**On Day 14**
WYOMING GAME AND FISH DEPARTMENT - PINED	432 EAST MILL STREET	PINEDALE	Sublette	63%	89%
SUBLETTE COUNTY SHERIFFS OFFICE / SUBLET	35 1/2 SOUTH TYLER AVENUE	PINEDALE	Sublette	63%	89%
LYMAN POLICE DEPARTMENT	100 EAST SAGE STREET	LYMAN	Uinta	66%	91%
BAIROIL POLICE DEPARTMENT	1101 ANTELOPE DRIVE	BAIROIL	Sweetwater	70%	93%

Fire Stations (Sorted by lowest to highest functionality on day 1 after earthquake)

				% of Functionality	
Name	**Address**	**City**	**County**	**On Day 1**	**On Day 14**
AFTON VOLUNTEER FIRE DEPARTMENT	191 SOUTH WASHINGTON STREET	AFTON	Lincoln	1%	11%
BEAR RIVER FIRE PROTECTION DISTRICT / CO	110 PINE STREET	COKEVILLE	Lincoln	3%	21%
THAYNE AND RURAL VOLUNTEER FIRE DEPARTMENT	256 NORTH MAIN STREET	THAYNE	Lincoln	5%	27%
UINTA COUNTY FIRE PROTECTION DISTRICT -	18151 STATE HIGHWAY 150 SOUTH	EVANSTON	Uinta	5%	27%
COLTER BAY FIRE DEPARTMENT - GRAND TETON	COLTER BAY VILLAGE ROAD	MORAN	Teton	11%	44%
MOOSE FIRE DEPARTMENT - GRAND TETON NATI	UNITED STATES HIGHWAY 191	MOOSE	Teton	18%	57%
TETON VILLAGE SPECIAL FIRE DISTRICT	7648 GRANITE LOOP ROAD	TETON VILLAGE	Teton	21%	61%
ALPINE FIRE DEPARTMENT	220 MAIN STREET	ETNA	Lincoln	23%	60%

				% of Functionality	
Name	**Address**	**City**	**County**	**On Day 1**	**On Day 14**
JACKSON HOLE FIRE AND EMERGENCY MEDICAL	60 EAST PEARL AVENUE	JACKSON	Teton	24%	65%
JACKSON HOLE FIRE AND EMERGENCY MEDICAL	2505 NORTH MOOSE-WILSON ROAD	WILSON	Teton	29%	70%
JACKSON HOLE FIRE AND EMERGENCY MEDICAL	CENTRAL STREET	MORAN	Teton	29%	70%
JACKSON HOLE FIRE AND EMERGENCY MEDICAL	1315 NORTH WEST STREET	WILSON	Teton	30%	71%
JACKSON HOLE FIRE AND EMERGENCY MEDICAL	3230 SOUTH ADAMS CANYON ROAD	JACKSON	Teton	31%	72%
BONDURANT VOLUNTEER FIRE COMPANY	14245 UNITED STATES HIGHWAY 189	BONDURANT	Sublette	34%	71%
JACKSON HOLE FIRE AND EMERGENCY MEDICAL	10995 UNITED STATES HIGHWAY 89	JACKSON	Teton	35%	76%
UINTA COUNTY FIRE PROTECTION DISTRICT -	1136 FRONT STREET	EVANSTON	Uinta	37%	74%
UINTA COUNTY FIRE PROTECTION DISTRICT -	99 HAYDEN AVENUE	EVANSTON	Uinta	37%	74%
UINTA COUNTY FIRE PROTECTION DISTRICT -	72 STATE HIGHWAY 89	EVANSTON	Uinta	37%	74%
YELLOWSTONE NATIONAL PARK FIRE DEPARTMEN	EAST ENTRANCE ROAD	YELLOWSTONE NATIONAL PARK	Park	42%	81%
JACKSON HOLE FIRE AND EMERGENCY MEDICAL	15 ALTA SCHOOL ROAD	ALTA	Teton	42%	81%
KEMMERER FIRE DEPARTMENT	1225 CORAL STREET	KEMMERER	Lincoln	43%	78%
UINTA COUNTY FIRE PROTECTION DISTRICT -	508 COUNTY ROAD 107	EVANSTON	Uinta	47%	81%

				% of Functionality	
Name	**Address**	**City**	**County**	**On Day 1**	**On Day 14**
UINTA COUNTY FIRE PROTECTION DISTRICT -	9637 STATE HIGHWAY 89 NORTH	BEAR RIVER	Uinta	48%	82%
KENDALL VALLEY VOLUNTEER FIRE DEPARTMENT	2470 STATE HIGHWAY 352	CORA	Sublette	51%	83%
DANIEL VOLUNTEER FIRE COMPANY	12956 UNITED STATES HIGHWAY 189	DANIEL	Sublette	53%	85%

State Buildings at Risk to Earthquake

The HAZUS Advanced Engineering Building Module (AEBM) was used to estimate losses and casualties for WY state buildings based on the USGS 2008 National Earthquake Hazard Maps associated with the 2,500 year return period ground motions. The AEBM uses attributes related to number of occupants, building and contents value, building construction type and seismic design levels. This analysis was completed in 2007 and loss estimates have been inflated to reflect 2013 building costs. The 2014 state building dataset does not include adequate attributes to analyze using the AEBM. The state will work to update and improve their buildings dataset to refine future analysis.

The following table shows the top 25 state buildings at risk to earthquake, based on the AEBM study. Table is sorted by highest to lowest total economic loss.

Table 3 4.10 – Top 25 State Buildings at Risk to Earthquake

Building Name	Address	County	Total Economic Loss
St Pen.-Housing Unit S	2900 Higley Blvd	Carbon	$4,667,220
St Hospital # 23- Correction Complex	831 Highway 150 S Box	Uinta	$3,806,790
St Hospital # 33-Adult Care Fclty.	831 Highway 150 S Box	Uinta	$3,397,860
Capitol Bldg-Offices, Meeting Rooms	200 W 24th St	Laramie	$3,150,180
WYDOT Office-Office, Shop	1040 E Evans Rd	Teton	$3,102,450
Herschler Bldg-Offices, Cafeteria	122 W 25th St	Laramie	$1,990,470
WGF District Hdqt.-Offices	420 N Cache St	Teton	$1,438,350
WYDOT-Engr., Mech., & Maint.	310 N Washington	Lincoln	$1,244,850
St Hospital # 18-Campbell/Uinta Clinic	831 Highway 150 S Box	Uinta	$1,093,920
St Hospital # 10-Teton/Sweetwater	831 Highway 150 S Box	Uinta	$1,006,200
St Hospital # 5-Natrona/Laramie Hall	831 Highway 150 S Box	Uinta	$990,720
St Pen.-Medium Security Support	2900 Higley Blvd	Carbon	$973,950
St Hospital #17-Bighorn/Goshen Admis	831 Highway 150 S Box	Uinta	$963,630
WGF-DOT Purchase	380 N Cache	Teton	$946,860
St Pen.-Kitchen, Warehouse	2900 Higley Blvd	Carbon	$900,420
St Hospital # 4-Fremont/Albany Old Dorm	831 Highway 150 S Box	Uinta	$887,520
St Hospital # 6-Admin. Bldg	831 Highway 150 S Box	Uinta	$865,590
St Hospital # 3-Lincoln/Platte Halls	831 Highway 150 S Box	Uinta	$852,690
St Pen.-Medium Security Inmate Housing	2900 Higley Blvd	Carbon	$850,110
St Pen.-Maximum Security Inmates	2900 Higley Blvd	Carbon	$821,730
Emerson Bldg-Tech Wing	2001 Capitol	Laramie	$804,960
St. Pen. - Maximum Security	2900 Higley Blvd	Carbon	$793,350
Supreme Court Build-Library,	2301 Central	Laramie	$766,260

Building Name	Address	County	Total Economic Loss
Courtrooms			
St Hospital #7-Admin. Offices	831 Highway 150 S Box	Uinta	$755,940
Armory	350 E 6th Ave	Lincoln	$699,180

In addition to the AEBM study described above, the 2014 state building dataset was compared to the 2,500 year probabilistic earthquake scenario potential ground acceleration. Using GIS, critical state buildings greater than 1,000 square feet were intersected with areas >0.4 PGA (%g) with 2% probability of being exceeded in 50 years (2500-yr return period). The following are the additional critical state buildings at high risk to earthquake:

Game and Fish Warden Station North, 465 S. Cache St., Jackson, Teton County
Game and Fish Warden Station South, 345 Deloney St., Jackson, Teton County
Game and Fish Old District 1 Office, 360 N. Cache St., Jackson, Teton County

Assessment of Potential Earthquake Damage

Hazards U.S. (HAZUS) is nationally standardized, geographic information systems (GIS)-based, risk assessment and loss estimation computer program 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. HAZUS was developed for the Federal Emergency Management Agency (FEMA) by the National Institute of Building Sciences (NIBS). There have been a number of versions of HAZUS generated by FEMA, with HAZUS Multi-Hazard (HAZUS-MH) being the most recent release. HAZUS-MH incorporates a flood and hurricane wind module with the previously existing earthquake module.

HAZUS was originally designed to generate damage assessments and associated ground motions based largely upon analysis at the census-tract level. Census tracts average 4000 inhabitants, with the tract boundaries usually representing visible features. HAZUS-99 calculated a ground motion value for the centroid of a census tract and applied that value to the entire tract. The calculations are based on USGS National Seismic Hazard Maps. In many of the western states, census tracts are very large, and parts of the tracts may be subjected to ground shaking that is considerably different than the value at the centroid. In 2003 and 2004, FEMA Region VIII and their subcontractor on HAZUS, PBS&J from Atlanta, have worked closely with the Wyoming Geological Survey and the Wyoming Office of Homeland Security to develop a census-block-based analysis for HAZUS-MH in Wyoming. Census blocks are a subdivision of census tracts. Many blocks correspond to individual city blocks bounded by streets, but blocks—especially in rural areas—may include many square miles and may have some boundaries that are not streets. Ground motion values for Wyoming can now be calculated at the centroid of census blocks.

The results of the probabilistic 2004 HAZUS-MH analysis for each county are presented in **Table 3.4.11**. Probabilistic loss estimates reflect total damage/loss exposure for each county based on maximum ground motions modeled from the USGS 2500-year (2% probability of exceedance in 50 years) model. They do not reflect losses for a specific seismic event within or near each county. The probabilistic loss estimates may significantly over-estimate actual losses sustained from an individual earthquake. The data shows aggregated loss potential, rather than potential losses for a specific event.

There are two methods of ranking counties to determine where earthquake impacts may be the greatest. Either the loss ratios or total damage figures can be used (**Table 3.4.12**). 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 as it gives an indication of the percent of damage to buildings. The total damage figure by itself does not reflect the percentage of building damage. If a county has a number of valuable buildings, such a Laramie County, small damage to a number of valuable buildings may result in a higher total damage figure that may be found in a county with fewer, less expensive buildings with a higher percentage of damage.

Local mitigation plans utilize information provided by the State Multi-Hazard Mitigation Plan, and reflect little-to-no additional information regarding estimated potential losses. Statewide, HAZUS-MH analyses were generated in 2004 using both a census-tract and a census block method of analysis. The statewide results of both methods of analysis for building damage (structural and non-structural) are below:

Statewide Building Damage - Census Block Analysis: $2,436,291,000

Statewide Building Damage - Census Tract Analysis: $2,054,470,000

Table 3.4.11 HAZUS-MH Summary by County

County	Capital Stock Losses (Thousands of Dollars)				Loss Ratio (%)	Income Losses (Thousands of Dollars)				Total Loss (Thousands of Dollars)
	Structural	Non-structural	Contents	Inventory		Relocation	Capital-related	Wages	Rental	Loss
Albany	9,714	36,865	13,946	151	2.32	276	2,717	3,198	4,210	71,078
Big Horn	3,470	12,203	4,647	65	2.43	84	533	694	963	22,660
Campbell	5,116	20,093	9,419	282	1.37	144	1,484	2,013	1,592	40,144
Carbon	7,140	26,320	10,480	170	3.08	190	2,120	2,700	1,810	50,920
Converse	6,054	24,172	9,787	185	4.15	152	984	1,303	1,845	44,482
Crook	836	2,640	896	17	1.04	21	107	139	211	4,867
Fremont	14,890	61,030	24,640	460	3.75	380	2,920	3,940	3,190	111,450
Goshen	2,168	6,982	2,543	69	1.13	57	392	528	623	13,364
Hot Springs	3,038	10,871	4,176	52	4.20	82	799	1,149	969	21,136
Johnson	3,293	13,062	5,514	94	3.40	86	557	648	1,066	24,320
Laramie	13,605	47,839	17,577	233	1.25	406	3,926	4,402	4,976	92,963
Lincoln	65,670	225,594	64,429	2,538	31.08	1,211	8,579	10,359	15,347	391,727
Natrona	36,764	137,379	57,269	1,149	3.99	981	9,890	13,033	12,245	268,911
Niobrara	423	1,585	617	12	1.20	12	72	83	132	2,935

County	Capital Stock Losses (Thousands of Dollars)				Loss Ratio (%)	Income Losses (Thousands of Dollars)				Total Loss (Thousands of Dollars)
	Structural	Non-structural	Contents	Inventory		Relocation	Capital-related	Wages	Rental	Loss
Park	11,430	42,694	15,289	429	2.98	285	5,173	6,217	4,487	86,004
Platte	1,875	6,894	2,697	36	1.60	51	326	418	554	12,850
Sheridan	7,830	29,154	12,057	233	2.09	213	1,898	2,402	2,636	56,423
Sublette	9,654	30,667	9,436	222	8.24	206	2,438	3,052	2,665	58,340
Sweetwater	12,782	50,213	20,753	542	2.84	313	2,180	2,514	3,719	93,017
Teton	92,477	359,169	110,323	2,402	24.72	1,821	37,784	43,975	34,030	681,981
Uinta	39,912	135,111	38,841	1,007	15.84	782	5,888	8,741	11,004	241,284
Washakie	4,115	13,761	5,656	134	3.54	99	904	1,019	1,236	26,925
Weston	897	3,016	1,085	21	0.96	26	147	266	302	5,760

Table 3.4.12 County Impact in Order of Ratio Losses and Dollar Losses

County	Loss ratio	Total loss (thousands of dollars)
Lincoln	31.08	391,727
Teton	24.72	681,981
Uinta	15.84	241,284
Sublette	8.24	58,340
Hot Springs	4.20	21,136
Converse	4.15	44,482
Natrona	3.99	268,911
Fremont	3.75	111,450
Washakie	3.54	26,925
Johnson	3.40	24,320
Carbon	3.08	50,920
Park	2.98	86,004
Sweetwater	2.84	93,017
Big Horn	2.43	22,660
Albany	2.32	71,078
Sheridan	2.09	56,423
Platte	1.60	12,850
Campbell	1.37	40,144
Laramie	1.25	92,963
Niobrara	1.20	2,935
Goshen	1.13	13,364
Crook	1.04	4,867
Weston	0.96	5,760

County	Total loss (thousands of dollars)	Loss ratio
Teton	681,981	24.72
Lincoln	391,727	31.08
Natrona	268,911	3.99
Uinta	241,284	15.84
Fremont	111,450	3.75
Sweetwater	93,017	2.84
Laramie	92,963	1.25
Park	86,004	2.98
Albany	71,078	2.32
Sublette	58,340	8.24
Sheridan	56,423	2.09
Carbon	50,920	3.08
Converse	44,482	4.15
Campbell	40,144	1.37
Washakie	26,925	3.54
Johnson	24,320	3.4
Big Horn	22,660	2.43
Hot Springs	21,136	4.2
Goshen	13,364	1.13
Platte	12,850	1.6
Weston	5,760	0.96
Crook	4,867	1.04
Niobrara	2,935	1.2

Regional Impacts of Earthquakes

Using the loss ratios in **Table 3.4.12**, Lincoln, Teton, Uinta, and Sublette counties would have the most significant impact from earthquakes. This is consistent with probabilistic acceleration maps, and projected damage potential from exposed active fault models. Total dollar loss in those counties is projected to be nearly $1.4 billion.

The second most impacted areas would be Hot Springs, Converse, Natrona, Fremont, Washakie, Johnson, Carbon, Park, and Sweetwater counties. Total dollar loss in those counties is projected to be just over $657.4 million.

The third most impacted areas would be Big Horn, Albany, Sheridan, Platte, and Campbell counties. Total dollar loss in those counties is projected to be about $203.2 million.

The counties with the least impact would be Laramie, Niobrara, Goshen, Crook, and Weston counties. Total dollar loss in those counties is projected to be almost $119.9 million. This is consistent with probabilistic acceleration maps, and projected damage potential from exposed active fault models.

Local Mitigation Plan Risk Assessments

A review of the local plans shows they have utilized the most accurate earthquake data available at the time their plan was written. Most also utilize maps contained within the Wyoming State Multi-Hazard Mitigation Plan. In February, 2011 each county was offered new, scenario-based HAZUS-MH information in draft form. The information provided utilized HAZUS estimates in scenario-based calculations. As mentioned earlier, the HAZUS-MH data has been finalized and published. It is expected that those counties impacted by potential earthquake hazards in Wyoming (most counties) will utilize this best available data in their next local plan update.

Below is a table outlining information gathered from earthquake hazard information within the local mitigation plans. The table outlines the local perspective on earthquake risk within the county, ranking it from high to low, based on three areas of concern in the local plan: population impacted, probability of occurrence within their borders, and property impacted.

When compared to the percentage of population increase in the state, it is noted those counties in zones where earthquakes are most prevalent, the western part of the state, are experiencing some of the most significant growth. This would indicate earthquake hazards do not appear to significantly modify growth patterns within Wyoming. It would also lead one to draw the conclusion that in the event of a significant earthquake, those counties experiencing greater growth within their boundaries will have greater need of critical infrastructure like hospitals, police and fire departments, which are likely to be operating at a decreased capacity. The draw on critical infrastructure from surrounding areas may also be taxed.

However, the areas in the west tend to be populated by those better able to address the demands of an emergency because of low density and greater resilience of the population.

Table 3.4.13 - Local Risk Determination – Earthquake

COUNTY	Plan Y/N	Year Approved	Included in Plan	Probability-High, Medium, Low	Previous Incidents Magnitude 5 or Greater
ALBANY	Y	2010	Y	Medium	30+
BIG HORN	Y	2011	Y	Low	4
CAMPBELL	Y	2011	Y	Low	19
CARBON	Y	2009	Y	Medium	25
CONVERSE	Y	2012	Y	Low-Medium	30
CROOK	Y	2013	Y	Low	2
FREMONT	Y	2012	Y	Medium	30+
GOSHEN	Expired	2007	Y	Low	7
HOT SPRINGS	N				
JOHNSON	Y	2013	Y	Low	13
LARAMIE	Y	2013	Y	Low	7
LINCOLN	Expired	2007	Y	High	Thousands
NATRONA	Y	2011	Y		Several
NIOBRARA	Y	2010	Y	Low	6
PARK	Y	2011	Y	Medium	12
PLATTE	Expired	2004	Y	Low	1
SHERIDAN	Y	2009	Y	Low	14
SUBLETTE	Expired	2008	Y	High	Numerous
SWEETWATER	N				
TETON	Y	2010	Y	High	Hundreds
UINTA	Y	2011	Y	Low	23
WASHAKIE	Y	2011	Y	Low	4
WESTON	N				
NORTHERN ARAPAHO TRIBE	N				
EASTERN SHOSHONE TRIBE	N				

State Mitigation Strategy: Earthquake

Conduct HAZUS analyses to determine effects building code adoption may have on reducing loss estimates.	Remains a potential project, not yet begun.
Conduct study on phasing in of earthquake provisions of code for state funded and/or inspected buildings.	Removed. Studies are not mitigation activities.
Development of enhanced soil layer for use in HAZUS.	Completed. Enhanced soil layer was used for the 2004 and updated for the 2011 HAZUS projects.
Study on retrofit feasibility of government owned buildings, essential facilities, culverts, and bridges.	Modified. Studies are not mitigation activities. (see below)
Retrofit state and local government-owned buildings, essential facilities, culverts, and bridges as funding allows for those determined to be cost effective.	List of critical infrastructure for visual assessments requested from local emergency managers. Visual assessments begun in Teton County. The intent is to develop a 'wish list' to be prioritized for future mitigation.
Retrofit pipelines with flexible connectors where they intersect with active faults.	Modified to reflect mitigation activity rather than a 'study.'
Education on earthquakes and on seismic provisions of the building code.	Education activities remain on-going. Wyoming-specific flyer developed and inserted into newspapers in western Wyoming in 2012. Wyoming participated in the ShakeOut for the first time in 2013.
Analysis of effects of earthquakes on public buildings and shelters.	Removed. Studies are not mitigation activities.
Retrofit State Capitol and Herschler Building.	Removed. Included in project above.
Provide all-hazards weather radios to all residences in Wyoming.	On-going activity. All-hazards weather radios have been purchased as funding allows and distributed to schools and other critical facilities. They have also been distributed as incentives to participate in preparedness activities.
Identify and inspect shelters in hazard prone areas.	This activity is nearly completed… and will continue as an on-going activity. However, it is not a mitigation activity, and is removed from the list.
Research feasibility and costs of adding new frontage roads /detour routes to I-80, I-90, and I-25 to prevent significant delay	Removed

in traffic flow and resultant economic loss and possible loss of life.	
Provide hazards information to shelters, emergency facilities in public buildings, campgrounds, and phone books.	Removed
Provide emergency phones at strategic locations with direct lines to emergency dispatch services.	No longer useful. Traveling public typically has cell phones. Modified to reflect current cell phone use. (see below)
Encourage continued cell tower upgrades, retrofits and enhancements to ensure communication hubs are available in the event of an earthquake.	On-going activity.
Develop reseeding plans for losses due to all hazard events	Removed from the Earthquake Mitigation list. This is more relevant to wildland-urban interface fire and/or flooding.
GIS training for local jurisdictions with emphasis on hazards recognition and analysis for application to mitigation planning.	Removed
Investigate opportunities for developing or improving warning systems as a means to reduce loss of life, damage to property, and economic losses.	Warning systems have been developed and improved throughout the state at the local level, utilizing Homeland Security Grant Program funding and other funding. This is an on-going project, which is diminishing in need and priority.
Education programs encompassing multi-hazard insurance for business, resident and government application.	Multi-hazard insurance is promoted in the private insurance market, and is typically required by banks holding home or business mortgages. The Wyoming Office of Homeland Security has a staff person devoted to the National Flood Insurance Program.
Planning studies regarding transportation of essential and/or key personnel during all hazard events	Removed. This is a response planning activity, and best incorporated into the State Operations Plan.
Continue outreach to counties on identifying cost effective and feasible mitigation projects.	On-going activity.
Promote Continuity of Operations and Continuity of Government, statewide.	The Wyoming Office of Homeland Security has a staff person devoted to this activity. Wyoming Continuity of Operations and Continuity of Government planning is actively being pursued. This remains an on-

	going activity.
Maintain and continue to expand hazards databases that were generated for the State Hazard Mitigation Plan. Seek new sources of information.	New sources of earthquake information were implemented in the last update and are incorporated into this update also. This remains an on-going activity.
Identify, document, and advertise all volunteer agency's locations and contact information.	Wyoming VOAD is becoming more energized. The Wyoming Red Cross is spearheading this effort and is in the process of completing a VOAD tool which provides locations, contact information and capability details. This will remain an on-going activity because of turnover and entities entering, leaving, and changing disaster response activities.

3.5 Expansive Soil

Expansive soils are soils that expand when water is added, and shrink when they dry out. This continuous change in soil volume can cause homes built on this soil to move unevenly and crack. Each year in the United States, expansive soils cause $2.3 billion in damage to houses, other buildings, roads, pipelines, and other structures. This is more than twice the damage from floods, hurricanes, tornadoes, and earthquakes combined. (Kerrane) U.S. Housing and Urban Development (HUD) estimated $9 billion damages in 1981 resulting from expansive soils. It indicated that shrink-swell problems were the second most likely problem a homeowner would encounter, after insects.

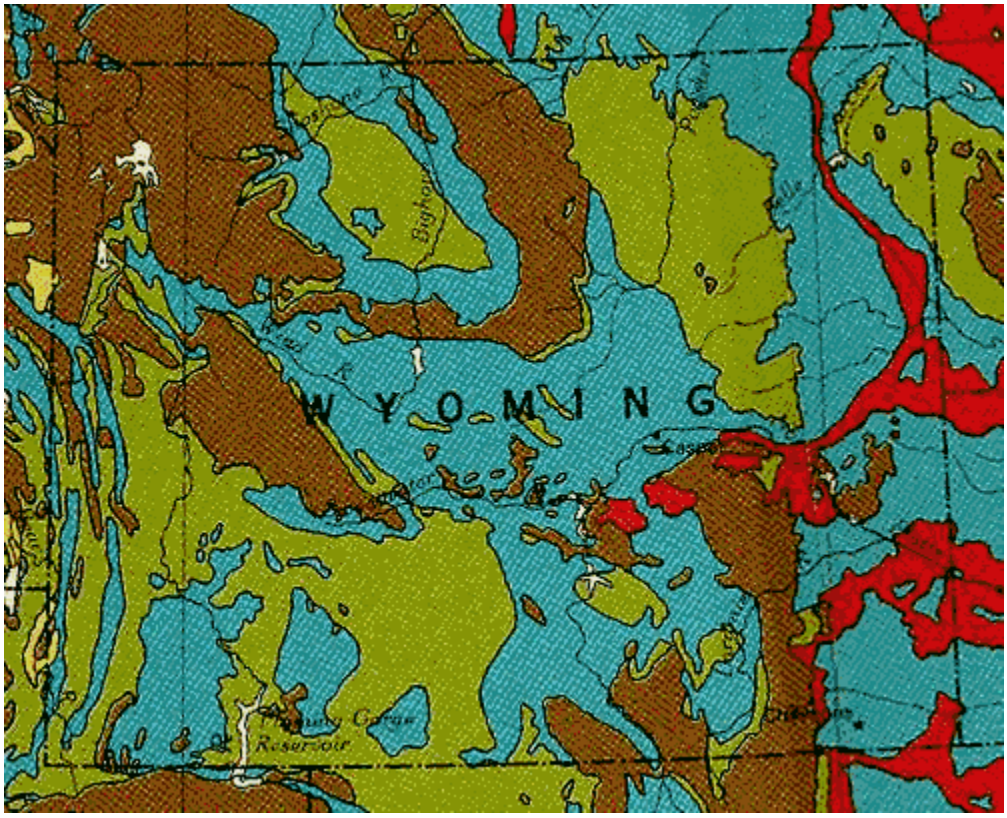
Damage to sidewalk and street resulting from expansive soils

Some Wyoming clays have the potential to swell or shrink when transitioning between wet or dry. These clays are primarily montmorillonites. There is one type of montmorillonite, sodium montmorillonite (bentonite) that is especially prone to shrinking and swelling. Another montmorillonite, calcium montmorillonite, also shows some shrink-swell capabilities. Areas where these clays are known to be present are shown in **Map 3.5.1**. All of the areas shown on the map are geological formations that contain bentonite, except for the Casper Mountain area in Natrona County where calcium montmorillonite is present. There are other areas in Wyoming with soils that have a shrink-swell component due to montmorillonites that are included in the soils. Those soils have not been completely mapped.

A, initial view; B, after introduction of a small amount of water; C, 48 hour time lapse

The hazard these expansive soils create can be significant although they have, for the most part, been recognized and mitigated in urbanized areas. Many of the expansive soils do not create large areas of destruction; however, they can disrupt supply lines (i.e. roads, power lines, railways, and bridges) and damage structures. Expansive soils do not change size quickly. **(See Images above)** Observing damage in real-time can sometimes be difficult. Although damage may not occur in a matter of minutes, it still has potential to severely damage structures and roads over time if not sufficiently mitigated.

Map 3.5.1 Wyoming Expansive Soils

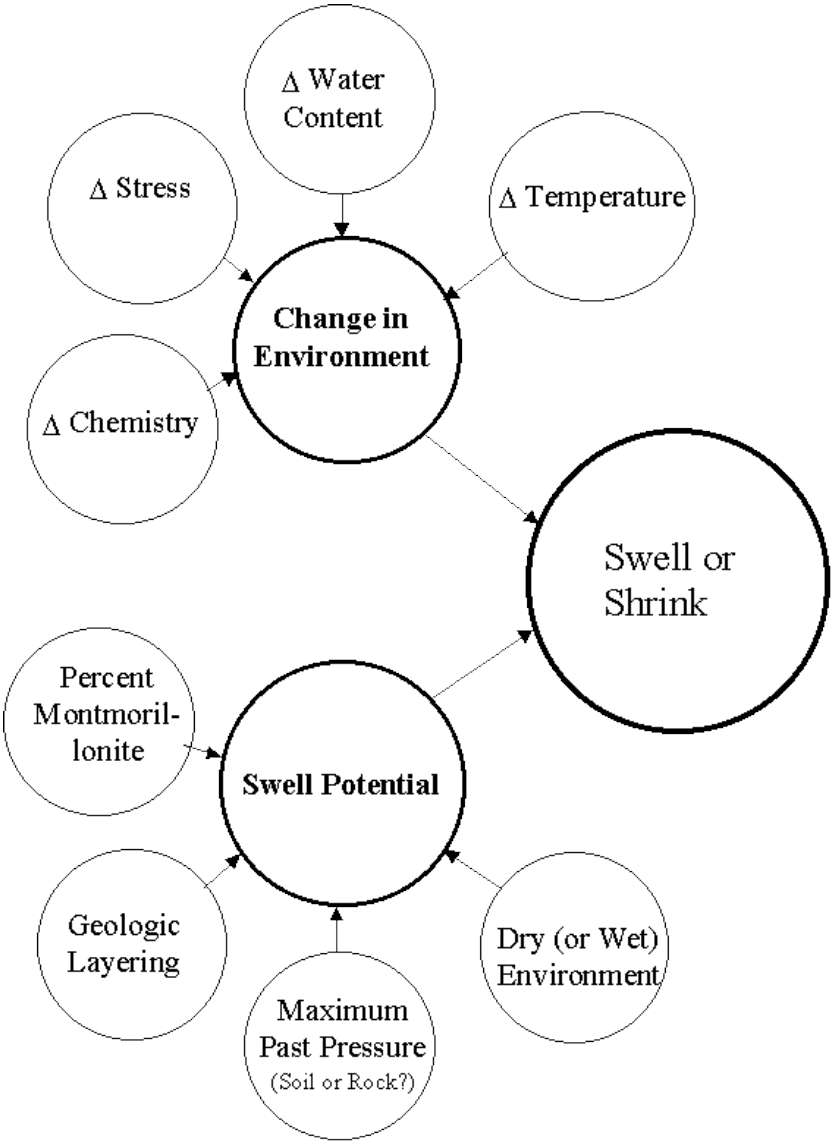


Red	High Potential for High Swell
Blue	Likely Potential for Mod. To High Swell
Green	Moderate Potential for Some to Low Swell
Brown	Low Potential for Swell

(Edgar, 2002)

Potential vs. Realized Swell

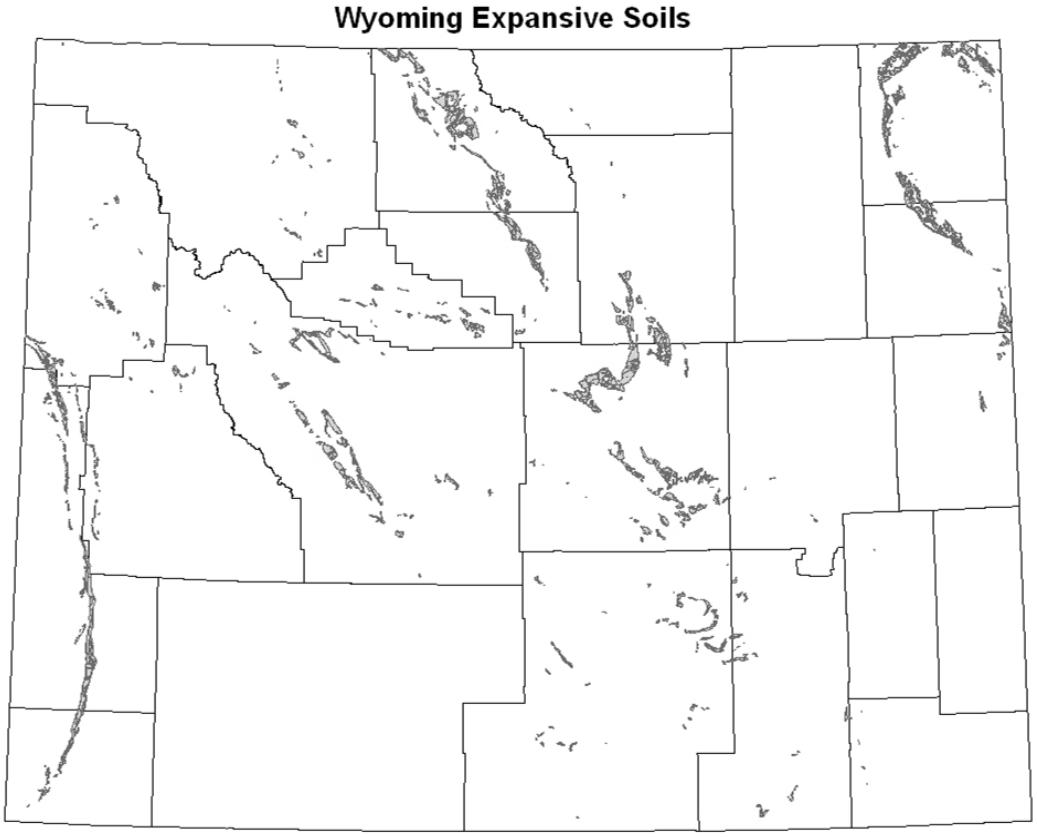
Many soils and rocks have the potential to swell. That is a function of its minerology. The actual swelling will be caused by a change in the environment in which the material exists.



History

Very little work has been done to study the extent of expansive soils in Wyoming. Although there have been instances in the Casper area where foundations and other concrete work have fractured and been displaced, historical accounts of actual damaging events caused by expansive soils have been difficult to locate. Even less is known about expansive soil locations outside of the Casper area.

Map 3.5.2 Thomas Edgar's Map of Wyoming Expansive Soils



As seen on **Map 3.5.2** and the map presented in Thomas Edgar's technical paper **(Map 3.5.1)** there are other areas in the state where expansive soils are present. This includes the eastern slope of the Wind River Mountains, the eastern side of the Bighorn Basin, the flanks of the Black Hills, and along the eastern edge of the Overthrust belt in north central Lincoln and Uinta counties. Very few reports regarding expansive soils have been described from these areas.

Impacts

As previously mentioned, damage from known expansive soil areas (namely the Casper area) has been poorly documented. Collecting a dollar estimate of damage caused by expansive soils has proven difficult, if not impossible. It is estimated that there has been less than $5 million of actual expansive soil related damage in the Casper area and the rest of the state.

Photo 3.5.3 Expansive soils under very dry conditions result in desiccation cracks

Future Impacts

There are two measurements used for calculating future impacts, historic dollar damages, and building exposure values. There are not enough current data to accurately estimate historic damages.

For the 2008 update to the State Plan, the Wyoming State Geological Survey (WSGS) calculated the building exposure value for buildings that may occur within the areas of expansive soils. All expansive soils mapped have been digitized and the expansive soils layer was then digitally crossed with 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 **Map 3.5.4**. The rank of counties based upon expansive soil building exposure values is shown in **Table 3.5.5**. These damage estimates assume an instantaneous event, which would damage all of the property on suspected expansive areas at one time. The information was not updated due to both the lack of historically-documented damage and a lack of further, additional expansive soil inundation information.

The loss scenario pictured and outlined in the map and table below is extremely unlikely, meaning the exposed damage estimates are most likely vastly overstated. It is far more likely damage from expansive soils will be individual events, which will cause damage to a small number of buildings or road segments over time.

Map 3.5.4- Exposure to Expansive Clays

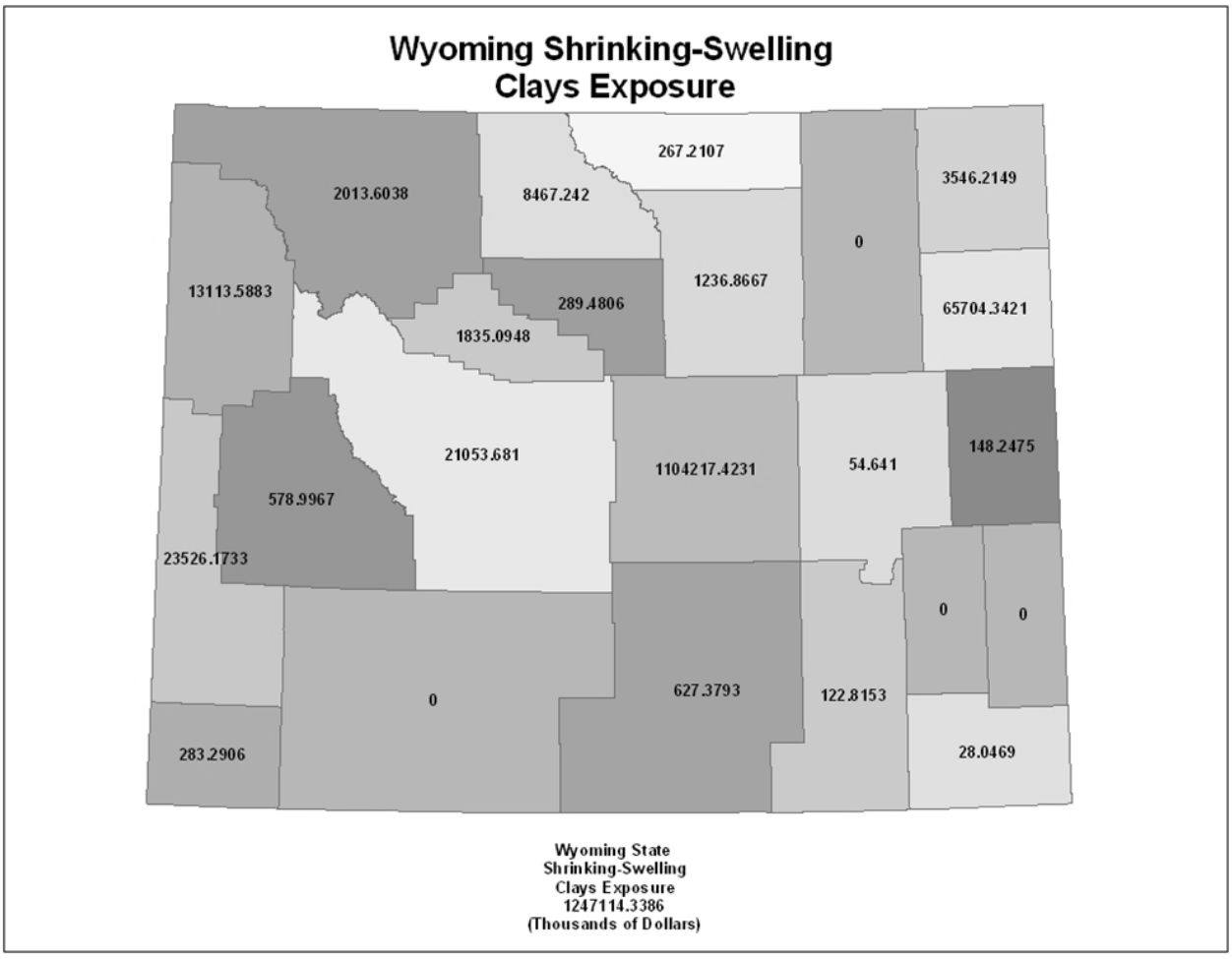


Table 3.5.5- Building Exposure by County for Expansive Soils in Wyoming

County	Exposure value (USD)
Natrona	1,104,217,423
Weston	65,704,342
Lincoln	23,526,173
Fremont	21,053,681
Teton	13,113,588
Bighorn	8,467,242
Crook	3,546,215
Park	2,013,604
Hot Springs	1,835,095
Johnson	1,236,867
Carbon	627,379
Sublette	578,997
Washakie	289,481
Uinta	283,291
Sheridan	267,211
Niobrara	148,248
Albany	122,815
Converse	54,641
Laramie	28,047
Campbell	0
Goshen	0
Sweetwater	0
Platte	0
TOTAL	$1,247,114,339

Given the risk associated with expansive soils is most likely to be to a small number of individual structures and short road segments over time, loss of life is not associated with expansive soils, and the risk to structures and infrastructure appears to be vastly overstated, it was determined not to further address population vulnerability as associated with the hazard of expansive soils within the state. Should this hazard be determined to be of greater significance in the future, more attention will be given in the State's Multi-Hazard Mitigation Plan to the vulnerability of Wyoming's population as it relates to expansive soils.

In the unlikely event expansive soils are determined to be a significant hazard in Wyoming, the risk may most greatly impact areas where development is occurring and the potential for damage is increased as a result of construction completed without mitigation efforts addressing expansive soils.

According to the 2010 census, current areas where the greatest percentage population increase is occurring within Wyoming are Sublette (>50%) and Campbell Counties (25% - 49.9%). According to the 2010 census, the counties experiencing the greatest numerical increase in population are Laramie and Campbell Counties increasing by 10,000 - 20,000 people over the past 10 years, equating to an additional 1-2 thousand persons per year. Development can be related to the population increase as issued building permits reflect the greatest housing development occurred in Laramie, Natrona, Campbell, and Albany Counties. **[Table 1.3]** According to the maps depicting areas where expansive soils are most prevalent, Natrona and Campbell Counties are most likely of the four to experience damage resulting from expansive soil **(Map 3.5.2)** with limited-to-no exposure to expansive soil likely in the other two counties **(Map 3.5.4)**.

Local Mitigation Plan Risk Assessments

A review of Wyoming's local plans reflects little recognition of the hazard expansive soil. This would appear to be indicative of either a lack of information or the absence of this hazard in Wyoming's counties. Those who address the hazard within their plan have utilized data researched and available to them through the State Multi-Hazard Mitigation Plan. You will note the lack of documented instances of damage. Therefore it stands to reason this hazard would not be addressed locally. Those who addressed expansive soils within their local plan have ranked the risk of expansive soil within their borders based on the population impacted, probability of occurrence within their borders and the property impacted.

Given the lack of local recognition to expansive soil as a hazard, a potential research project for future updates to the state plan may be to further map the extent expansive soils within the state, with the possibility of removing this hazard from the plan.

Below is a table outlining information mined from the local plans' expansive soil hazard sections. The table shows little documentation available of historical incidents of damage caused by expansive soil within each county's borders as outlined in their plans. Further, the table extrapolates, based on population impacted, probability of occurrence within their borders, and property impacted, the risk perceived by each county relative to expansive soil hazards.

Table 3.5.6 Local Risk Determination – Expansive Soils

COUNTY	Plan Y/N	Year Approved	Included in Plan	Probability- High, Medium, Low	Previous Incidents Magnitude 5 or Greater
ALBANY	Y	2010	N		
BIG HORN	Y	2011	N		
CAMPBELL	Y	2011	N		
CARBON	Y	2009	N		

CONVERSE	Y	2012	N		
CROOK	Y	2013	Y	Low	Few Reports
FREMONT	Y	2012	N		
GOSHEN	Expired	2007	N		
HOT SPRINGS	N				
JOHNSON	Y	2013	Y	Low	None Listed
LARAMIE	Y	2013	N		
LINCOLN	Expired	2007	N		
NATRONA	Y	2011	Y	Low	Rare
NIOBRARA	Y	2010	N		
PARK	Y	2011	N		
PLATTE	N		N		
SHERIDAN	Y	2009	N		
SUBLETTE	Expired	2008	N		
SWEETWATER	N				
TETON	Y	2010	N		
UINTA	Y	2011	N		
WASHAKIE	Y	2011	N		
WESTON	N				
NORTHERN ARAPAHO TRIBE	N				
EASTERN SHOSHONE TRIBE	N				

Expansive Soil Probability

Unlikely = Value 1
Limited # Reported ÷ Unknown # years = Unknown % annual probability of a damaging expansive soils

Expansive Soils Risk Factor

Expansive Soils Risk Factor Value = 1.57 [(Probability Unlikely: 1 x .30) + (Minor Impact: 1 x .30) + (Small Spatial Extent: 2 x .20) + (6-12 hrs Warning Time: 3 x .10) + (Less Than 24 hrs Duration: 2 x .10)]

State Mitigation Strategies: Expansive Soils

Enhance Wyoming soils mapping to determine extent of expansive soils.	Low priority to map expansive soils.
Research feasibility and costs of adding new frontage roads /detour routes to I-80, I-90, and I-25 to prevent significant delay in traffic flow and resultant economic loss and possible loss of life.	Removed
Provide hazards information to shelters, emergency facilities in public buildings, campgrounds, and phone books.	Medium priority. Information about individual hazards is being provided through different methods including PSAs, flyers, and state-wide exercises. On-going.
Provide emergency phones at strategic locations with direct lines to emergency dispatch services.	Removed
Develop reseeding plans for losses due to all hazard events.	Removed
GIS training for local jurisdictions with emphasis on hazards recognition and analysis for application to mitigation planning.	On-going.
Investigate opportunities for developing or improving warning systems as a means to reduce loss of life, damage to property, and economic losses.	Removed. Not applicable to expansive soils.
Education programs encompassing multi-hazard insurance for business, resident and government application.	Multi-hazard insurance is promoted in the private insurance market, and is typically required by banks holding home or business mortgages. The Wyoming Office of Homeland Security has a staff person devoted to the National Flood Insurance Program. Education is an on-going project.
Planning studies regarding transportation of essential and/or key personnel during all hazard events.	Removed. This is a response planning activity. Reference the State Operations Plan.
Continue outreach to counties on identifying cost effective and feasible mitigation projects.	Ongoing.
Promote Continuity of Operations and Continuity of Government, statewide.	The Wyoming Office of Homeland Security has a staff person devoted to this activity. Wyoming Continuity of Operations and Continuity of Government planning is actively being pursued. This remains an on-going activity.
Maintain and continue to expand hazards databases that were generated for the State Hazard Mitigation Plan. Seek new sources of information.	New sources of earthquake information were implemented in the last update and are incorporated into this update also.

	Maintenance of hazard database continues through the mitigation plan update process. This remains an on-going activity.
Identify, document, and advertise all volunteer agency's locations and contact information.	Wyoming VOAD is becoming more energized. The Wyoming Red Cross is spearheading this effort and is in the process of completing a VOAD tool which provides locations, contact information and capability details. The Wyoming Department of Health has developed and continues to maintain a volunteer database, which is available to the Wyoming Office of Homeland Security, as we continue to maintain a collaborative working relationship with one another. This will remain an on-going activity because of turnover and entities entering, leaving, and changing disaster response activities.

Sources Cited:

Edgar, Thomas V., P.E., Ph.D., 'Foundations on Expansive Soils', February 7, 2002.

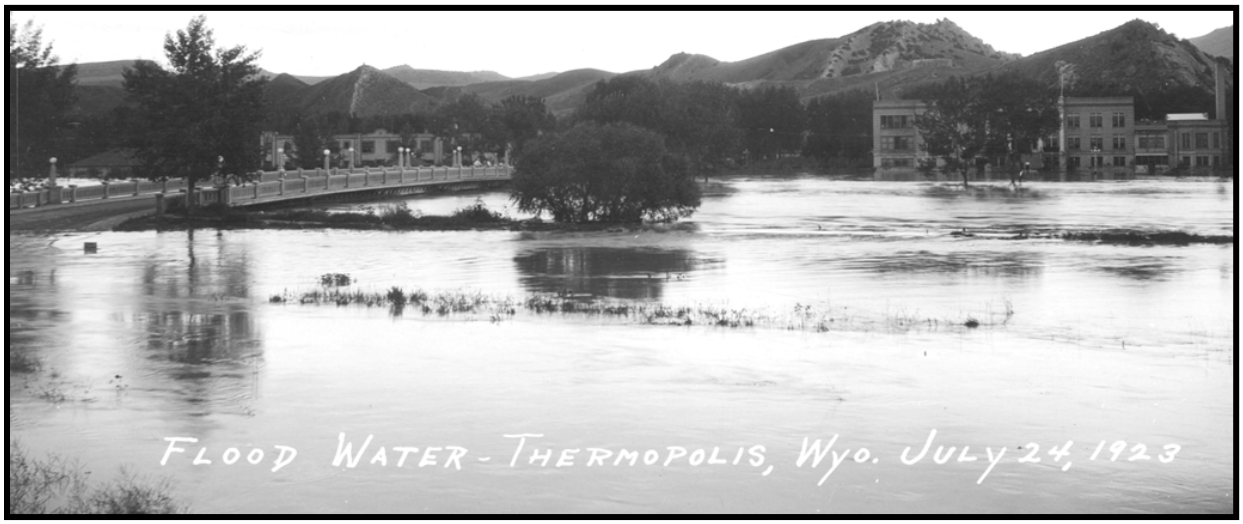
Kerrane, Jeffrey P. Esq., http://www.bensonpc.com/downloads/public/What_Are_Expansive_Soils.pdf, Accessed 10/25/2013

3.6 Flood

Flooding can and has caused significant damage in Wyoming and is one of the more significant natural hazards in the state (**Photo 3.6.1**). It can cause millions of dollars in damage in just a few hours or days. Every county and many communities in the state have experienced some kind of flooding after spring rains, heavy thunderstorms, winter snow thaws, or ice jams. According to information available through SHELDUS, flooding is the second the second highest

A flood, as defined by the National Flood Insurance Program (NFIP), 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.

Photo 3.6.1 Big Horn River at Thermopolis, July 24, 1923. Photo courtesy of Wyoming State Archives.



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. Floods can occur for reasons other than precipitation or rapidly melting snow including ice jams and natural or man-made dam failures, both of which have occurred in Wyoming.

Below are two tables outlining Wyoming's presidentially-declared and state-declared emergencies resulting from flooding. **(Tables 3.6.2 and 3.6.3)**

Table 3.6.2 Presidential Disaster Declarations – Floods 1963-2013

Number	Declared	Description
4007	July 22, 2011	Severe Storms, Flooding and Landslides
1923	07/14/2010	Flooding
740	08/07/1985	Severe Storms, Hail, Flooding
557	05/29/1978	Severe Storms, Flooding, Mudslides
155	07/04/1963	Heavy Rains, Flooding

http://www.fema.gov/disasters/grid/state-tribal-government/74?field_disaster_type_term_tid_1=All
Accessed 10/25/2013

Table 3.6.3 State-Level Emergencies – Flood 2005-2013

Date	Case #	# of Days	Location	Resource Used	Total Costs	Notes
5/3/2005	05-0002	1	Diamondville	CAP	$ 377.92	Photographic mission to assess the extent of flooding expected *(Gorny report)*
5/11/2005	05-0004	5	Sheridan County	Nat'l Guard	$ 333,881.58	WANG, Honor Farm, City of Sheridan, Sheridan County *(Gorny report)*
6/6/2005	05-0009	9	Albany County	Honor Farm & Guard	$ 2,850.00	Costs are pmt to Honor Farm only - no cost info avail for Guard. Incident participation was used to replace a drill previously scheduled for Laramie area *(Gorny report)*
8/15/2006	06-0019	2	Goshen County (LaGrange)	CAP	$ 122.72	Aerial recon
5/20/2008	08-0010	3	Baggs	Nat'l Guard	$ 30,705.72	Guard sandbagging, MSV#2
7/3/2009	0016IC-070609		Natrona County	WOHS	$ 21,147.41	State Disaster Declaration
3/8/2014		5	Big Horn & Washakie Counties	WOHS, Wranglers, Smoke Busters, Guard, VOAD		3/14/2014- State Disaster Declaration Executed- Ice Jam Flooding

Flood Analysis Provided to Wyoming Counties

Planning level flood loss estimates were made available for every county in Wyoming with the 2010 update to the Wyoming Hazard Mitigation Plan. FEMA's HAZUS-MH MR2 GIS-based natural hazard loss estimation software was utilized to complete the county-level analysis. The HAZUS-MH flood model results included analysis for each of the 23 counties 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.

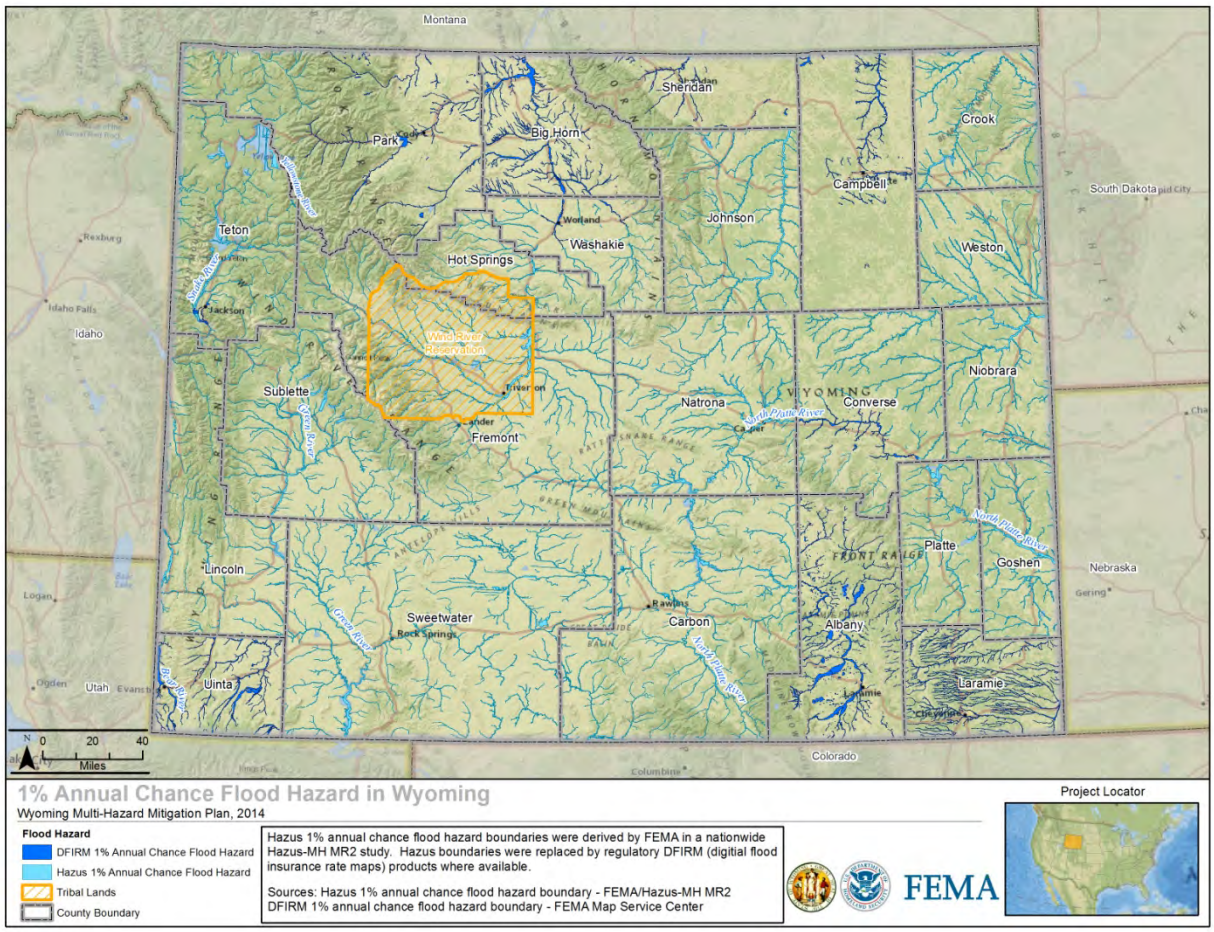
Potential losses derived from HAZUS-MH used default national databases and may contain inaccuracies; loss estimates should be used for planning level applications only. The damaged building counts generated are susceptible to rounding errors and are likely the weakest output of the model due to the use 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. 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-MH 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.

Photo3.6.4 Lincoln County Flood, 1983

Photo 3.6.5 Cheyenne, near Carlson Street - August 2008 curb and gutter flooding

Reports and Maps

Map 3.6.6 – 1% Annual Chance Flood Hazard



A series of maps and analysis were compiled for this update. FEMA Region VIII's Risk Analysis/GIS Division lent their skills to Wyoming. Compiled in 2014, the HAZUS Flood Loss Estimates table **(Table 3.6.7)** includes building and contents value loss estimates, % building damage, per capita loss, and displaced population and shelter needs estimates for each county.

Table 3.6.7 - HAZUS Loss Estimates - Flood

County	Building Damage Count	Building Loss ($K)*	% Building Damage	Contents Loss ($K)*	% Contents Loss	Total Loss** ($K)*	Per Capita Loss ($)*	Short Term Shelter	Displaced Population	% Short Term Shelter
Albany	132	$12,357	0.50%	$15,170	1.00%	$28,526	$786	985	1,528	64%
Big Horn	605	$67,808	8.30%	$72,226	13.80%	$143,642	$12,311	1,059	2,272	47%
Campbell	85	$15,585	0.70%	$23,858	1.50%	$41,518	$900	515	1,029	50%
Carbon	131	$20,650	1.60%	$26,242	3.20%	$48,340	$3,043	223	1,151	19%
Converse	50	$10,055	1.10%	$8,750	1.40%	$19,195	$1,388	219	590	37%
Crook	67	$8,346	1.80%	$7,960	2.70%	$16,652	$2,351	170	425	40%
Fremont	221	$30,422	1.30%	$34,732	2.20%	$67,539	$1,683	1,140	2,445	47%
Goshen	201	$17,602	2.00%	$18,545	3.10%	$37,726	$2,847	770	1,297	59%
Hot Springs	133	$17,946	4.80%	$33,733	13.50%	$53,351	$11,087	375	712	53%
Johnson	17	$6,426	1.10%	$7,274	2.00%	$14,104	$1,646	23	269	9%
Laramie	157	$29,515	0.50%	$57,832	1.40%	$89,850	$979	755	1,458	52%
Lincoln	8	$7,499	0.60%	$11,751	1.50%	$20,112	$1,111	92	603	15%
County	***Building***	***Building***	***%***		***%***	***Total***	***Per***	***Short***	***Displaced***	***% Short***

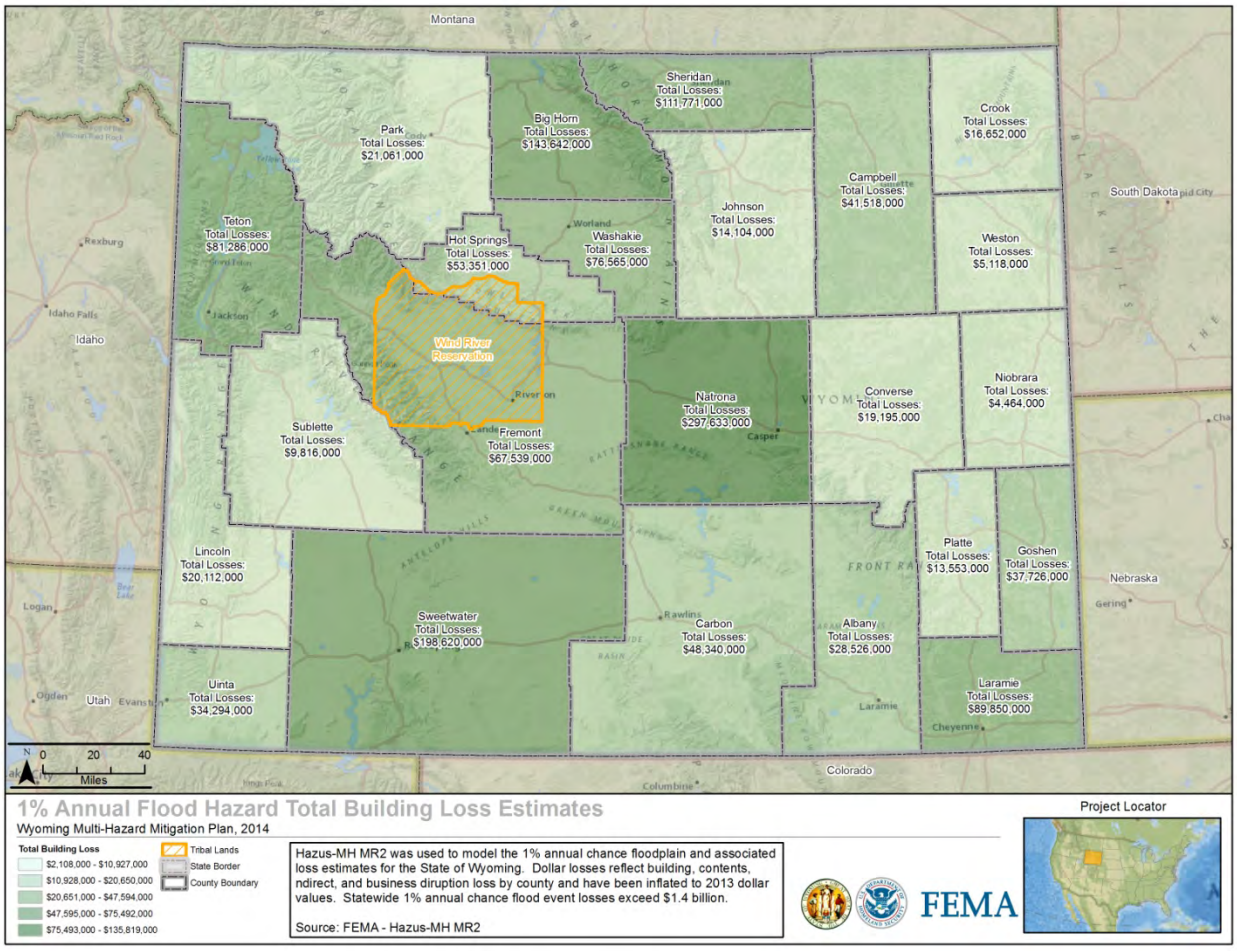
	Damage Count	*Loss ($K)**	*Building Damage*	*Contents Loss ($K)**	*Contents Loss*	*Loss** ($K)**	*Capita Loss ($)**	*Term Shelter*	*Population*	*Term Shelter*
Natrona	1,866	$135,819	2.70%	$149,814	4.20%	$297,633	$3,945	5,740	7,049	81%
Niobrara	6	$2,108	1.20%	$2,269	1.80%	$4,464	$1,797	97	223	43%
Park	27	$10,927	0.50%	$9,644	0.70%	$21,061	$747	82	533	15%
Platte	16	$6,481	1.00%	$6,697	1.50%	$13,553	$1,564	92	455	20%
Sheridan	471	$47,594	1.70%	$60,314	3.00%	$111,771	$3,839	2,095	3,566	59%
Sublette	3	$4,565	0.70%	$4,908	1.20%	$9,816	$958	16	300	5%
Sweetwater	543	$75,492	2.60%	$112,330	5.90%	$198,620	$4,534	1,550	2,230	70%
Teton	334	$39,559	1.90%	$39,949	3.00%	$81,286	$3,817	1,965	2,869	68%
Uinta	155	$15,966	1.10%	$17,278	1.90%	$34,294	$1,624	922	1,439	64%
Washakie	195	$27,453	4.50%	$44,180	10.50%	$76,565	$8,973	730	1,278	57%
Weston	7	$2,520	0.50%	$2,464	0.80%	$5,118	$710	13	123	11%
Statewide	5,430	$612,695	1.58%	$767,919	2.95%	$1,434,732	$2,546	19,628	33,844	58%

2013 Dollars

****Total Loss is the sum of the building and content losses as well as indirect and business disruption losses***

The Statewide Floodplain Boundary map (above, **Map 3.6.6**) shows the statewide flood hazard. It was completed using the best available data, a combination of regulatory Digital Flood Insurance Rate Maps (DFIRM) and FEMA's HAZUS-MH MR2 study. Below is a a map depicting the total loss estimates should the 100 year flood occur for each Wyoming County (**Map 3.6.8**).

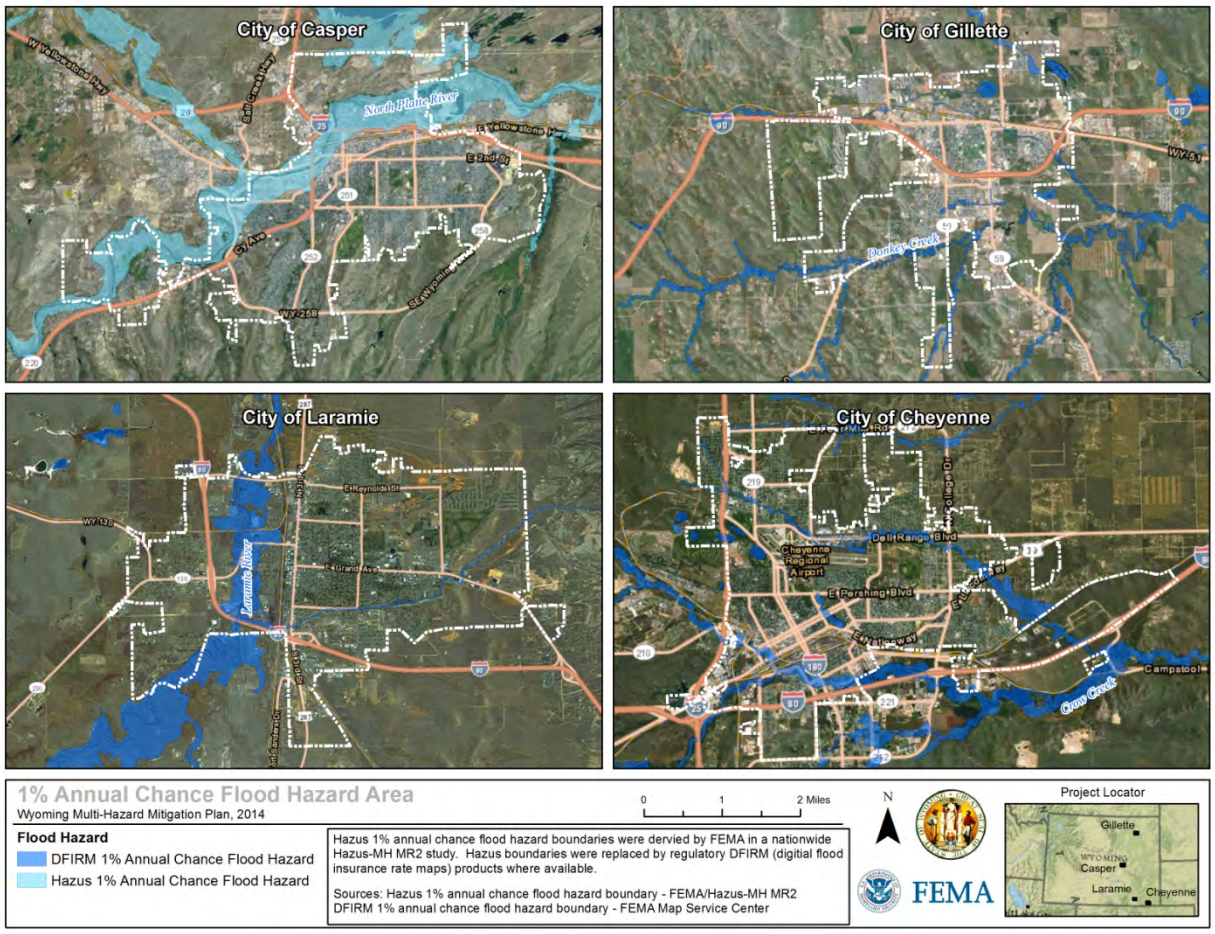
Map 3.6.8 – 1% Annual Flood Hazard Total Building Loss Estimates



When summed together the total estimated statewide flood losses exceed $1.4 billion for Wyoming.

A map was also prepared for four of Wyoming's largest municipalities, depicting the area in each community which is susceptible to a 1% chance of flooding each year, sometimes referred to as the '100-year flood.' (**Map 3.6.9**) These four communities have experienced significant development over the past several years, making it important to appropriately regulate and monitor development in the flood hazard area.

Map 3.6.9 – 1% Annual Chance Flood Hazard Area, Casper, Cheyenne, Gillette, Laramie



History

The documented flood history for Wyoming extends back to July 1895 in Casper, Wyoming. The flood produced a 20-foot-high wall of water sweeping down Garden Creek, wiping out a camp of settlers at present-day Westwood School. Three people drowned.

The most damaging flood in Wyoming's history was the August 1, 1985 flood in Cheyenne. The dollar property loss was $65 million. In 2010 dollars the damage would be nearly $132.2 million. Twelve deaths and 70 injuries were associated with that event. The greatest loss of life associated with flooding, however, did not occur in 1985. In September 1923, five days of widespread rainfall caused a 60- to greater than 100-year flood resulting in a railroad bridge being washed out east of Casper. The event took 18 lives on September 27, 1923.

Photo 3.6.10 Encampment Flood, June 2008

Another significant flood occurred May 15, 1978. Heavy wet snow and record rains did 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 were downed, with much damage to cars and personal property. Total estimated damages came to $15.5 million.

August 27, 2002 the town of Kaycee in Johnson County was inundated by flash flooding from a storm that struck the southern part of the county. The flooding caused significant devastation, with the Wyoming Office of Homeland Security [then WEMA] reporting a final count on Wednesday, August 28, 2002 of $459,166 in damage, including 19 trailers, 22 houses, and 12 of Kaycee's 15 businesses. **(Photo 3.6.11)**.

Photo 3.6.11—A flash flood on the Middle Fork Powder River west of Kaycee –Two days after the flood

Wyoming experienced significant flooding in 2010 and again in 2011, each resulting in presidential declarations. The flooding in 2011 was more widespread than in 2010. The 2010 flood received a Presidential Declaration on July 14, 2010 and was the result of a sudden warm up creating mountain snow melt, further exacerbated by early spring rains. It impacted Fremont County and portions of the Wind River Indian Reservation which lies within Fremont County. The preliminary damage assessment totaled just over $7 million, reflecting a statewide per capita impact of $14.27.

Photo 3.6.12 - June 2010 Fremont County Flood-Lander 'Sandbox'

Flooding in 2011, resulted in a presidential declaration on July 22, 2011and impacted the Wind River Indian Reservation and 15 of Wyoming's 23 counties. The 2011 flooding was the result of significant mountain snowpack which melted over a two-month period. Preventative action taken by local counties, augmented by Wyoming National Guard Troup assistance and assistance from the Wyoming Office of Homeland Security, resulted in less flood damage than otherwise would have been experienced. Even though the flooding impact was felt throughout the state, the flooding in 2011 resulted in a preliminary damage assessment totaling $4.2 million (statewide per capita impact of $7.61), considerably less that the 2010 flood when only one county was impacted by flooding. The preventative action taken in advance of the spring snow-melt was viewed as a best practice to be re-implemented in future flooding events.

Photos 3.6.13 - June 2011 Statewide Flooding - Berming and Sandbagging

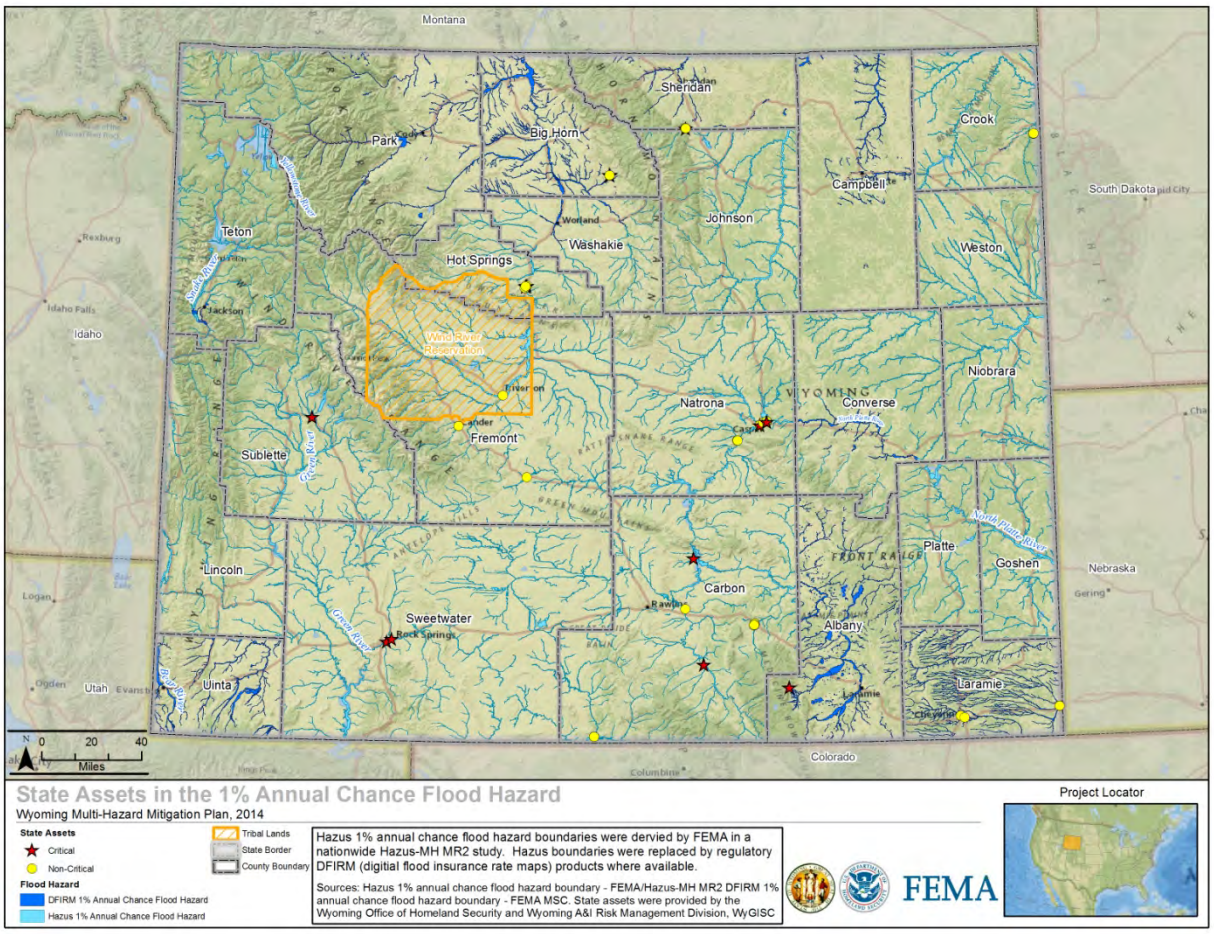
Photo 3.6.13 – Flood Waters on Capital Avenue, Cheyenne, July 15, 1896.

Photograph courtesy of the Wyoming State Archives

State assets are not immune from flood risk. Some state structures are located within the 100-year flood plain. **Map 3.6.14** below shows where state assets intersect with the boundary of the 1% annual chance of flood. The flood hazard boundaries were derived by FEMA in a nationwide HAZUS-MH MR2 study. The HAZUS boundaries were replaced by regulatory Wyoming Digital Flood Insurance Rate Maps (DFIRM) where available.

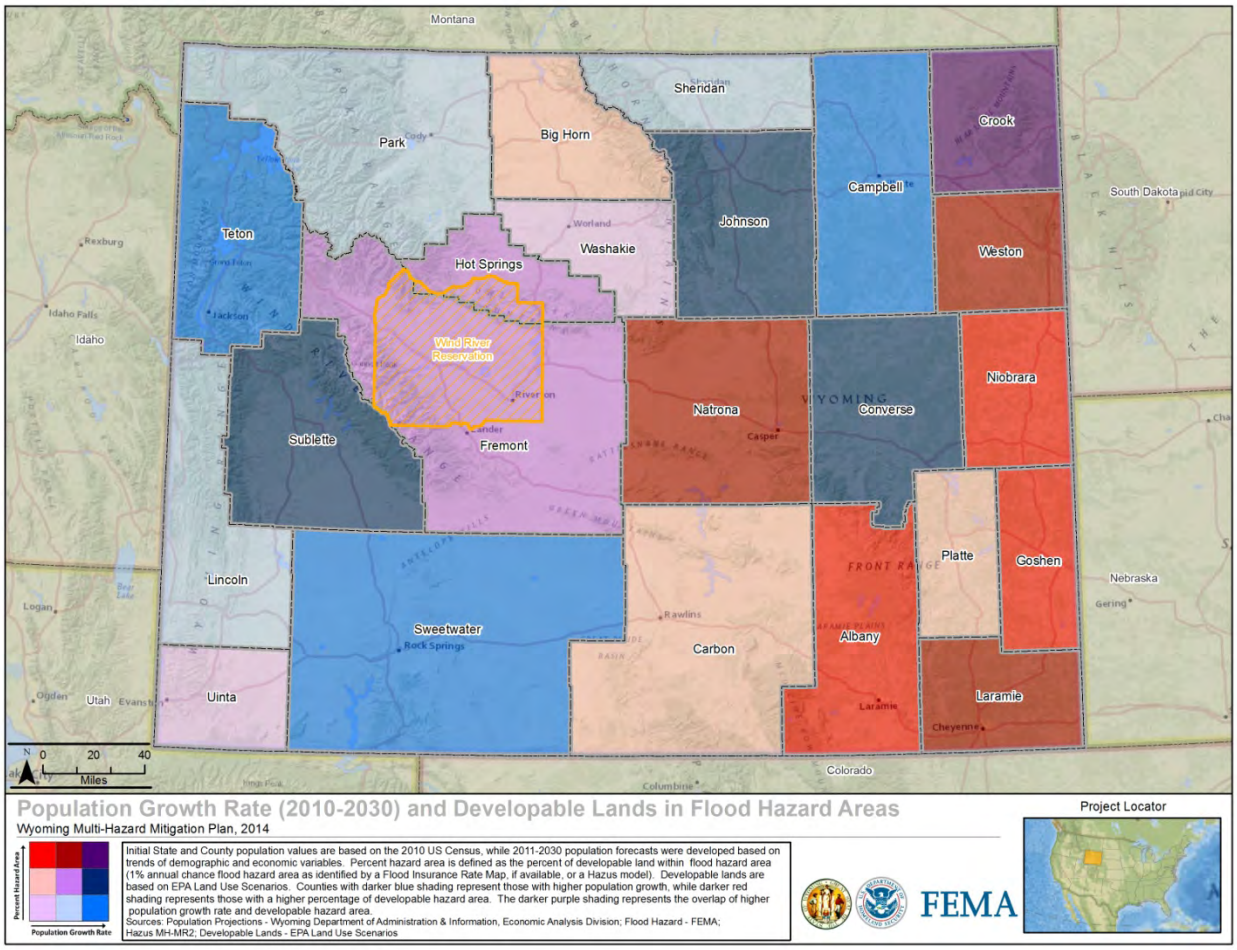
The abbreviated flood history attached (**Appendix J**) was in large part derived from the monthly storm data reports generated and released by the National Oceanic and Atmospheric Administration (NOAA), National Climatic Data Center (NCDC). Other sources are unpublished reports from the Wyoming Office of Homeland Security, newspaper accounts, and periodicals from public libraries. The table is arranged by county in alphabetical order and represents those floods that have caused damage, injuries, or loss of life in addition to other flooding events.

Map 3.6.14 – State Assets in the 1% Annual Chance Flood Hazard



The percentage of developable lands within a county located in high hazard areas was calculated, a matrix was created and the hazard was mapped showing where growth rates intersect with a high percentage of developable lands. This was done using the population growth rates by county (**Appendix L**). With this matrix approach in the map below (**Map 3.6.15**), Counties with darker blue shading represent those with higher population growth rates, while dark red shading represents those with a higher percentage of developable hazard area. The darker the purple shading represents the overlap of high population growth rates and developable hazard areas.

Map 3.6.15 – Intersection of Developable Lands in Flood Hazard Areas and Population Growth Rate 2010-2030



Local Mitigation Plan Risk Assessments

Local flood vulnerability based on risk assessments contained in each county's Multi-Hazard Mitigation Plan have been reviewed by the Wyoming Office of Homeland Security. A summary of local risk assessments are contained in **Table 3.6.14** below. Local plans incorporate risk assessments, GIS maps of 100 and 500 year flood plain maps, and tables related to the National Flood Insurance Program, all obtained from the Wyoming Office of Homeland Security. Because of a lack of resources, Wyoming counties rely heavily on the State Mitigation Plan for the majority of their risk assessments. Limited additional information is added.

Table 3.6.16 – Local Flood Risk Assessments

COUNTY	Plan Y/N	Year Approved	Included in Plan	Loss Potential	Population Impacted	Probability
ALBANY	Y	2010	Y	High	Medium	Medium
BIG HORN	Y	2011	Y	High	Medium	Medium
CAMPBELL	Y	2011	Y	High	Medium	Medium
CARBON	Y	2009	Y	High	Medium	Medium
CONVERSE	Y	2012	Y	Medium	Medium	Medium
CROOK	Y	2013	Y	Medium	Medium	Medium
FREMONT	Y	2012	Y	Medium	Medium	High
GOSHEN	Expired	2007	Y	Low	Low	Medium
HOT SPRINGS	N					
JOHNSON	Y	2013	Y	Medium	Medium	High
LARAMIE	Y	2013	Y	High	Medium	Medium
LINCOLN	Expired	2007	Y	Medium	Low	Medium
NATRONA	Y	2011	Y	Medium	High	High
NIOBRARA	Y	2010	Y	Medium	Low	Low
PARK	Y	2011	Y	Medium	Medium	High
PLATTE	Expired	2004	Y	Medium	Medium	High
SHERIDAN	Y	2009	Y	High	Medium	Medium
SUBLETTE	Expired	2008	Y	Low	Medium	High
SWEETWATER	N					
TETON	Y	2010	Y	High	Low	Low
UINTA	Y	2011	Y	Medium	Medium	Medium
WASHAKIE	Y	2011	Y	High	Medium	Medium
WESTON	N					
NORTHERN ARAPAHO TRIBE	N					
EASTERN SHOSHONE TRIBE	N					

Photo 3.6.17 – 2011 Flooding caused State Highway 130 in Carbon County to wash out. Incident resulted in 4 deaths and 1 injury in the middle of the night.

Flood Probability

Highly Likely = Value 4
385 flood events ÷ 118 years = 3 flood events every year or a >100.0 % annual probability of a damaging flood event

Flood Risk Factor

Flood Risk Factor Value = 3.11 [(Probability Likely 4 x .30) + (Impact 2.6 x .30) + (Spatial Extent 2.8 x .20) + (Warning Time 2.6 x .10) + (Duration 3.1 x .10)]

State Mitigation Strategies - Flood

The following mitigation projects have been proposed by state, federal, and local entities in the process of generating the Wyoming Multi-Hazard Mitigation Plan.

Continue to encourage and promote participation in NFIP.	On-going activity
Locate septic systems in flood prone areas, and work with local jurisdictions to remedy potential problems.	
Study on flood-proofing government buildings and essential/critical facilities in floodplains.	
Active participation in RiskMAP	On-going activity
Flood hazard and flood insurance education.	On-going activity
Generate and publish summary of Wyoming Department of Transportation hydrologic and flood potential assessments.	
Drainage improvement projects.	On-going activity
Precisely locate structures in existing floodplain, and generate cost estimates for raising or removing structures.	
Early warning stream stage continuous recorders with warning function established throughout state.	
Storm-drain inspection and cleaning program.	Removed. This is a maintenance activity.
Provide all-hazards weather radios to all residences in Wyoming.	On-going activity
Identify and inspect shelters in hazard prone areas.	On-going activity
Research feasibility and costs of adding new frontage roads /detour routes to I-80, I-90, and I-25 to prevent significant delay in traffic flow and resultant economic loss and possible loss of life.	
Provide hazards info to shelters, emergency facilities in public buildings, campgrounds, and phone books.	
Provide emergency phones at strategic locations with direct lines to emergency dispatch services.	Removed. Outdated activity as most travelers utilize cell phones.
Develop reseeding plans for losses due to all hazard events.	Removed. Recovery activity.
GIS training for local jurisdictions with emphasis on hazards recognition and analysis for application to mitigation planning.	
Investigate opportunities for developing or improving warning systems as a means to reduce loss of life, damage to property, and economic losses.	On-going activity
Education programs encompassing multi-hazard insurance for business, resident and government application.	On-going activity
Education programs encompassing multi-hazard mitigation for business, resident and government application.	On-going activity
Planning studies regarding transportation of essential and/or key personnel during all hazard events.	Removed. This is a response activity.

Continue outreach to counties on identifying cost effective and feasible mitigation projects.	On-going activity
Promote Continuity of Operations and Continuity of Government, statewide.	On-going activity. A staff person within the Wyoming Office of Homeland Security has this responsibility.
Maintain and continue to expand hazards databases that were generated for the State Hazard Mitigation Plan. Seek new sources of information.	On-going activity
Identify, document, and advertise all volunteer agency's locations and contact information.	On-going activity

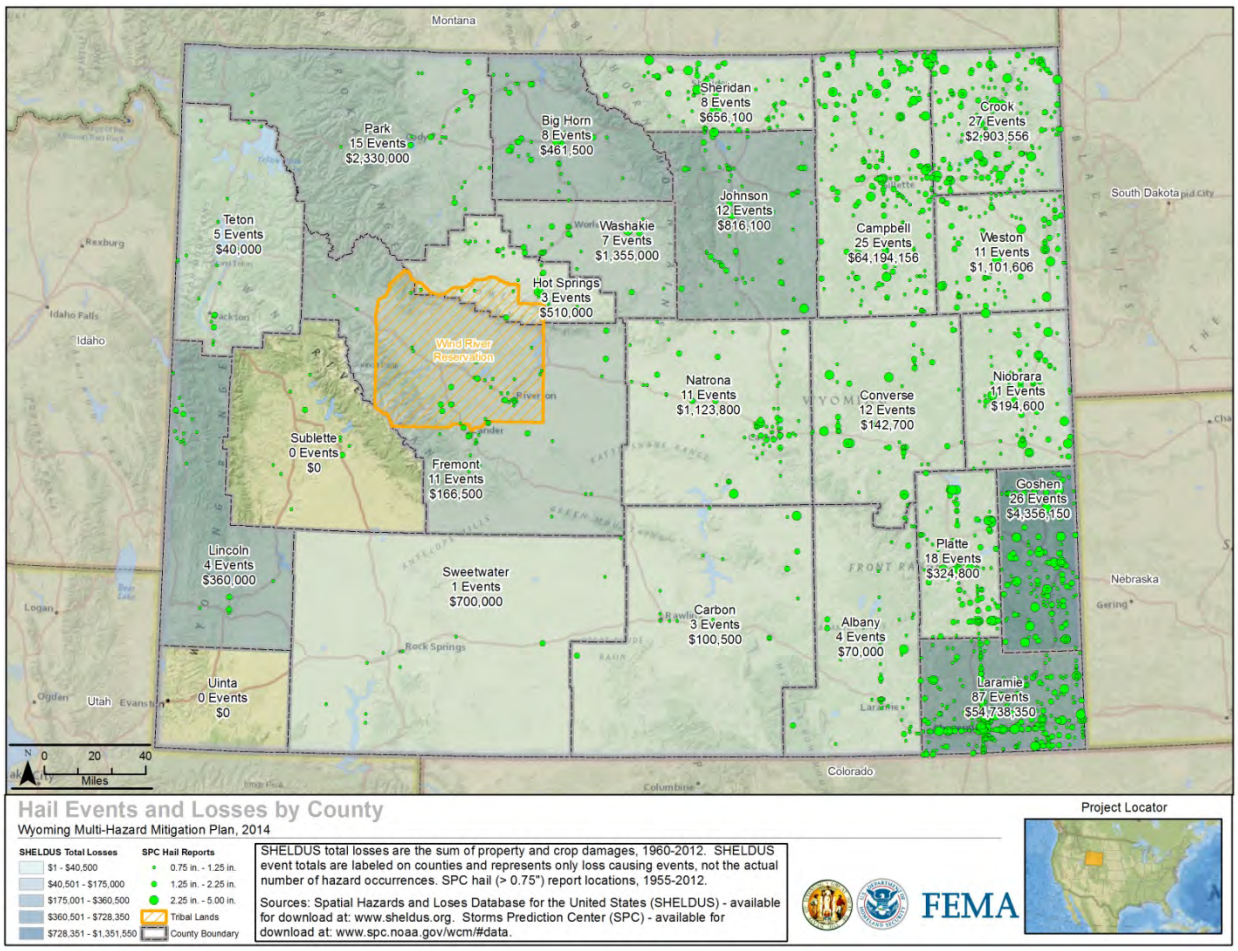
3.7 Hail

Photo 3.7.1 – Hail Damage in Ten Sleep, August 2010

Hail causes more than $1 billion of property damage nationally each year. The southeast corner of Wyoming lies within the nation's "Hail Alley." Together with adjacent portions of Colorado and Nebraska, this region of Wyoming is battered by more hailstorms than any other part of the United States. Climatological data shows this area of Wyoming averages five to nine days of hail annually.

Charts 3.1.4 and **3.1.5** show that though hail represents only nine percent (9%) of the number of hazard incidents recorded in SHELDUS, hail damage ranks #1 and has cost the residents of Wyoming in excess of $136 million, representing 37% of losses from natural hazards. This would indicate there is room for improvement in mitigation activity related to minimizing hail losses.

Map 3.7.2 – Hail Events and Losses by County



History

There have been more than 2,036 reports of hail events documented from June 1926 through April 2007. An additional 142 events were reported between May 2007 and December 2009. There are significant gaps in the record prior to 1926. Continued research is required to complete the data gaps. One of the earliest years on record with significant hail damage was 1962. There was nearly $4 million (over $28.75 million in 2010 USD) in recorded damages. The most damaging event that year occurred in Casper on July 31, 1962. Several inches of hail covered the southern half of Casper causing considerable damage to houses and cars.

Another year in which significant damage occurred across the state was 1977. There were 29 events with measurable damage of almost $15.1 million (nearly $54.5 million in 2010 USD). There were four separate events that each caused over $2.75 million (almost $9.9 million in 2010 USD) in damage. On June 16, 1977, a storm with hail one inch to two inches in diameter cut across Cheyenne from the northwest to the southeast with much damage to houses, cars, trees, and gardens. On July 5, 1977, hail up to one inch fell over an area starting just south of Powell and extending eastward. Most damage was to buildings and cars. On July 11, 1977, hail up to one inch fell over an area between Heart Mountain and Powell. Most damage

was to irrigated crops with some damage to buildings and cars. On July 26, 1977, hail up to 1.75 inches fell in a strip from five to six miles north of Powell to the southeast for 10 miles. Most damage was to irrigated crops with some damage to buildings and cars.

There was also heavy hail damage in 1978, with nearly $12.5 million ($45.3 million in 2014 USD) in reported damage. One storm accounted for much of the damage. On July 31, 1978, two thunderstorms did considerable damage to parts of Cheyenne. Hail up to 3 inches in diameter did estimated $9.0 million ($32.6 million in 2014 USD) damage to homes, property, and vehicles.

In 1979, there were also damages in excess of $9.1 million ($29.6 million in 2014 USD) reported across the state. Damages in excess of $2.75 million ($8.9 million in 2014 USD) occurred in both Sheridan and Fort Laramie.

On July 30, 1979, an extremely large and intense thunderstorm moving through the Cheyenne area caused extensive hail damage to cars, homes, and city buildings. Hail up to two inches in diameter was verified in town with reports of baseball-sized hail south of the city. Damage was in excess of $2.5 million ($8.3 million in 2014 USD). as reported by the Wyoming Tribune Eagle. State Farm Insurance reported more than $3.2 million in claims for the event, and the State of Wyoming All-Hazard Mitigation Plan from December 1999, reported that $16.5 million in damage may have occurred during the storm. The $16.5 million figure was obtained from the Western Insurance Information Service, and may have included damage from Fort Collins, Colorado.

On August 1, 1985, a nearly stationary severe thunderstorm produced the most damaging flash flood on record for Cheyenne and the state. Twelve people lost their lives, 70 were injured, and damage to homes, cars, and businesses was estimated at $65 million ($142.7 million in 2014 USD). At the National Weather Service Forecast Office near the airport, 6.06 inches of rain fell in just over 3 hours. By 1930 MST, in addition to blinding rain, hail up to two inches in diameter and winds to 70 mph were occurring in the Cheyenne area. Many streets turned into 2- to 4-inch deep rivers with large amounts of hail floating on top. Basements of homes and businesses quickly filled up with water and hail as flood waters crashed through doors and windows. Some basements equipped with drains were flooded with two to five feet of hail after the water drained away. In some areas of Cheyenne the hail had piled up into 4- to 8-foot drifts (**Figure 3.7.2**).

Photo 3.7.3 – 1985 Hailstorm in Cheyenne

On September 2, 1986, thunderstorm winds damaged the roof of a house, toppled power poles, and uprooted pine trees on Casper Mountain. Hail up to two inches in diameter moved through Casper, causing extensive damage to vehicles, buildings, and vegetation. Damage was estimated at $29 million ($62.5 million in 2014 USD).

On August 3, 1987, a hailstorm hit Cheyenne with 0.5- to 2-inch-diameter hail. This storm heavily damaged cars at three major car dealerships west of downtown. Many of the cars were severely dented, with numerous broken or cracked windshields. Another hard hit area was F.E. Warren Air Force Base, where numerous vehicles were dented and windows shattered or broken. Three people were slightly injured during the hailstorm. The damage was estimated at $37 million ($76.9 million in 2014 USD).

On July 30, 1993, a number of thunderstorms worked their way through northeast Wyoming. The Gillette area was hit hard, with one report of 4-inch-diameter hail from the central tower at the Gillette airport. There was significant roof and window damage to homes and businesses. No injuries were noted. The damage was reported to be $17 million ($27.8 million in 2014 USD). The Gillette area again experienced $17 million ($27.8 million in 2014 USD) in hail damage on June 21, 2003. Extensive hail damage occurred to roofs and automobiles.

On August 26, 2002, $30 million ($39.4 million in 2014 USD) in hail damage occurred in Cheyenne. Hail from one inch up to 2.75 inches in diameter fell over the central and western parts of Cheyenne. Significant damage was reported to automobiles and roofs.

An abbreviated hail history is presented in **(Appendix K)**. The data were derived from the monthly Storm Data reports generated by the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC). Other sources are unpublished reports from the Wyoming Office of Homeland Security, newspaper accounts, and periodicals from public libraries. The table represents hailstorms that have caused damage, injuries, or loss of life.

Below (**Table 3.7.4**) is a table detailing the number of hail events, injuries and cost of damages by county between 1960 and 2012. You can see from the information available in SHELDUS, there have been 309 hail events generating damages exceeding $136.6 million.

Table 3.7.4 – Hail Events, Casualties, and Damage-County & Statewide – SHELDUS (1960-2012)

County	*Total Events*	*Total Injuries*	*Total Fatalities*	*Total Property Damage*	*Total Crop Damage*	*Total Damage*
Albany	4	0	0	$70,000	$0	$70,000
Big Horn	8	1	0	$101,000	$360,500	$461,500
Campbell	25	2	0	$64,188,606	$5,550	$64,194,156
Carbon	3	0	0	$100,000	$500	$100,500
Converse	12	1	0	$117,550	$25,150	$142,700
Crook	27	4	0	$2,893,056	$10,500	$2,903,556
Fremont	11	0	0	$44,000	$122,500	$166,500
Goshen	26	0	0	$3,004,600	$1,351,550	$4,356,150
Hot Springs	3	1	0	$507,500	$2,500	$510,000
Johnson	12	0	0	$541,050	$275,050	$816,100
Laramie	87	3	0	$54,010,000	$728,350	$54,738,350
Lincoln	4	0	0	$110,000	$250,000	$360,000
Natrona	11	1	0	$1,123,700	$100	$1,123,800
Niobrara	11	0	0	$189,550	$5,050	$194,600
Park	15	0	0	$2,215,000	$115,000	$2,330,000
Platte	18	0	0	$284,300	$40,500	$324,800
Sheridan	8	0	0	$655,500	$600	$656,100
Sublette						
Sweetwater	1	0	0	$700,000	$0	$700,000
Teton	5	2	0	$35,000	$5,000	$40,000
Uinta						
Washakie	7	0	0	$1,180,000	$175,000	$1,355,000
Weston	11	0	0	$1,101,606	$0	$1,101,606
Statewide	**309**	**15**	**0**	**$133,172,017**	**$3,473,400**	**$136,645,417**

As you can see in **Table 3.7.4**, though Laramie County experienced the greatest number of hail events, Campbell County reports the greatest monetary losses from hail. **Table 3.7.5** shows the probability of hail events by county. Laramie County's probability of experiencing a hail event far surpasses those of the other 22 counties.

Photo – Hail - June 16, 2008

http://commons.wikimedia.org/wiki/File:Hail_RichmondHill.jpg Accessed 2/19/14

Table 3.7.5 – Hail Event Frequency

County	*Total Events*	*Time Period*	*Frequency*	*Probability*
Albany	4	52 Years	7.69%	Occasional
Big Horn	8		15.38%	Likely
Campbell	25		48.08%	Likely
Carbon	3		5.77%	Occasional
Converse	12		23.08%	Likely
Crook	27		51.92%	Likely
Fremont	11		21.15%	Likely
Goshen	26		50.00%	Likely
Hot Springs	3		5.77%	Occasional
Johnson	12		23.08%	Likely
Laramie	87		167.31%	Highly Likely
Lincoln	4		7.69%	Occasional
Natrona	11		21.15%	Likely
Niobrara	11		21.15%	Likely
Park	15		28.85%	Likely
Platte	18		34.62%	Likely
Sheridan	8		15.38%	Likely
Sublette	0		0.00%	Unlikely
Sweetwater	1		1.92%	Occasional
Teton	5		9.62%	Occasional
Uinta	0		0.00%	Unlikely
Washakie	7		13.46%	Likely
Weston	11		21.15%	Likely
Statewide	**309**	**52 Years**	**594.23%**	**Highly Likely**

Probability

<1% - Unlikely

1%-10% Occasional

10%-90% Likely

>90% Highly Likely

Local Mitigation Plan Risk Assessments

A review of the local mitigation plans reflects hail as a common hazard among Wyoming counties. Each county has ranked hail risk within their borders based on the population impacted, probability of occurrence within their borders and the property impacted.

Below is a table outlining information mined from the local plans' hail hazard sections. Nearly all counties consider hail to rank as a 'medium' hazard within their borders, with three counties ranking the hazard as 'high.'

Table 3.7.6 – Local Mitigation Plan Risk Assessment-Hail

COUNTY	Plan Y/N	Year Approved	Included in Plan	Rank-High, Medium, Low	Loss Potential
ALBANY	Y	2010	Y	Medium	Not Stated
BIG HORN	Y	2011	Y	High	Historical Totals Only
CAMPBELL	Y	2011	N		
CARBON	Y	2009	Y	Medium	$1.1 million
CONVERSE	Y	2012	Y	High	Medium
CROOK	Y	2013	Y	High	Medium
FREMONT	Y	2012	Y	High	High
GOSHEN	Expired	2007	Y	High	6.8 million
HOT SPRINGS	N				
JOHNSON	Y	2013	Y	High	Medium
LARAMIE	Y	2013	N	High	High
LINCOLN	Expired	2007	Y	Medium	$850,000
NATRONA	Y	2011	Y	Medium	Not Stated
NIOBRARA	Y	2010	Y	Medium	$41,000 avg./event
PARK	Y	2011	Y	High	High
PLATTE	Expired	2004	Y	Medium	$194,000
SHERIDAN	Y	2009	Y	Medium	$7.1 million
SUBLETTE	Expired	2008	N		
SWEETWATER	N				
TETON	Y	2010	Y	Medium	$340,000 +
UINTA	Y	2011	N		
WASHAKIE	Y	2011	Y	High	High
WESTON	N				
NORTHERN ARAPAHO TRIBE	N				
EASTERN SHOSHONE TRIBE	N				

Probability of Hailstorm

Highly Likely = Value 4
309 Hail Events Reported ÷ 52 years = 6 flood events every year or a >100.0 % annual probability of a damaging flood event

Hailstorm Risk Factor

Hailstorm Risk Factor Value = 2.67 [(Probability 4 x .30) + (Impact 1.8 x .30) + (Spatial Extent 2.4 x .20) + (Warning Time 3.3 x .10) + (Duration 1.4 x .10)]

Mitigation Strategies - Hail

Education	
Provide all-hazards weather radios to all residences in Wyoming.	
Identify and inspect shelters in hazard prone areas.	
Research feasibility and costs of adding new frontage roads /detour routes to I-80, I-90, and I-25 to prevent significant delay in traffic flow and resultant economic loss and possible loss of life.	
Provide hazards info to shelters, emergency facilities in public buildings, campgrounds, and phone books.	
Provide emergency phones at strategic locations with direct lines to emergency dispatch services.	
Develop reseeding plans for losses due to all hazard events.	
GIS training for local jurisdictions with emphasis on hazards recognition and analysis for application to mitigation planning.	
Investigate opportunities for developing or improving warning systems as a means to reduce loss of life, damage to property, and economic losses.	
Education programs encompassing multi-hazard insurance for business, resident and government application.	
Planning studies regarding transportation of	

essential and/or key personnel during all hazard events.	
Continue outreach to counties identifying cost effective and feasible mitigation projects.	
Promote Continuity of Operations and Continuity of Government, statewide.	
Maintain and continue to expand hazards databases that were generated for the State Hazard Mitigation Plan. Seek new sources of information.	
Identify, document, and advertise all volunteer agency's locations and contact information.	

3.8 Landslide

Photo 3.8.1 – Landslide between Apine and Jackson Spring 2011

Landslides are one of the most common geologic hazards in Wyoming. Some of the highest landslide densities in the country are found within Wyoming. According to the Wyoming Department of Transportation Geology Program, there are 248 landslide sites around the state impacting Wyoming's roads documented in their database. This includes areas repaired, landslide mitigation projects in process, and locations being monitored. Given the number of landslide sites impacting highways around the state, the probability is high that landslide activity will continue to impact the traveling public using Wyoming's highway system. Landslides also impact residents and businesses who construct structures in areas subject to landslides.

Wyoming landslide areas continue to be monitored and mitigated for landslide activity. In the three years since the last mitigation plan was published WyDOT has expended 17,500 man hours at a cost of nearly $950,000 to remove landslide debris from Wyoming's highway system. Investments of more than $43 million have mitigated 47 landslide areas over the past three years.

One of the largest landslide complexes in the country is located southwest of Cody in northwestern Wyoming. The Carter Mountain landslide is more than 5 miles wide and 20 miles long. Landslides cause damage every year in Wyoming, but because many occur in remote areas, public awareness of their dangers is low. That may change this year.

Early in April 2014 Jackson reported a water main break which resulted in a loss of water to a neighborhood. Shortly thereafter, the break was determined to be the result of a slow-moving landslide in the vicinity of Budge Road in Jackson. Homes and businesses in the vicinity have been impacted, with one home being condemned by the City at the time of this mitigation plan update.

A geologist was hired to assist and evacuation orders were issued for households in the high-risk area to protect life and prevent injury. Businesses in the high-risk area were impacted, with businesses forced to close. The business closings, in turn impacted the livelihood of more than 100 employees.

Employee housing, located at the business sites were also ordered to be evacuated. Employees are not only out of work, they are also unable to stay in their homes. Many of the employees found friends or family to stay with. Some utilized shelters established by the Red Cross.

The landslide continues to be a slowly-developing situation which could continue for months or even years. Ways to mitigate property damage and impacts to the community are being actively pursued at this time. This may be an isolated incident in the community. Given the topography of the area, however, Jackson may be susceptible to future landslides.

There are many types of landslides present in Wyoming. In order to properly describe landslide type, the Geologic Hazards Section of the Wyoming State Geological Survey (WSGS) developed a landslide classification modified from Varnes (1978) and Campbell (1985). As can be seen in **Figure 3.8.2** 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.

Falls and topples are easy to visualize. In a fall, material detached from a steep slope or cliff descends through the air, and may bounce and roll. In a topple, a mass rotates forward on a pivot point. If a toppling mass pivots far enough, a fall may result.

Slides are characterized by shear displacement along one or several surfaces. Two general types of slides are recognized, rotational and translational. In a rotational slide, the surface of rupture is concave upward, and the mass rotates along the concave shear surface. Rotational slides are usually called slumps, and they can occur in bedrock, debris, or earth. In a translational slide, the surface of rupture is a planar or gently undulatory surface. In bedrock and earth, translational slides are usually called block slides if an intact mass slides down the slope. If rock fragments or debris slide down a slope on a distinct shear plane, the movements are called rock slides or debris slides. It is easy to see that confusion can result by applying the term “slide” to all types of landslides.

Lateral spreads are characterized by lateral extension movements in a fractured mass. Lateral spread movements may occur in bedrock and soil as a result of liquefaction or plastic flow of subjacent materials, or in bedrock without a well-defined basal shear surface or zone of plastic flow. Lateral spreads in bedrock without a well-defined zone of shearing or flow, usually occur on ridge crests.

In general, a flow is a moving mass that has differential internal movements that are distributed throughout the mass. While most flows occur in debris and earth, one type of flow, gravitational sagging, does occur in bedrock. Flows in debris and earth can be cohesive or non-cohesive. Both cohesive and non-cohesive flows are further subdivided by water content and material properties.

Cohesive flows in debris include soil creep, solifluction, block streams, talus flows, and rock glaciers. Soil creep is an imperceptibly slow deformation that continues under constant stress. Solifluction is a slow flow in soil that is often observed in areas with perennially or permanently frozen ground. Block streams are slow moving tongues of rocky debris on steep slopes, and are often fed by talus cones. Talus flows are slow flows that occur in the basal portions of talus slopes. Rock glaciers are not true landslides, but have been included in the classification scheme because they are mass movements composed of coarse debris.

Interstitial ice between debris fragments plays a role in the movement of rock glaciers, which are similar in form to a true glacier.

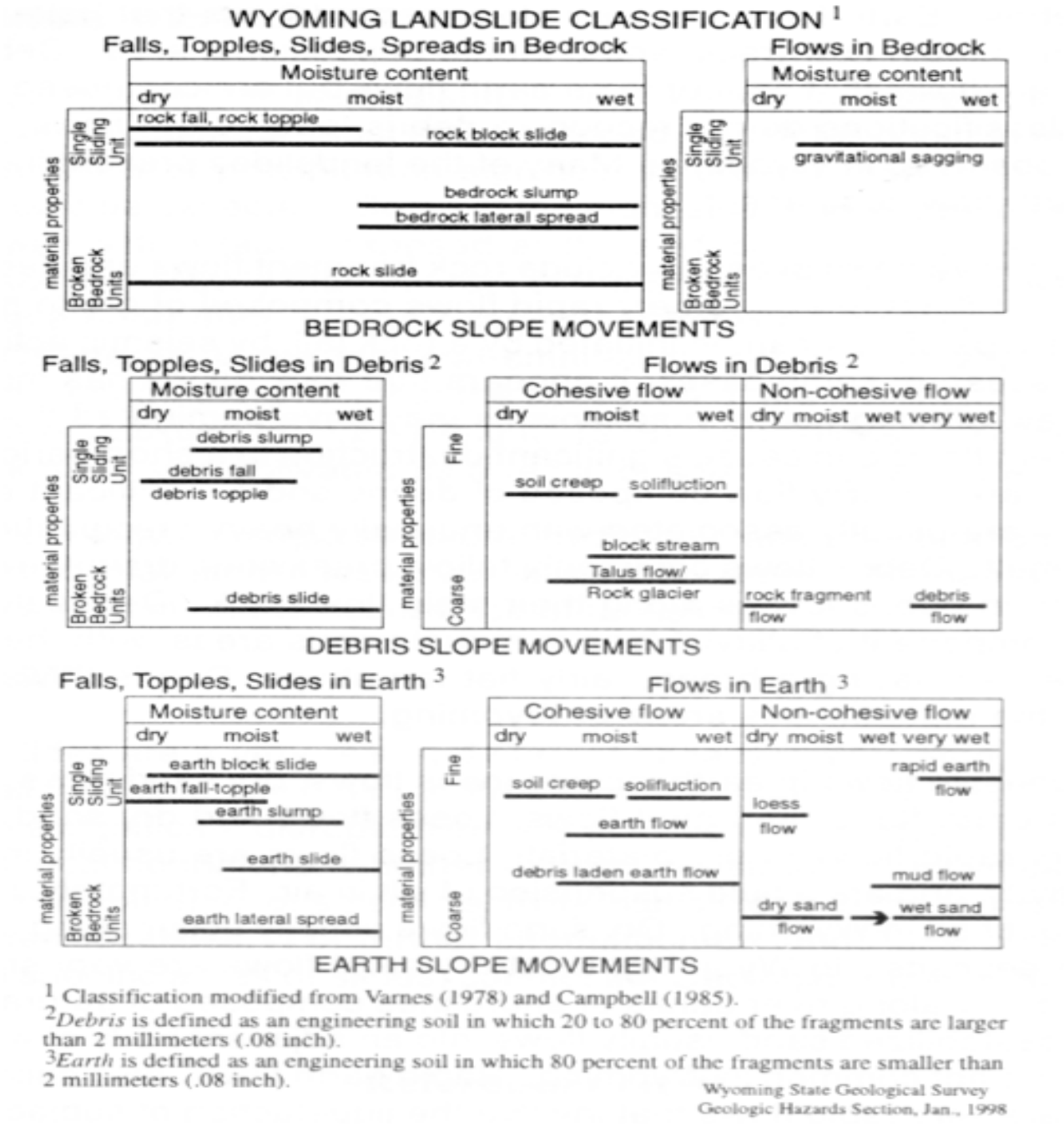
Cohesive flows in earth include soil creep, solifluction, earth flows, and debris laden earth flows. Soil creep and solifluction in earth are similar to those in debris. Earth flows are very slow to rapid flows that have a distinct source area, a main flow track, and a lobate depositional area. Debris laden earth flows are flows that appear to be earth flows but are composed of debris. Standard classifications do not recognize debris laden earth flows, but many have been observed in Wyoming. Many of the landslides present in Wyoming have an earth flow component.

Non-cohesive flows in debris include rock fragment flows and debris flows. Rock fragment flows are extremely rapid flows composed of dry to moist rock debris. This type of flow can be initiated by a rock fall, by seismic activity, or by other processes. In some cases, it appears that rock debris has moved on a cushion of air, although other mechanisms may have dominated the process. Rock fragment flows can cause significant destruction in a short period of time. Debris flows are a slurry flow composed of debris and a significant amount of water. They are usually associated with unusually heavy precipitation or with rapid snowmelt. Debris flows commonly follow preexisting drainage ways, and commonly form debris levees along their main flow track. Debris flows are a significant component of alluvial fans in mountainous areas with the main debris flow deposit having a broad, fairly flat, fan shape. Debris flows are very common in the mountainous areas of Wyoming.

Non-cohesive flows in earth include loess flows, dry sand flows, wet sand flows, rapid earth flows, and mud flows. Loess flows and dry sand flows are rapid to very rapid flows of dry material. Loess flows are usually initiated by seismic activity, and are a fluid suspension of silt in air. Fortunately, none have yet been identified in Wyoming. Dry sand flows usually occur along shorelines or in Aeolian deposits. In Wyoming, most dry sand flows are very small. Wet sand flows occur along river banks or shorelines composed of saturated clean sand. The destabilized sand usually flows into an adjacent body of water. Wet sand flows are not common in Wyoming. Rapid earth flows, also called quick clay flows, are very rapid flows that involve the liquefaction of subjacent material and the entire slide mass. They usually initiate in sensitive materials, such as quick clay, and are not common in Wyoming. Mud flows are slurry flows composed of

earth and a significant amount of water. They differ from debris flows only in the size of their component materials.

Figure 3.8.2 – Wyoming Landslide Classifications



1 Classification modified from Varnes (1978) and Campbell (1985).
2 *Debris* is defined as an engineering soil in which 20 to 80 percent of the fragments are larger than 2 millimeters (.08 inch).
3 *Earth* is defined as an engineering soil in which 80 percent of the fragments are smaller than 2 millimeters (.08 inch).

Wyoming State Geological Survey
Geologic Hazards Section, Jan., 1998

Most landslides mapped in Wyoming are classified as being complex. For example, many landslides in the state are slump/earth flow complexes. That type of landslide is composed of a slump at its head, with the main body and deposit being an earth flow. Block slides often grade into rock slides, which can further grade into earth flows or debris laden earth flows. Such a movement would be classified as a block slide/rock slide/flow complex.

Photo 3.8.2 – Clearing Landslide between Alpine and Jackson, February 2011

History and Distribution of Landslides

The generalized landslide distribution in Wyoming is shown in **Map 3.8.4**. Most of the mapped landslides occur in mountainous areas with levels of precipitation significantly greater than in the state's basins, as would be expected. Some of the highest landslide densities also occur in areas with active faults exposed at the surface, and in areas with higher levels of seismic activity than the rest of the state. To date few studies have been done on the relationship between landslides and seismic activity.

Wyoming roads and highways are where the most significant impact is felt from landslide hazards in Wyoming. Residents and visitors alike are impacted by landslides when roads are impacted by landslides. Landslides cause road closures and can result in significant resource allocation to landslide sites. The state agency most significantly impacted when roads are blocked is the Wyoming Department of Transportation (WyDOT). WyDOT reports 248 locations have active landslide areas impacting roadways. These areas

continue to be monitored and mitigated for landslide activity. In the three years since the last mitigation plan was published WyDOT has expended 17,500 man hours at a cost of nearly $950,000 to remove landslide debris from Wyoming's highway system. Mitigation investments of more than $43 million have mitigated 47 landslide areas over the past three years.

Historical landslides outside the highways in Wyoming are not well defined. There are some notable landslides that have been documented, however.

On June 23, 1925, the lower Gros Ventre landslide north of Jackson activated, damming the Gros Ventre River. The landslide mass was a block slide/rock slide/rock fragment/flow complex. Bedrock is dipping towards the Gros Ventre River, with Tensleep Formation sandstones on top of Amsden Formation shales. The sandstones were fairly saturated with water, and the interface between the sandstones and relatively slippery shales was well lubricated. Small earthquakes may have caused the slope to destabilize, and a large mass of sandstone detached. It moved rapidly downslope, breaking up as it moved. The rapidly moving mass shot across the Gros Ventre River, moved partly up the slope on the opposite valley wall, and settled back into the river, forming a landslide dam and lake. Two years later, on May 18, 1927, the landslide dam partially failed, resulting in flooding and the loss of six lives in Kelly, Wyoming.

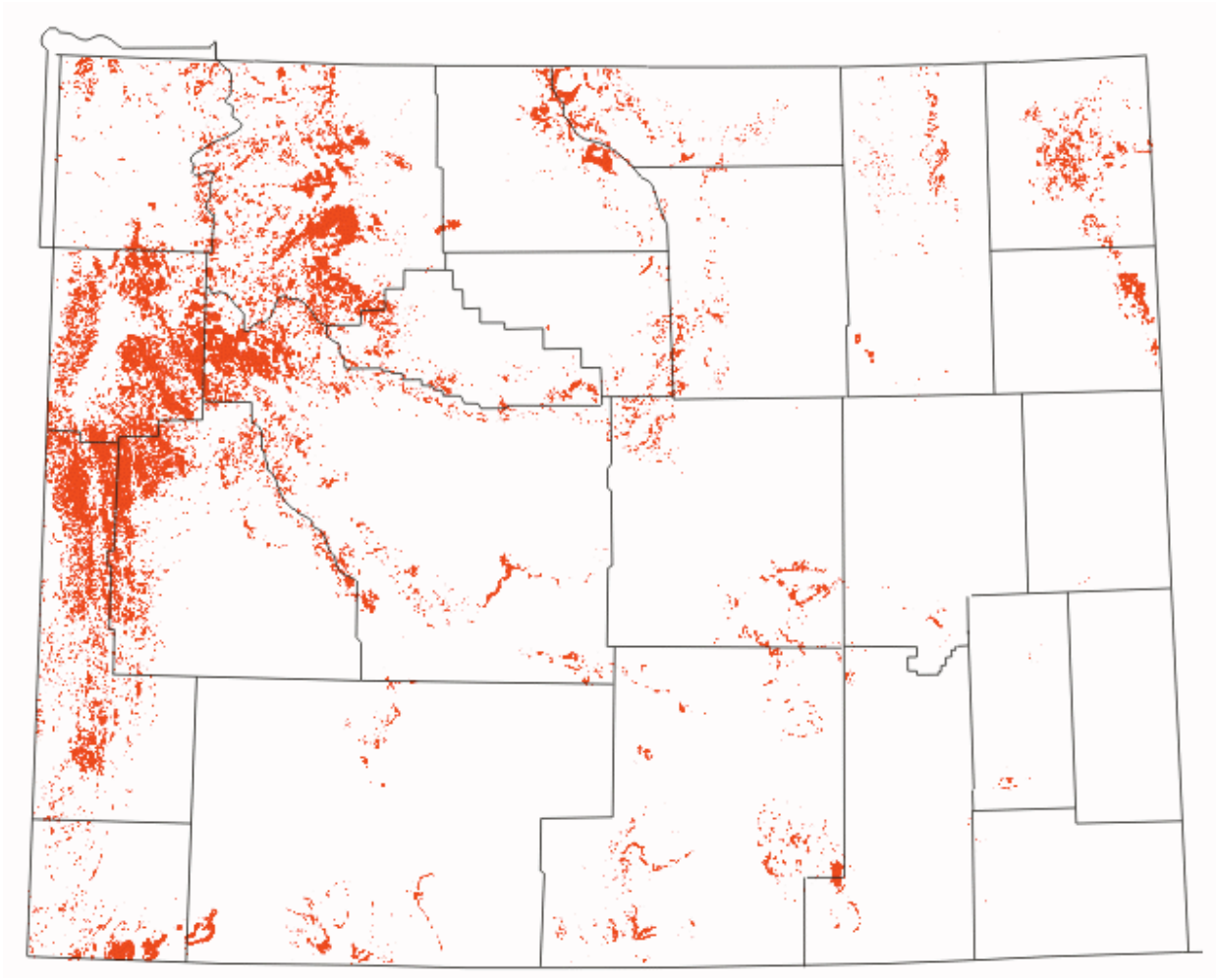
In July, 1937, landslides in the Big Horn Basin destroyed large sections of railroad tracks and washouts swept away a large number of highway bridges. Railroads and highways were washed out and mining property damaged. Heavy flood damage also occurred in the Big Horn Basin, particularly in the Wind River Canyon and in the vicinity of Shoshoni. The damage in the Wind River Canyon resulted from land slides, 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 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.

In the mid-1980s, a slump/flow complex destabilized at Fossil Butte National Monument in Lincoln County. The landslide moved downslope and destroyed the main rail line of the Union Pacific Railroad over a few hundred feet. The line was closed for a number of days, and all rail traffic that would normally be routed through the area had to be diverted through Colorado.

On May 18, 1997, a slump/debris flow complex formed south of Jackson. The debris flow covered and closed U.S. Highway 26/89 through the Snake River Canyon in Teton County. Approximately 300 feet of the highway was covered with up to 15 feet of landslide material. Because of the negative economic impact on the area, the Wyoming Governor declared the area a disaster, and the National Guard was mobilized to help clear the roadway. The road was opened to twice-a-day commuter traffic in three weeks and to full-time traffic in six weeks.

On July 18, 2004, a rockslide/debris flow complex closed the east entrance to Yellowstone National Park on U.S. Highway 14/16/20. The landslide, which was within the park boundaries, closed the road through

Map 3.8.4 – Wyoming Landslide Area Shown in Red



http://www.wrds.uwyo.edu/wrds/wsgs/hazards/landslides/lshome.html Accessed 2/19/2014

traffic until July 24, 2004. Three vehicles were trapped within the landslide mass, and a fourth was stranded. There was an economic impact on Park County because of the reduction in tourist traffic. There have been a number of other debris flow complexes that have closed U.S. Highway 14/16/20 historically, usually east of Yellowstone National Park.

In May 2011 a landslide occurred on Highway 89 between Afton and Jackson. As in the 1997 landslide described above, the May 2011 landslide represented an economic hardship for local residents. Residents living in Afton and working in Jackson were forced to take a 75 mile detour around the landslide into Idaho and over two mountain passes to get to work as Highway 89 is the only direct route between the two towns.

Damage caused by landslide activity is typically to highways within the state and is addressed by the Wyoming Department of Transportation (WyDOT). WyDOT has had recurring problems with landslides in

the Bondurant, Hoback Junction, Snake River Highway, Atlantic City, Miller Mountain, Sheridan, Buffalo, Thayne, and Togwotee Pass areas.

Local geology, geologic structure, hydrology, and precipitation are the primary reasons that landslides occur in specific areas. Human activities such as road and highway construction can also have an effect on the occurrence of landslides.

Photo 3.8.5 – 600-foot long landslide on Highway 70 near Baggs, May 2011

Photo courtesy of Wyoming Department of Transportation

WyDOT estimates that the approximate yearly cost to remove landslides from roads, maintain landslide-damaged roads, and to study or stabilize landslides averages nearly $800,000 (when the outlier costs from 1998 are included in the calculation). The average year results in nearly $300,000 expended on landslide debris removal costs when the costs are averaged from 1999 forward. **Table 3.8.6** below shows the past fifteen years of road repair expenditures by WyDOT resulting from landslides.

Table 3.8.6 – Yearly Cost of Landslide Related Activities – Wyoming Department of Transportation

Yearly Costs of Landslide-Related Activities.	
Fiscal year	**Cost**
1998	$ 8,000,000
1999	$ 396,500
2000	$ 288,900
2001	$ 194,300
2002	$ 157,200
2003	$ 184,300
2004	$ 154,700
2005	$ 237,700
2006	Not available
2007	$ 216,400
2008	$ 347,200
2009	$ 377,100
2010	$ 461,000
2011	$ 356,688
2012	$ 268,149
2013	$ 322,987

Local Mitigation Plan Risk Assessments

Local mitigation plans recognize landslides as a hazard within their borders. They have ranked landslide risks within their borders based on population impacted, probability of occurrence and property impacted. The table below (**Table 3.8.7**) outlines local risk to each county from landslide hazards.

Park County, located in the Northwest corner of the state and dominated by national forest and mountainous terrain, notes that landslides impact to property is high within their county, but with a medium probability

Table 3.8.7 – Local Landslide Risk

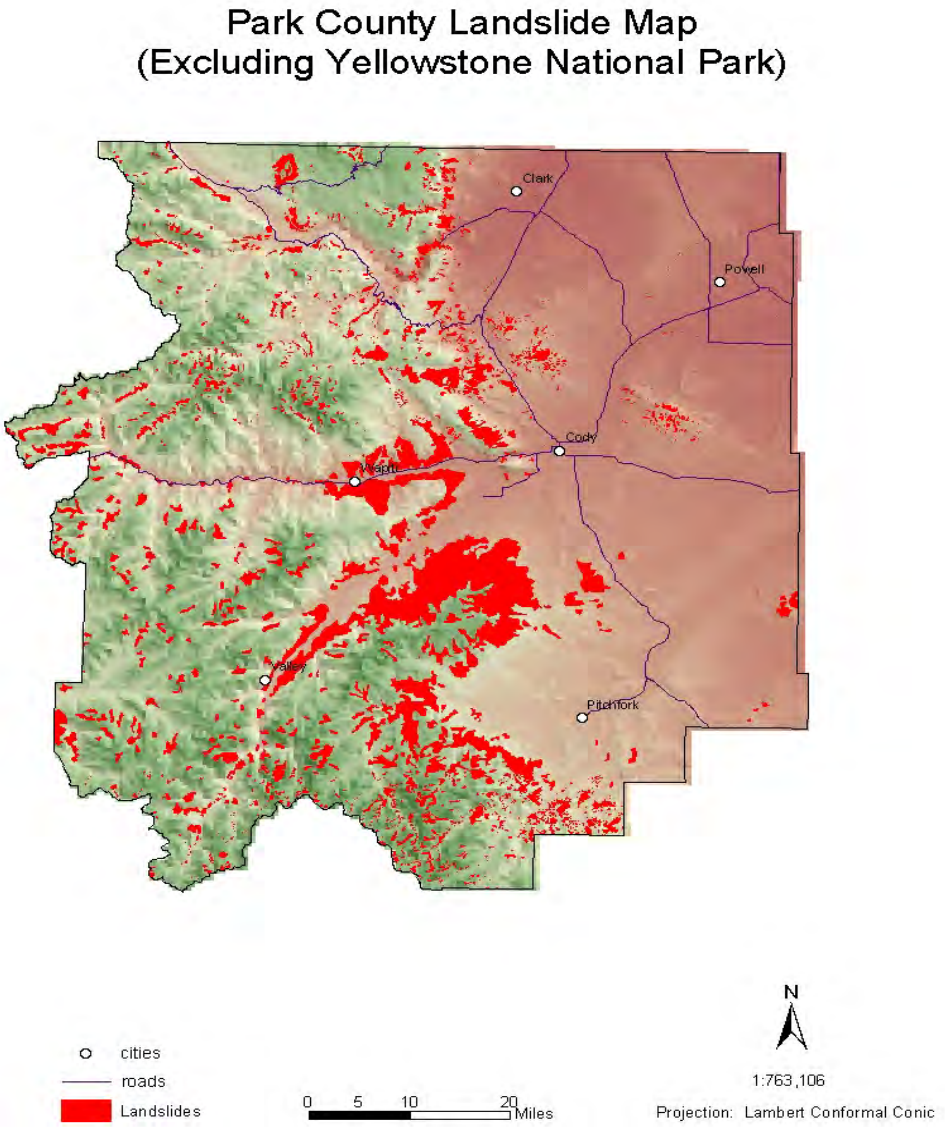
COUNTY	Plan Y/N	Year Approved	Included in Plan	Rank-High, Medium, Low
ALBANY	Y	2010	Y	Low
BIG HORN	Y	2011	N	
CAMPBELL	Y	2011	Y	Medium
CARBON	Y	2009	Y	Low
CONVERSE	Y	2012	Y	Low
CROOK	Y	2013	Y	Low
FREMONT	Y	2012	Y	Medium
GOSHEN	Expired	2007	N	
HOT SPRINGS	N			
JOHNSON	Y	2013	Y	Low
LARAMIE	N	2013	Y	
LINCOLN	Expired	2007	Y	Low
NATRONA	Y	2011	Y	
NIOBRARA	Y	2010	Y	Low
PARK	Y	2011	Y	Medium
PLATTE	Expired	2004	Y	Low
SHERIDAN	Y	2009	Y	Medium
SUBLETTE	Expired	2008	Y	Medium
SWEETWATER	N			
TETON	Y	2010	Y	Medium
UINTA	Y	2011	N	
WASHAKIE	Y	2011	Y	Low
WESTON	N			
NORTHERN ARAPAHO TRIBE	N			
EASTERN SHOSHONE TRIBE	N			

of occurrence, and low population impacted. Park County's landslide map below (**Map 3.8.8**) shows areas impacted by landslide hazard represents a significant portion of the county.

Probably due to the relative slow movement inherent to Wyoming's landslide hazard which makes loss of life less likely, Wyoming counties consider landslides to be a medium or low-risk hazard from a local perspective. Landslides in Wyoming typically occur in less populated areas, with most significant losses to

transportation nodes, namely roads and highways, rather than personal property. The most significant impact tends to be when no alternative route exists between populated areas and access is blocked by the presence of a landslide.

Map 3.8.8 – Park County Landslide Map



Counties in eastern plains regions of the state reflect little-to-no risk associated with landslides and do not analyze the risk. Others, like Park and Albany County, do expect landslides to occur within their borders. Most county plans reflect landslide areas are outside heavily populated areas. Risk is still associated with those areas, as landslide areas tend to be picturesque, 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.

Probability of Landslide

Highly Likely = Value 4
Multiple Annually Reported ÷ 15 years = # Landslide events every year or a >100.0 % annual probability of a Landslide event

Landslide Risk Factor

Landslide Risk Factor Value = 2.5 [(Probability 4 x .30) + (Impact 2 x .30) + (Spatial Extent 1 x .20) + (Warning Time 3 x .10) + (Duration 2 x .10)]

Mitigation Projects Accomplished or In Progress- WyDOT

PROJECT DESCRIPTION	PROJECT	2011	2012	2013	Grand Total
ALPN-HOBK/BLUE TRAILS SLIDE	N103106	1,243,479.83	1,953,829.45	193,294.08	3,390,603.36
CAPS-KAYC/CASTLE CR SLIDE	I254152	632,459.51	1,555,844.26	4,909.52	2,193,213.29
ER/ALPN-HOBK/DOUBLE DRAW SLIDE	N103107	66,951.52	510,893.85	18,794.87	596,640.24
ER/BRET SLIDE/MP 29.1/US 14	DR50924	42,192.28	917,142.74	193,387.49	1,152,722.51
ER/GRANITE CR SLIDE/31.5/US 14	DR50897	354,840.10	808,963.86	37,104.11	1,200,908.07
ER/GREY-BURG/SHELL FALLS SLIDE	DR50926	8,999.55	300,063.00	123.97	309,186.52
ER/GREY-BURG/SLIDE	DR50964	926.89	69,868.78	347,096.92	417,892.59
ER/I90, MP1-16.3, SLIDES	DR41300	48,589.67	11,086.78		59,676.45
ER/I-90/EB/4.8 LANDSLIDE	DR41323	5,739.71	433,339.08	486.81	439,565.60
ER/I-90/WB/16.3/LANDSLIDE	DR41314	8,016.57	908,094.68	1,564.44	917,675.69
ER/I-90/WB/7.8 LANDSLIDE	DR41324	4,752.67	622,538.04		627,290.71
ER/MOOR-SUND/LOGCABIN SLIDE	DR41320	2,866.96	141,961.18	535.54	145,363.68
ER/MRAN-DUBO/QUARANTINE SLIDE	DR50933	29.73	422,104.90	39,155.28	461,289.91
ER/MRAN-DUBO/SLIDE	DR50927		10,080.43	55,463.65	65,544.08
ER/MRAN-DUBO/SLIDE/LAVA CK	DR50966		29,043.48	9,535.25	38,578.73

ER/UPPER SHELL SLIDE/29.5/US14	DR50925	15,722.46	62,370.23	109,783.27	187,875.96
ER/US 14A/SLIDE	DR50914	26,490.99		89,727.82	116,218.81
ER/US14/RUPE HILL SLIDE/197.00	DR41319	8,466.85	139,383.09	405,226.75	553,076.69
ER/US14A CLEAN PIPE SLIDE 69.0	DR50972			8,239.04	8,239.04
ER/US14-EMERGENCY SLIDE REPAIR	DR41296	313,529.22	23,028.62	136.93	336,694.77
FARS-LAND/DOUBLE NICKLE SLIDE	P142045	132,454.82	6,230,017.12	457,191.45	6,819,663.39
FARS-LAND/JOHNNIE LEE SLIDE	P142044	100,470.15	303,750.07	7,683.83	411,904.05
GREY-BURG/SKI AREA SLIDE/33.20	N371035		1,903.06	3,987.05	5,890.11
HULT-ALDN/HULT EAST/SLIDE	0601052			48,041.37	48,041.37
LAND SLIDE	DR51112		14,042.10	10,537.95	24,580.05
LAND SLIDE - CLEAN UP	DR13343			26,841.27	26,841.27
LAND-HUDS/SLIDE	N203066	153,969.61	299,752.76	29,661.63	483,384.00
LANDSLIDE	DR41536		718.52		718.52
LOVL-BURG/SLIDE	P351029	349,128.17	6,626.96	1,706.28	357,461.41
MRAN-DUBO/QS WET MEADOW/SLIDE	N302051			71,899.26	71,899.26
MUDG-CASP/NARROWS/SLIDE REPAIR	N212107	114,426.13	298,221.35	4,911,844.03	5,324,491.51
SHER-UCRS/TIFT SLIDE	DR41810			9,272.45	9,272.45
SLIDE MONITORING	B109036	418.20			418.20
SLIDE MONITORING 2011	B119036	50,154.60	400.40		50,555.00
SLIDE MONITORING 2012	B129066		47,236.82	14,160.60	61,397.42
SLIDE MONITORING 2013	B139066			76,283.09	76,283.09
SLIDE REPAIR-CRACK IN ROAD	DR41444		811.18		811.18
MARSHALL HILL SLIDE	901094	2,250,946.00			2,250,946.00
DEAD DEER SLIDE	901094	646,777.34			646,777.34
CARIBOU SLIDE	DR41302		831,000.00		831,000.00
CRAZY WOMAN SLIDE	I902121			2,989,039.87	2,989,039.87
WYO 70 SLIDE (Dry Sandstone)	DR12295		2,987,514.06		2,987,514.06
RANCHESTER EAST SLIDE	DR41299		895,673.75		895,673.75
THREE PEAT SLIDES	N301027			2,335,073.50	2,335,073.50
UPPER RED CANYON SLIDE	DR41301			885,556.00	885,556.00
DAYTON-BURGESS MP 75.4 US14	DR41305			477,761.00	477,761.00
UPPER MARTEN SLIDE	DR41380			2,007,280.50	2,007,280.50
Grand Total		**6,582,799.53**	**20,837,304.60**	**15,878,386.87**	**43,298,491.00**

Mitigation Strategies: Landslide

Apply soil stabilization measures to minimize or	Ongoing activity

prevent impacts to roadways	
Manage development in landslide hazard areas	
Limit activity that strips slopes of top soil in landslide hazard areas	
Stabilize vegetation on steep, publicly-owned slopes	Ongoing activity
Monitor landslide-prone areas (manually & through use of technology)	Ongoing activity
Install catch-fall nets for rocks at steep slopes near roadways	Ongoing activity
Improve set-backs at land-slide prone locations	Ongoing activity

3.9 Lightning

Lightning remains a certain danger in 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 (**Map 3.9.2**). Lightning's unpredictable nature causes it to be one of the most feared weather elements.

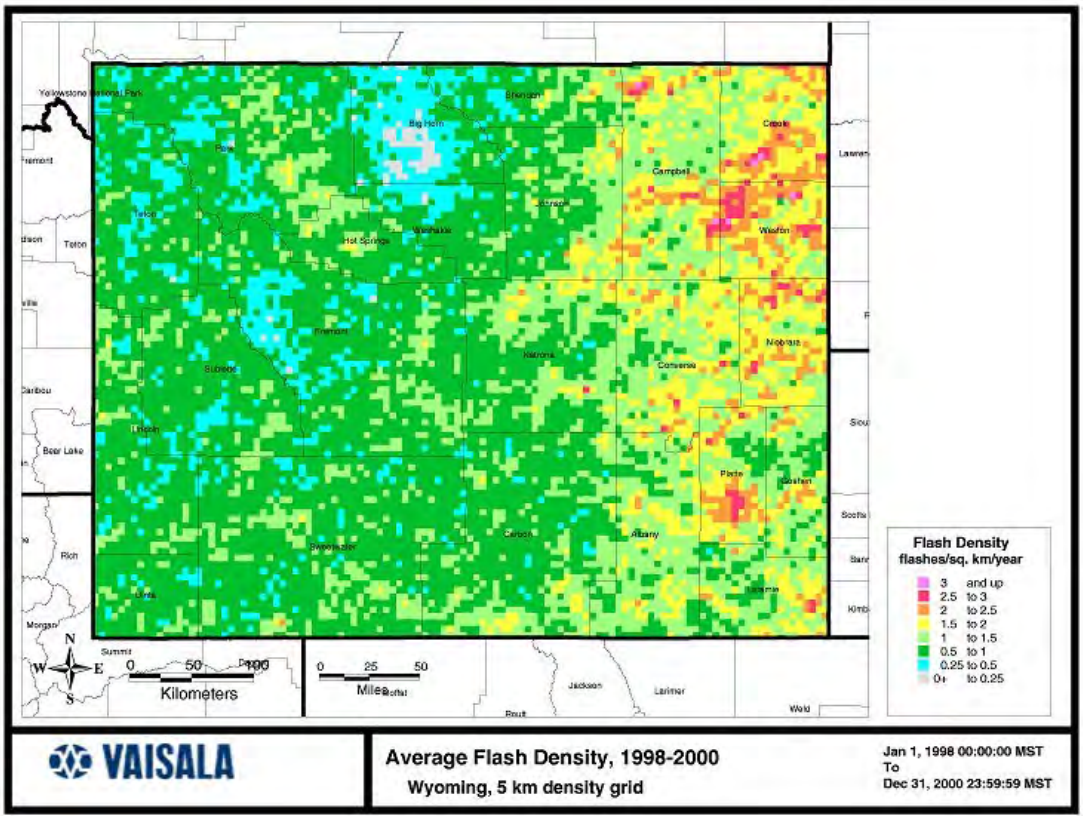
Photo 3.9.1 – Lightning over Devils Tower

Photograph courtesy of Christopher McLeod

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 climbers in jeopardy without warning. Hikers and climbers above the timberline should plan to be off exposed mountain tops and ridges by 1400 MST during the summer months to avoid being struck by lightning unless proper shelter is available (Wyoming Climate Atlas).

A history of recorded lightning events in Wyoming can be found in Appendix M. Nationwide lightning strikes are routinely monitored by Vaisala, Inc. with accuracies to within a 1 kilometer resolution. For the period of 1998 through 2000, the Wyoming annual lightning strike frequency is depicted in **Map 3.9.2**. Clearly the eastern plains have more than three times the cloud to ground lightning strikes as does the western half of the state. Platte, Weston, Crook, and parts of Campbell, Niobrara, and Laramie counties are the most active in the state. These values probably vary by 50% in a year depending on whether there is a drought or enhanced monsoonal flow. However, the locations of maximum and minimum strikes do not change much from year to year.

Map 3.9.2 – Average annual lightning flash density 1998-2000



Lightning is the leading cause of wildland fires in Wyoming (**Map 3.9.3**), and indirectly is responsible for millions of dollars worth of fire damage. Whether in a drought or wet period, Wyoming's hot and windy summers can cause rapid changes to the fire risk over grasslands and forests.

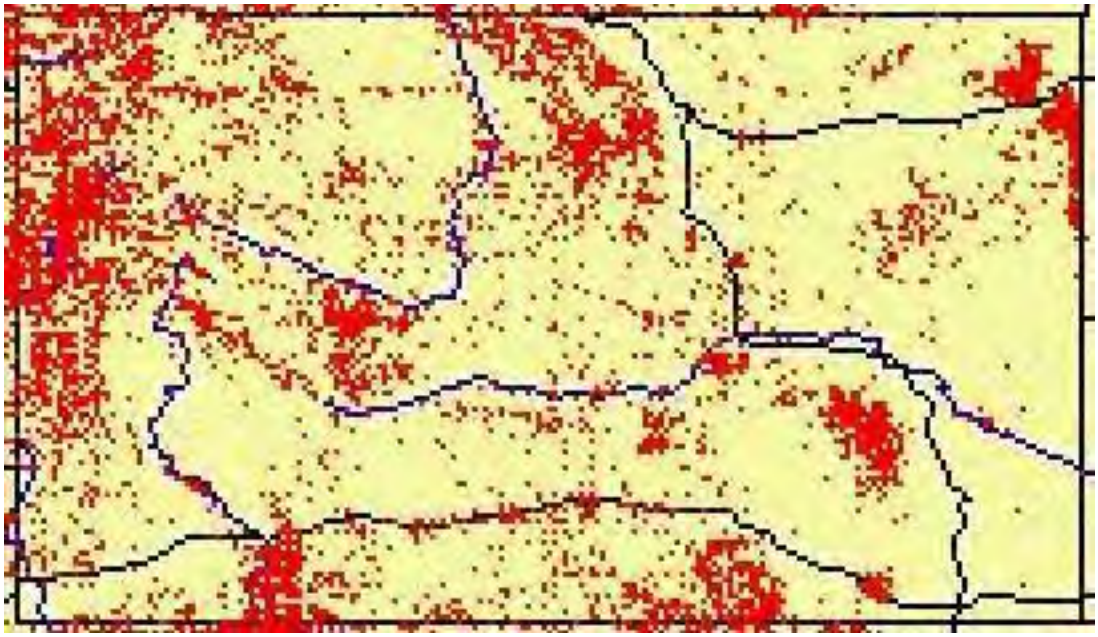
In **Map 3.9.3** a 31-year record of lightning-caused wildfires as well as the percent of lightning-induced wildfires is shown. The worst events occurred in July and August 1988, when, according to the U.S. Bureau of Land Management, lightning ignited 29 fires, setting 4159 acres ablaze, resulting in a total of $780,330 in damage.

Historical trends demonstrate that lightning will continue to be the leading cause of wildland fires in the state, and it will maintain dominance in the eastern plains of Wyoming. Given the greater likelihood of lightning in the eastern plans of Wyoming, counties most likely to be impacted by lightning and the potentially resulting wildland fire are Crook, Weston, Niobrara, Goshen, Laramie, Platte, Converse and Campbell Counties. However, as documented by the Average Flash Density Map above (**Map 3.9.2**), all counties are subject to lightning.

Due to the nature of lightning, those at greatest risk for life-threatening lightning hazard impacts fall within two categories: those enjoying outdoor activities and those in poor health who rely on electricity. Outdoorsmen are susceptible to direct lightning strikes and/or to wildfire started by lightning. Individuals reliant on electricity to meet day-to-day health needs, those reliant on oxygen machines for example, may

be impacted by lightning because of lightning-caused power outages. Both of these groups are susceptible to serious injury or death.

Map 3.9.3 – Lightning-induced fire source points 1970-2000



Source: Wyoming Climate Atlas

Historical losses experienced as a result of lightning events are highlighted on a county-by-county basis in the map below (**Map 3.9.4**).

SHELDUS records there have been 208 lightning events in Wyoming over the past 52 years resulting in 28 deaths and 137 injuries. Lightning events in Wyoming result in more than one injury for every two events and more than one death for every ten events, or one death every two years and an injury every 1 ½ years. (**Chart 3.1.6** & **Table 3.9.6**) While the monetary losses are also significant over the past 52 years ($2.9 million), the loss of life and injuries resulting from lightning are particularly concerning. Educating the public on the dangers represented by lightning should be considered as a high-priority mitigation activity. Further, educating the public on actions to take to minimize lightning risk should be included in the messaging.

Map 3.9.4 – Lightning Events and Losses by County

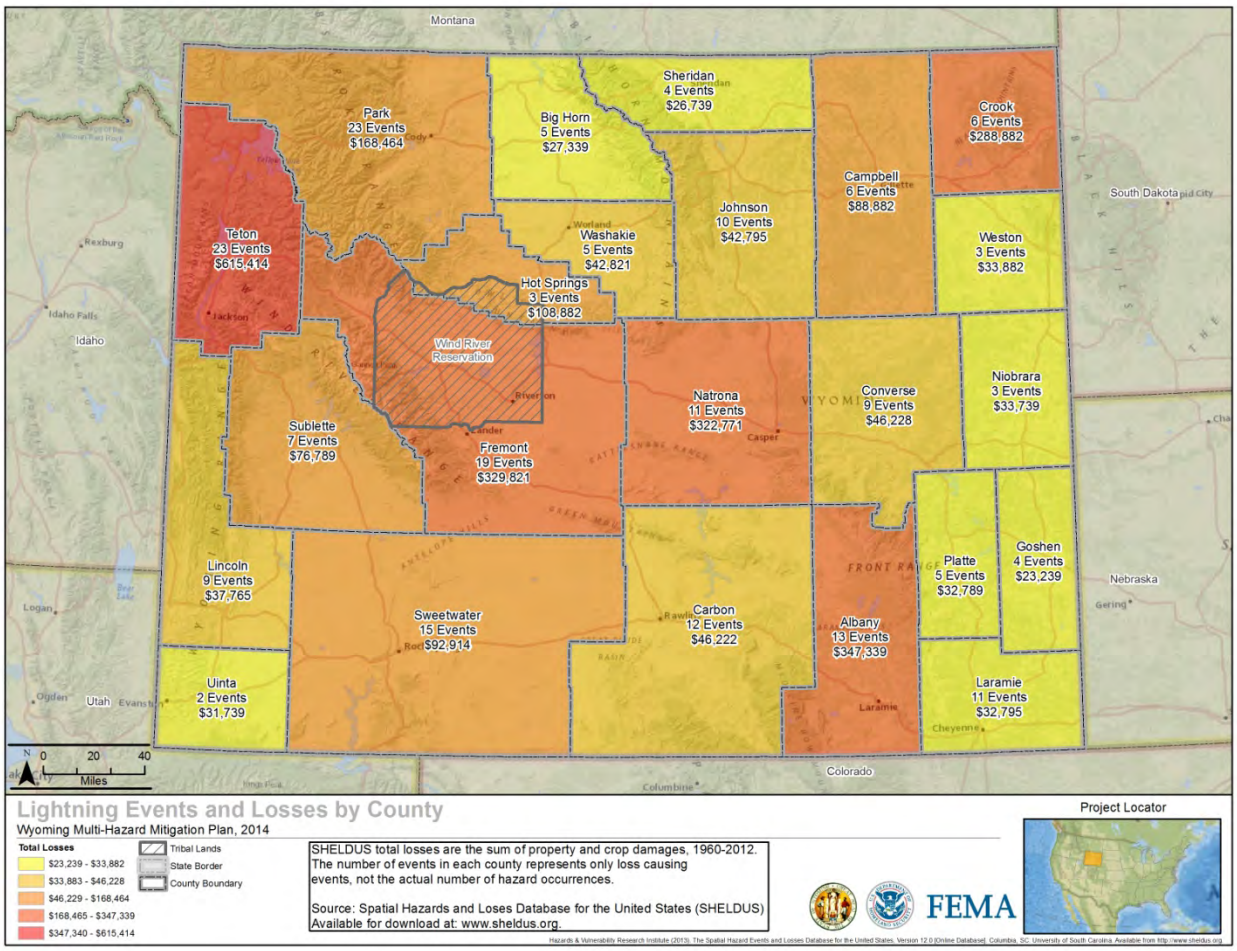


Table 3.9.6 – Lightning Events, Injuries, Fatalities and Damage

County	*Total Events*	*Total Injuries*	*Total Fatalities*	*Total Property Damage*	*Total Crop Damage*	*Total Damage*
Albany	13	2	3	$342,339	$5,000	$347,339
Big Horn	5	3	1	$27,339	$0	$27,339
Campbell	6	1	0	$88,882	$0	$88,882
Carbon	12	5	4	$40,222	$6,000	$46,222
Converse	9	0	3	$41,228	$5,000	$46,228
Crook	6	2	0	$288,882	$0	$288,882
Fremont	19	7	3	$289,821	$40,000	$329,821
Goshen	4	0	2	$23,239	$0	$23,239
Hot Springs	3	0	0	$108,882	$0	$108,882
Johnson	10	14	1	$42,795	$0	$42,795
Laramie	11	7	1	$32,795	$0	$32,795
Lincoln	9	6	1	$37,265	$500	$37,765
Natrona	11	3	0	$322,771	$0	$322,771
Niobrara	3	0	0	$30,739	$3,000	$33,739
Park	23	12	2	$168,464	$0	$168,464
Platte	5	7	0	$31,789	$1,000	$32,789
Sheridan	4	2	1	$26,739	$0	$26,739
Sublette	7	5	2	$34,789	$42,000	$76,789
Sweetwater	15	9	1	$92,914	$0	$92,914
Teton	23	51	2	$615,414	$0	$615,414
Uinta	2	0	0	$31,739	$0	$31,739
Washakie	5	1	1	$42,821	$0	$42,821
Weston	3	0	0	$33,882	$0	$33,882
Statewide	**208**	**137**	**28**	**$2,795,750**	**$102,500**	**$2,898,250**

County	*Total Events*	*Time Period*	*Frequency*	*Probability*
Albany	13	52 Years	25.00%	Likely
Big Horn	5		9.62%	Occasional
Campbell	6		11.54%	Likely
Carbon	12		23.08%	Likely
Converse	9		17.31%	Likely
Crook	6		11.54%	Likely
Fremont	19		36.54%	Likely
Goshen	4		7.69%	Occasional
Hot Springs	3		5.77%	Occasional
Johnson	10		19.23%	Likely
Laramie	11		21.15%	Likely
Lincoln	9		17.31%	Likely
Natrona	11		21.15%	Likely
Niobrara	3		5.77%	Occasional
Park	23		44.23%	Likely
Platte	5		9.62%	Occasional
Sheridan	4		7.69%	Occasional
Sublette	7		13.46%	Likely
Sweetwater	15		28.85%	Likely
Teton	23		44.23%	Likely
Uinta	2		3.85%	Occasional
Washakie	5		9.62%	Occasional
Weston	3		5.77%	Occasional
Statewide	**208**	**52 Years**	**400.00%**	**Highly Likely**

Probability

<1% - Unlikely

1%-10% Occasional

10%-90% Likely

>90% Highly Likely

Below is a table (**Table 3.9.7**) outlining information from local plans' lightning hazard sections. The table extrapolates the risk perceived by each county, based on population impacted, probability of occurrence within their borders, and property impacted, relative to lightning hazards.

Table 3.9.7 – Local Risk Assessment, Lightning

COUNTY	Plan Y/N	Year Approved	Included in Plan	Rank-High, Medium, Low
ALBANY	Y	2010	Y	Low
BIG HORN	Y	2011	N	
CAMPBELL	Y	2011	Y	High
CARBON	Y	2009	Y	Low
CONVERSE	Y	2012	N	
CROOK	Y	2013	Y	Low
FREMONT	Y	2012	N	
GOSHEN	Expired	2007	Y	Low
HOT SPRINGS	N			
JOHNSON	Y	2013	Y	High
LARAMIE	Y	2013	Y	Low
LINCOLN	Expired	2007	Y	Low
NATRONA	Y	2011	Y	Medium-High
NIOBRARA	Y	2010	Y	Low
PARK	Y	2011	Y	Low
PLATTE	Expired	2004	N	
SHERIDAN	Y	2009	Y	Low
SUBLETTE	Expired	2008	Y	Low
SWEETWATER	N			
TETON	Y	2010	Y	Medium
UINTA	Y	2011	N	
WASHAKIE	Y	2011	Y	Low
WESTON	N			
NORTHERN ARAPAHO TRIBE	N			
EASTERN SHOSHONE TRIBE	N			

Probability of Lightning

Highly Likely = Value 4
208 Reported ÷ 52 years = 4 Lightning events every year or a >100.0 % annual probability of a Lightning event

Lightning Risk Factor

Lightning Risk Factor Value = 2.41 [(Probability: Highly Likely 4 x .30) + (Impact: 1 x .30) + (Spatial Extent: 1 x .20) + (Warning Time: 3 x .10) + (Duration: 1 x .10)]

State Mitigation Strategy – Lightning

Lightning Awareness / Education Program- Develop lightning brochure, post warning signage, PSAs, school teaching program	High priority.
Education program encompassing multi-hazard insurance for business, resident and government application	
Warning systems as a means to reduce loss of life, property damage and economic losses	Ongoing activity.
Protect Critical Facilities and Equipment- Surge protection, lightning rods, grounding equipment, etc. on electronic equipment, communications equipment and critical facilities	Ongoing activity.
Subscribe to lightning monitoring system such as Vaisala	Low priority.
Improve GIS mapping of landslide hazard areas	Medium priority.

3.10 Liquefaction

Liquefaction, in laymen's terms, is when wet soil behaves like a liquid during the shaking caused by an earthquake. A more scientific explanation of liquefaction would be: An event which occurs when water-saturated materials are exposed to seismic waves. 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.

There have been few documented cases of liquefaction in Wyoming, in part due to the abundance of coarse-grained sediments in the alluvial deposits. The most notable event was during the 1959 Hebgen Lake

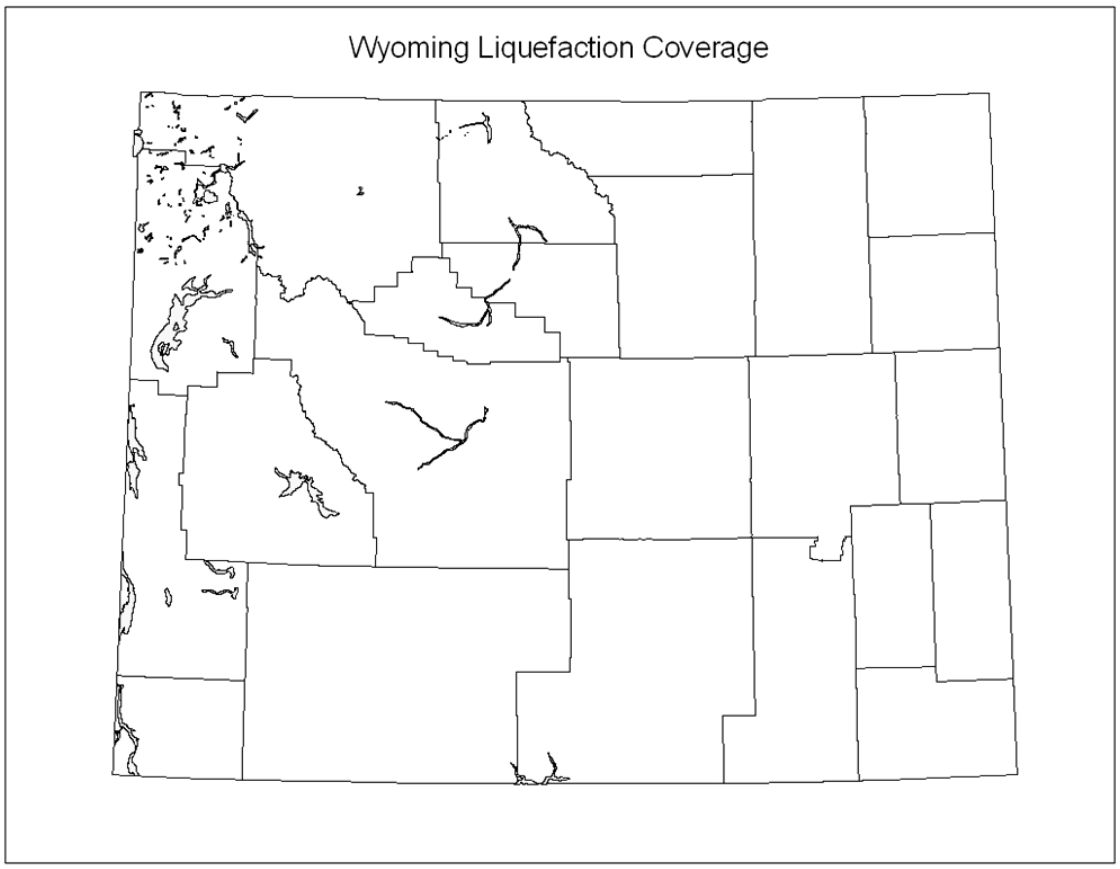
Photos 3.10.1 – Effect of Liquefaction in Christchurch New Zealand, February 2011 earthquake

Vehicle sinks into soil saturated by liquid during earthquake

Liquefaction allowed this sewer to float upward.
Source: http://en.wikipedia.org/wiki/Soil_liquefaction Accessed 2/28/2014

Earthquake (magnitude 7.5) in the West Yellowstone area. Fissures opened in many fields through which water and sand were ejected. Evidence of liquefaction appears in the Teton Mountain area (Dean Ostenaa, U.S. Bureau of Reclamation, personal communication, 1986). **Map 3.10.2** 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.

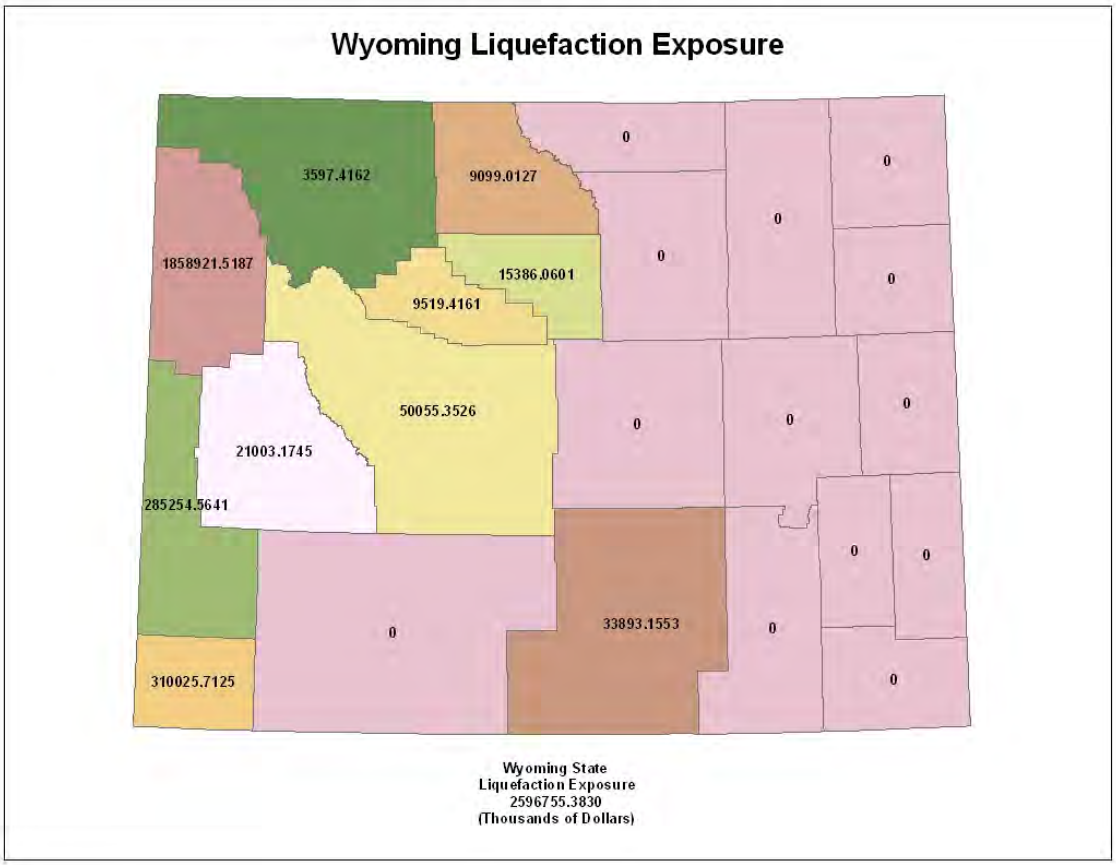
Map 3.10.2 – Potential Liquefaction Areas in Wyoming



There has been little, if any, reported damage from liquefaction in Wyoming. No damage was reported from the Hebgen Lake earthquake due to the remote location of both the earthquake and the resulting liquefaction.

A large earthquake could possibly create a significant amount of liquefaction-related damage to property in western Wyoming. As part of the plan update process in 2008 the WSGS calculated the exposure value for buildings which may occur within areas prone to liquefaction. Liquefaction prone areas were digitized and the liquefaction prone areas layer was digitally crossed with census block building values. In some cases, a liquefaction prone area boundary dissected a census block. In that case, the proportional value of the buildings in the census block was assigned to the liquefaction prone area. If a census block was within a liquefaction prone area, then the values of all the buildings in the census block are assigned. The values derived by county are shown in **Map 3.10.3**

Map 3.10.3 – Liquefaction Exposure



No information related to historical damage to state-owned property is available as it relates to liquefaction risk. A possible research project for future updates is to document the overlap of liquefaction risk areas and the location of state-owned structures and property.

Table 3.10.4 shows the county rankings for building exposure values tied to liquefaction prone areas. A single earthquake event would not likely cause liquefaction in all potential areas of an individual county. As a result, the county figures are useful primarily for comparison of potential between counties. The values do reflect the value of buildings exposed to the hazard.

Table 3.10.4 – Exposure by County, Liquefaction

County	Exposure Value (USD)
Teton	$1,858,921,520
Uinta	$310,025,710
Lincoln	$285,254,565
Fremont	$50,055,350
Carbon	$33,893,155
Sublette	$21,003,175
Washakie	$15,386,060
Hot Springs	$9,519,420
Bighorn	$9,099,015
Park	$3,597,420
Albany	$0
Campbell	$0
Converse	$0
Crook	$0
Goshen	$0
Johnson	$0
Laramie	$0
Natrona	$0
Niobrara	$0
Platte	$0
Sheridan	$0
Sweetwater	$0
Weston	$0
TOTAL	**$2,596,755,390**

While there are ten counties recognized to have liquefaction risk within their borders (Teton, Uinta, Lincoln, Fremont, Carbon, Sublette, Washakie, Hot Springs, Bighorn and Park Counties), liquefaction is not recognized locally as a risk in any Wyoming county as you can see in **Table 3.10.5** below.

Table 3.10.5 0 Local Risk Assessment - Liquifaction

COUNTY	Plan Y/N	Year Approved	Included in Plan
ALBANY	Y	2010	N
BIG HORN	Y	2011	N
CAMPBELL	Y	2011	N
CARBON	Y	2009	N
CONVERSE	Y	2012	N
CROOK	y	2013	N
FREMONT	Y	2012	N
GOSHEN	Expired	2007	N
HOT SPRINGS	N		
JOHNSON	y	2013	N
LARAMIE	Y	2013	N
LINCOLN	Expired	2007	N
NATRONA	Y	2011	N
NIOBRARA	Y	2010	N
PARK	Y	2011	N
PLATTE	Expired	2004	N
SHERIDAN	Y	2009	N
SUBLETTE	Expired	2008	N
SWEETWATER	N		
TETON	Y	2010	N
UINTA	Y	2011	N
WASHAKIE	Y	2011	N
WESTON	N		
NORTHERN ARAPAHO TRIBE	N		
EASTERN SHOSHONE TRIBE	N		

Probability of Liquefaction

Unlikely = Value 1
2 Reported ÷ 130 years = <1 Liquefaction event every 65 years or a <1.0 % annual probability of a Liquefaction event

Liquefaction Risk Factor

Liquifaction Risk Factor Value = 1.6 [(Probability Unlikely 1 x .30) + (Impact 2 x .30) + (Spatial Extent 1 x .20) + (Warning Time 3 x .10) + (Duration 2 x .10)]

State Mitigation Strategy- Liquefaction

Improve GIS mapping of areas subject to liquefaction hazard	Low Priority
Harden Critical Infrastructure	
Restrict development in liquefaction-prone areas	

3.11 Technological and Human-Caused Hazards

Wyoming faces technological and human-caused hazards. A technological threat addressed in this chapter is hazardous materials release. Wyoming has fixed facilities utilizing and storing hazardous materials and hazardous materials are also transported through the state's highway system, railway, or pipeline. Of the human-caused hazards, this chapter will address biological, chemical, explosives and radiological attacks and sabotage. This chapter will focus more on the impact of these hazards and mitigation actions taken than an in-depth description of each hazard or potential delivery system.

Wyoming currently has eight emergency response regions. In 2004 Wyoming divided the state into seven response regions. An additional, eighth region was carved out in the northwest portion of the state in 2012. Each region was provided Homeland Security Grant funds to establish and maintain a Regional Emergency Response Team (RERT). The teams were established as a mitigation effort, with the goal of minimizing state-wide response time and thereby reducing economic, property and human losses caused by technological and human-caused hazards. Federal and local funding has been utilized to purchase necessary response and personal protection equipment and provide training. Further, state funds have funded RERT responses. **Table 3.11.1** below, outlines the types of responses completed by each regional team over the life of the Teams.

Wyoming has identified more than 250 critical infrastructure targets. WOHS is a member of the Wyoming FBI Joint Terrorism Task Force. The task force has reviewed and prioritized 12 of these targets as being most favorable targets for a terrorist attack resulting in a loss of this critical infrastructure. The importance of these targets by the FBI has resulted in these targets as being classified at the "SECRET LEVEL."

Attacks and sabatoge are hazards with which Wyoming has had experience in fairly recent history. Wyoming is one of a few states who have had their infrastructure targeted in a conspiracy to sabotage through utilization of explosives against the oil pipelines and refineries, including a natural gas plant. One individual was convicted in federal court on two counts of Title 18, Section 2339(a) USC (providing material support to terrorists), Title 18, Section 373 USC (soliciting a crime of violence); Title 18, Section 842 USC (unlawful distribution of explosives); and Title 26, Section 5861(d) USC (possession of an unregistered destructive device {hand grenade}). In November 2007 he was sentenced to 30 years in federal prison.

Table 3.11.1 – RERT Mission Assignments 2004-2013

	TYPE	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	TOTAL	State Funds
WMD											
C	**Chemical**	1		1							$3,692.00
B	**Biological**	3	15	3	3	1	2	11	1	**39**	$27,444.00
R	**Radiological**	1	1		1					**3**	$353.00
N	**Nuclear**										
E	**Explosive**	4	15	7	56	14	23	9		**128**	$52,074.00
HAZMAT											
	Fixed Facility	8	6	12	5	1	4	5	1	**42**	$38,545.00
	Truck/Highway	11	9	16	3	3	6	18	2	**68**	$83,273.00
	Rail			1	1		1	1		**4**	$11,827.00
	Orphan Drum	2	2				1	3		**8**	$7,510.00
CRIMINAL											
	Exec. Protection		3		1	2	1	6	1	**14**	$6,746.00
	Meth Lab	6	3	7	6	5	1	7	1	**36**	$32,618.00
	Marijuana Grow			2	3	2		1		**8**	$3,821.00
	Arson K9			24						**24**	$10,224.00
	Crime Scene Aid			1	1	3		3		**8**	$18,510.00
	IED K9				1		1			**2**	
OTHER											
	Structure Fire		2	1	1			1		**5**	$2,140.00
	Vehicle Crash			2				1		**3**	
	Search & Rescue		3	4				2		**9**	$1,910.00
	Coroner Recovery	1	4	5						**10**	
	Training/Exercise	1	3	2	23		3			**32**	
	COMM Support			1	2					**3**	$129.00
	Flood		1	1	1					**3**	$4,392.00
TOTALS		**38**	**67**	**90**	**108**	**31**	**43**	**68**	**6**	**449**	**$305,208.00**

Two other individuals were investigated for terrorism activity by FBI and local authorities, and pled guilty in U.S. District Court for the destruction of interstate power lines. During 2003 two subjects were convicted in the U.S. District Court, District of Wyoming, for violation of Title 18, Section 1366(a) USC (destruction of an energy facility). On October 30, 2003, both subjects were sentenced to 2 years, six months in federal prison, 3 years probation and restitution in the amount of $1,035,431. This act of terrorism involved the destruction of a critical interstate power line by removing bolts to the power line tower. The original tower cascaded to other towers causing failure. The towers were located in Sweetwater County. Power failures occurred in several western states including the city of Los Angeles, California.

Terrorism risk assessments and response actions relative to terrorist threats to Wyoming's infrastructure is addressed in Wyoming's State Operations Plan. The State Operations Plan is in compliance with the National Response Framework, and applicable portions of the Wyoming State Operations Plan are incorporated into this plan by reference.

A general definition of *hazardous material* is a substance or combination of substances which because of its 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.

The U.S. Department of Transportation (DOT), U.S. Environmental Protection Agency (EPA), and the Occupational Safety and Health Administration (OSHA) all have responsibilities in regards to hazardous materials and waste. Presented below are the various definitions and general responsibilities of each of the agencies.

The U.S. DOT, which has control over transported hazardous materials, uses the following definition: hazardous material means a substance or material that the Secretary of Transportation has determined is capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and has designated as hazardous under Section 5103 of Federal Hazardous Materials Transportation Law (49 U.S.C. 5103). The term includes hazardous substances, hazardous wastes, marine pollutants, elevated temperature materials, materials designated as hazardous in the Hazardous Materials Table (see 49 CFR 172.101), and materials that meet the defining criteria for hazard classes and divisions in part 173 of sub-chapter C of this chapter. The U.S. DOT has nine classes of hazardous material:

- Explosives;
- Compressed gasses: flammable gasses, non-flammable compressed gasses, poisonous gasses;
- Flammable liquids: flammable (flash point below 141 degrees), combustible (flash point 141 degrees – 200 degrees);
- Flammable solids: flammable solids, spontaneously combustible, dangerous when wet;
- Oxidizers and organic peroxides: oxidizer, organic peroxide;
- Toxic materials: material that is poisonous, infectious agents;
- Radioactive material;

- Corrosive material: destruction of human skin, corrode steel at a rate of 0.25 inch per year; and
- Miscellaneous.

The EPA also has responsibility for hazardous materials, chemicals, and wastes that have the potential to be released into the environment through stationary facilities. The EPA addresses the need for facilities with hazardous waste substances to store containers in some kind of containment system through the Resource Conservation and Recovery Act. Stationary containers such as tanks, as well as portable storage containers such as 55-gallon drums, are required to have a system that will protect the environment from this waste if a leak were to occur. Hazardous waste regulations appear in Title 40 of the Code of Federal Regulations (CFR). Portable container containment is addressed under Subpart I, Use and Management of Containers (EPA 40 CFR 264.175). Facilities dealing with the storage of hazardous materials may also be required to have containment if they are to meet the Uniform Fire Code (UFC) standards. Within the UFC standards, Section 80, Division III refers to "Hazardous Materials Storage Requirements" pertaining to containers and tanks and Division IV refers to "Spill Containment" with regard to hazardous materials.

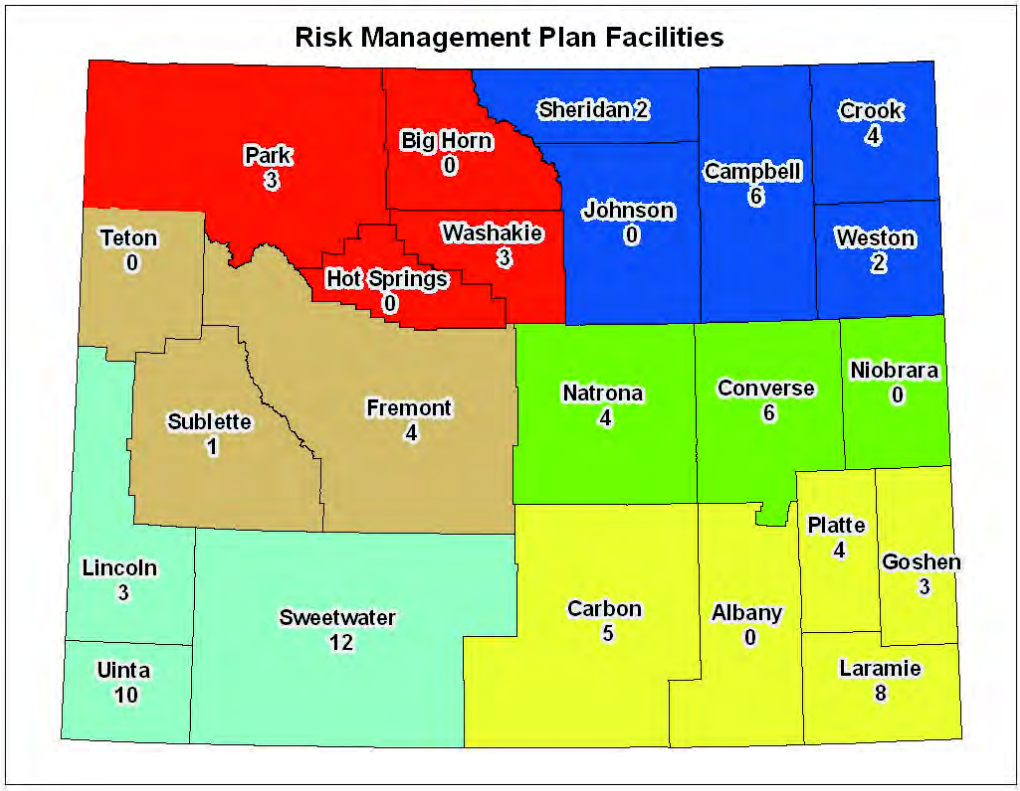
The Emergency Planning and Community Right-to-Know Act (EPCRA) requires certain regulated entities to report information about hazardous chemicals and substances at their facilities to federal, state, and local authorities. The objective is to improve the facilities, or government agency's ability to plan for and respond to chemical emergencies, and to give citizens information about chemicals present in their communities. The President has issued Executive Orders to federal agencies that mandate their compliance with certain EPCRA requirements. Part of EPA's mission is to ensure that federal facilities comply with these requirements. Sections 301 and 303 of EPCRA mandate the creation of two organizations; The State Emergency Response Commission (SERC) and the Local Emergency Planning Committee (LEPC). Sections 311-312 of EPCRA require facilities to submit material safety data sheets or Tier II forms (lists of hazardous chemicals on-site above threshold quantities) to SERC's, LEPC's, and local fire departments.

In addition to EPCRA, there is a Risk Management Program (RMP). When Congress passed the Clean Air Act Amendments of 1990, it required EPA to publish regulations and guidance for chemical accident prevention at facilities using extremely hazardous substances. The Risk Management Program Rule (RMP Rule) was written to implement Section 112(r) of these amendments. The rule, which built upon existing industry codes and standards, requires companies of all sizes that use certain flammable and toxic substances to develop a RMP, which includes a(n):

- Hazard assessment that details the potential effects of an accidental release, an accident history of the last five years, and an evaluation of worst-case and alternative accidental releases;
- Prevention program that includes safety precautions and maintenance, monitoring, and employee training measures; and
- Emergency response program that spells out emergency health care, employee training measures, and procedures for informing the public and response agencies (e.g. the fire department) should an accident occur.

By 1999 a summary of each facility's risk management program (known as a RMP) was to be submitted to EPA, making the information publicly available. The plans are required to be revised and resubmitted every five years. A summary of the RMP facilities by county can be reviewed in **Map 3.11.2.**

Map 3.11.2 – Number of Risk Management Plan Facilities by County



The Risk Management Plan is intended to reduce chemical risk at the local level by informing local fire, police, and emergency response personnel (who must prepare for and respond to chemical accidents), and is useful to citizens in understanding the chemical hazards in communities.

OSHA, established under the U.S. Department of Labor by the OSHA Act of 1970, regulates the storage and use of toxic and hazardous substances as they relate to worker health and safety. OSHA regulations are found in Title 29 of the CFR, Part 1910, Subpart H.

Probability of a Technological and Human-Caused Hazard

Highly Likely = Value 4
449 RERT Incident Responses ÷ 10 years = 45 Man-Made Hazard events every year or a >100.0 % annual probability of a Man-Made Hazard event

Technological and Human-Caused Hazard Risk Factor

Technological & Human-Caused Hazard Risk Factor Value = 2.8 [(Probability Highly Likely 4 x .30) + (Impact 2 x .30) + (Spatial Extent 2 x .20) + (Warning Time 4 x .10) + (Duration 2 x .10)]

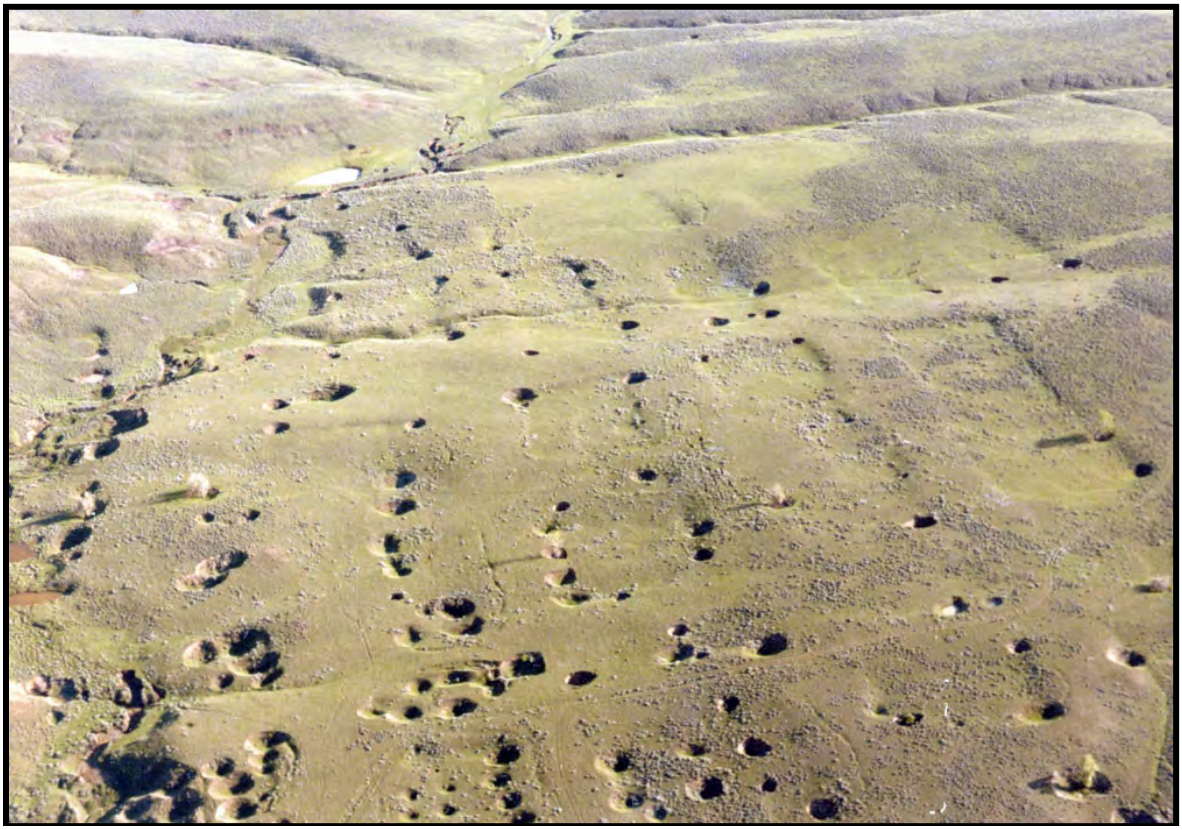
State Mitigation Strategy – Technological & Human-Caused

Encourage hazardous material collection days	
Educate public on storage and disposal of hazardous household items	
State-wide Commodity Flow Study	Existing studies require updating
Establish buffer zones around stationary facilities storing hazardous materials	
Educate public on sheltering in place	
Identify areas most susceptible to release of toxic gas (H2S, CO2), review response plans and evacuation plans, and update as necessary.	
Provide all-hazards weather radios to all residences in Wyoming.	On-going activity

3.12 Mine Subsidence

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 their underground pillars failed. 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. 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 pillars and caprock.

Photo 3.12.1 – Subsidence above Old Monarch Coal Mine north of Sheridan



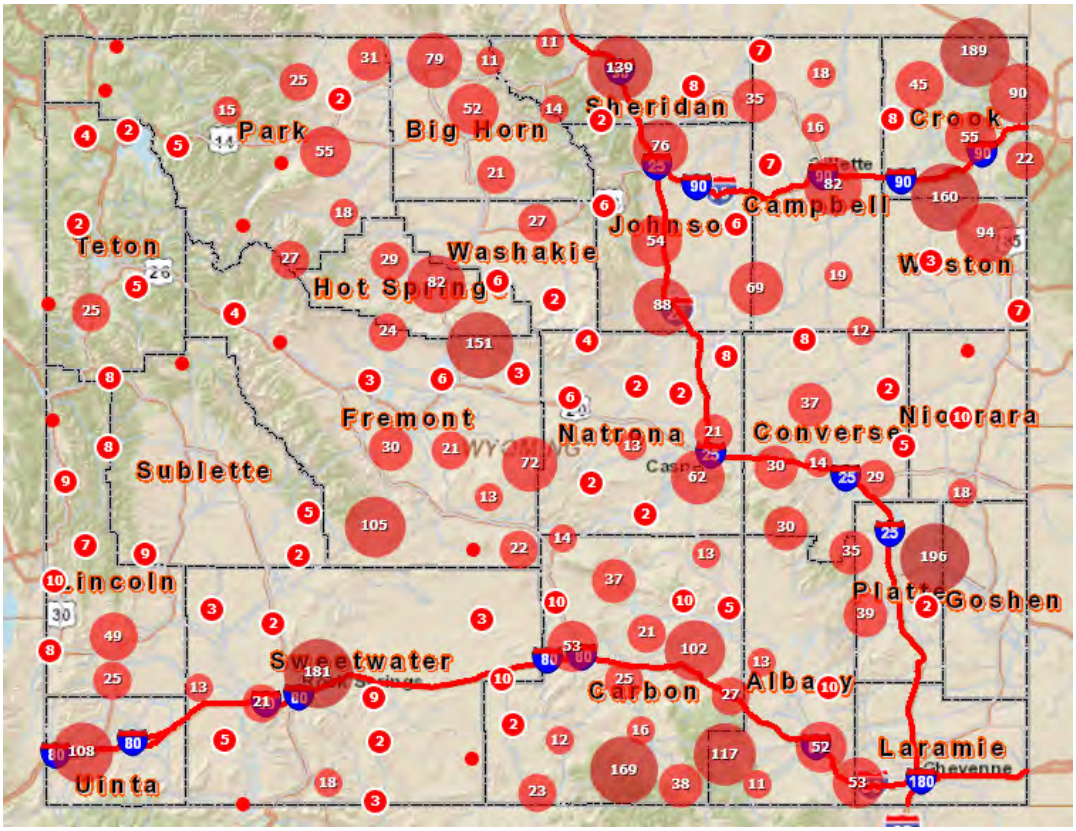
U.S. Geological Survey Photo

Significant areas of Wyoming have abandoned underground mines present. Mining subsidence has been threatening those areas since the onset of mining in the 1860s. Due to the long history of underground mining in the state, many more undermined areas have subsided than most people imagine. A written history of mine subsidence in or near urban areas was published in the *Governor's Workshop on Mine Subsidence* proceedings held on October 31, 1986 at the University of Wyoming. The WSGS generated a

report for each county in Wyoming on abandoned underground coal mines and hard rock mines which have been identified. Mining sites and subsidence have been reported through multiple avenues including the US Geological Survey, Wyoming Geological Survey, US Forest Service personnel, BLM personnel, hunters, and other private individuals. The Abandoned Mine Lands Division (AML) of the Wyoming Department of Environmental Quality (DEQ) have recorded and actively pursued mitigation of mined out areas throughout the state. One mitigation activity includes generating GIS layers of mined out sites. Two mining GIS inventory projects have been completed, one in 2001 and the other in 2004, wherein staff physically visited and geolocated mined out areas. The AML has accurately mapped approximately 3,000 of the nearly 4,000 reported abandoned mining sites. A high-level map showing numbers of abandoned mines in areas around the state is below (**Map 3.12.2**). More detailed, local information is available through the AML upon request.

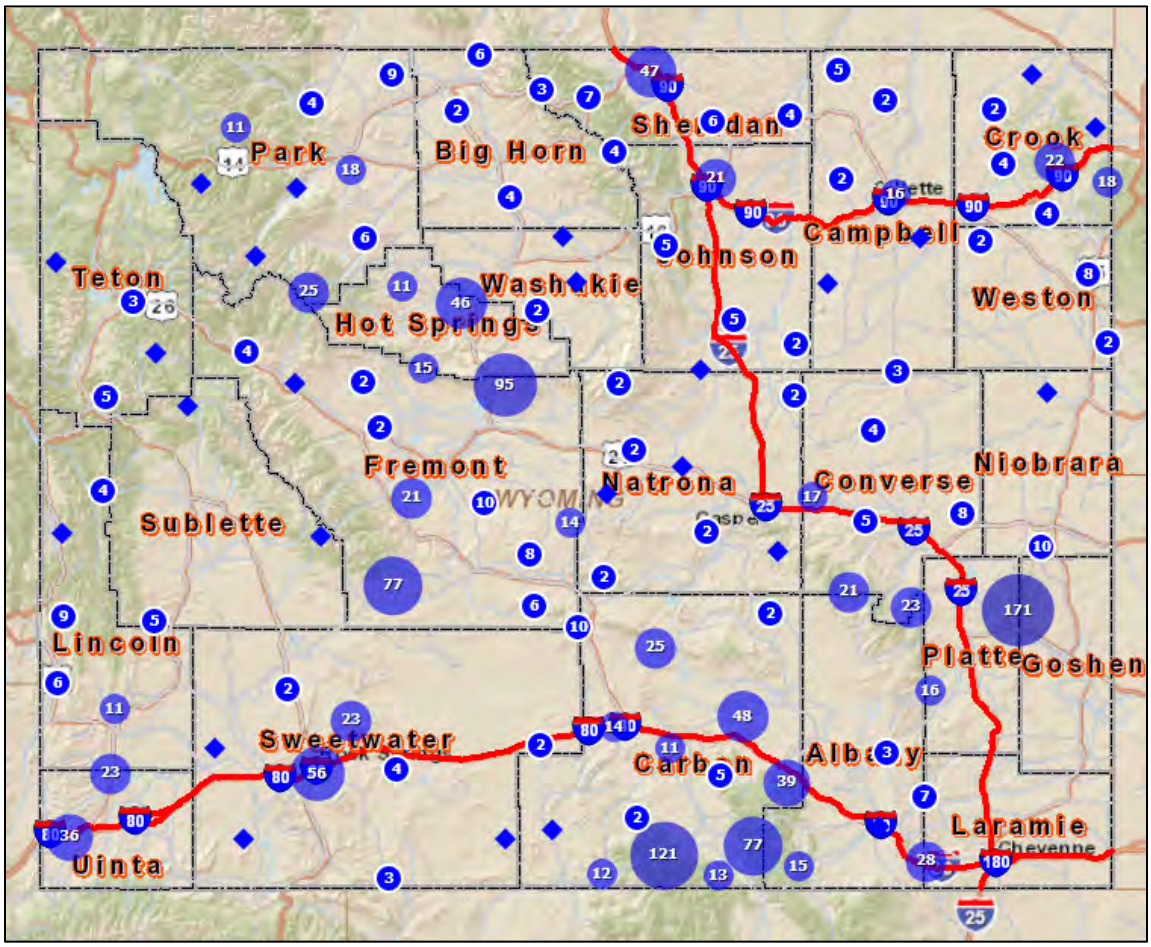
Subsidence problems have occurred in Rock Springs, Hanna, Glenrock, Superior, Reliance, Evanston, Kemmerer, Sheridan, and Gillette. A map showing documented mined-out areas in Wyoming is shown in **Map 3.12.2**. Many of the areas shown are susceptible to subsidence. **Map 3.12.3** shows mine sites with underground workings that are susceptible to subsidence. Property and infrastructure damage associated with mine subsidence in Wyoming communities is on-going.

Map 3.12.2 Mined-out areas and mine subsidence in Wyoming.



Many of Wyoming's coal mines are along and near Railroad routes through Wyoming. Mapping of Wyoming's mined out areas is considered virtually complete, though occasionally a previously unmapped area is discovered and mapped. Historically, much mitigation of Wyoming's mined out areas has been funded through fees charged on coal extracted from the state. The program is funded through the Office of Surface Mining from funds collected through a mine reclamation fee assessed on each ton of coal produced. The Surface Mining Control and Reclamation Act includes a provision that each state, including Wyoming, would receive an amount equal to 50% of the mine reclamation fee collected in that state. Historically, Congress did not appropriate the full 50% funding resulting in reduced reclamation resources for Wyoming. In 2007, SMCRA was amended to return the funding to the full 50% state share resulting in a significant increase in funding for Wyoming. In 2012, Congress limited AML reclamation funding for Wyoming to a maximum of $15 million per year. This significantly reduced the funding available for reclamation in Wyoming.

Map 3.12.3 – Abandoned Mine Sites with Subsidence-Prone Underground Workings



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 AML 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. In the Rock Springs area, the community's water tank, and water supply lines have been protected and Interstate 80 north of Rock Springs has also been protected.

These recent subsidence mitigation projects involve 'grouting' mined out areas. 'Grouting' involves a process of filling the underground mine cavity created by previous mining activity with light cement. This supports the cavity's ceiling, minimizing the likelihood of collapse and impacts to the surface topography. Depending on the situation, another mitigation option can be pursued which involves creating cement support pillars in the cavity to support the cavity's ceiling. Other methods use conventional construction equipment to dig out the collapsed area and install an earthen backfill to stabilize the subsidence feature.

An indirect measure of subsidence impact is the cost of mitigating the hazard. The AML Program at DEQ has spent $303.4 million through 2013 mitigating the effects of mine subsidence alone, as part of the abandoned mine reclamation program.

Another mitigation effort available to property owners, the AML makes subsidence insurance available to property owners in affected communities. Homeowners who elect to have their property mitigated for subsidence receive an additional benefit as the cost of subsidence insurance is covered for one year by the AML program at DEQ. The cost of insurance is affordable for property owners, and is based on the county's tax valuation of the property, with a maximum of $250,000 insurance available. Given the known risk, insurance is particularly valuable for homeowners in subsidence-prone areas.

The AML monitors underground coal fires burning in mined out areas around the state. Underground fires also make the surface above the fire more susceptible to subsidence. It doesn't make sense to open a coal seam at the site of a fire, exposing the flame to greater oxygen supply and further endangering people. Mitigation efforts can be undertaken to interrupt underground coal fires, however. The most cost effective and safest methods involve measures to deny oxygen to the fires. This may take the form of backfilling cracks and fire vents such as pictured below (**Photo 3.12.4**), installing massive earthen caps over the active fire zone to seal cracks and vents and other ways air can circulate within the fire zone. Methods may involve sealing openings and large cracks with cement. In places where a seam is burning, the fire may be interrupted by trenching across the seam in uninvolved coal, then isolating the unburned area from the advancing fire by filling the trench with inert, noncombustible earthen material.

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.

Photo 3.12.4 – Smoke from underground coal fire in the Powder River Basin north of Sheridan

Ed Heffern- BLM Wyoming

Photo 3.12.5 – Smoke from Underground coal fire at the Placheck Pit near Sheridan

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 and therefore it's difficult to put a risk factor to this hazard as it relates to development within Wyoming's borders.

Below is a table outlining local perspectives on subsidence hazards in their county. The table extrapolates, based on population impacted, probability of occurrence within their borders, and property impacted, the risk perceived by each county relative to subsidence hazards. You will note all counties recognizing subsidence as a hazard within their county's borders consider the hazard to rank low. Most are unable to state the number of incident occurrences and also reflect minor, if any damage.

Table 3.13.6 – Local Risk Assessment - Avalanche

COUNTY	Plan Y/N	Year Approved	Included in Plan	Rank-High, Medium, Low
ALBANY	Y	2010	Y	Low
BIG HORN	Y	2011	N	
CAMPBELL	Y	2011	N	
CARBON	Y	2009	Y	Low
CONVERSE	Y	2012	Y	Low
CROOK	Y	2013	Y	Low
FREMONT	Y	2012	N	
GOSHEN	Expired	2007	N	
HOT SPRINGS	N			
JOHNSON	Y	2013	Y	Low
LARAMIE	Y	2013	N	
LINCOLN	Expired	2007	Y	Low
NATRONA	Y	2011	N	
NIOBRARA	Y	2010	N	
PARK	Y	2011	N	
PLATTE	Expired	2004	N	
SHERIDAN	Y	2009	Y	Low
SUBLETTE	Expired	2008	N	
SWEETWATER	N			
TETON	Y	2010	N	
UINTA	Y	2011	N	
WASHAKIE	Y	2011	N	
WESTON	N			

COUNTY	Plan Y/N	Year Approved	Included in Plan	Rank-High, Medium, Low
NORTHERN ARAPAHO TRIBE	N			
EASTERN SHOSHONE TRIBE	N			

Probability of Mine Subsidence

Likely = Value 3
Unknown # Reported ÷ # years = Mine Subsidence events occur every year or a >100.0 % annual probability of a Mine Subsidence event

Mine Subsidence Risk Factor

Mine Subsidence Risk Factor Value = 2.2 [(Probability Likely 3 x .30) + (Impact 2 x .30) + (Spatial Extent 1 x .20) + (Warning Time 3 x .10) + (Duration 2 x .10)]

Active AML Subsidence Mitigation Projects Ongoing in 2014

ACTIVE AML PROJECTS	
ONGOING COAL RECLAMATION PROJECTS	**COUNTIES**
NORTHEAST/NORTHWEST PRIORITY 3 COAL	Campbell County , Crook County, Johnson County, Park County, Sheridan County , Weston County
SOUTHWEST PRIORITY 3 COAL	Lincoln County, Sublette County, Teton County , Uinta County
WEST-CENTRAL PRIORITY 3 COAL	Fremont County, Sweetwater County
NORTH-CENTRAL PRIORITY 3 COAL	Big Horn County, Converse County, Hot Springs County, Natrona County , Washakie County
CARBON COUNTY PRIORITY 3 COAL	Carbon County
NORTHERN LARGE PRIORITY 3 COAL SITES	Campbell County, Converse County
SOUTHERN LARGE PRIORITY 3 COAL SITES	Carbon County
PROJECT 17J PRIORITY 1 & 2 NORTHEAST COAL SITES	Campbell County, Weston County, Johnson County, Sheridan County
PROJECT 17G MINE FIRES (PRIORITY 1 & 2)	Statewide
PROJECT 17L PRIORITY 1 & 2 COAL SITES	Carbon County, Albany County
PROJECT 17M PRIORITY 1 & 2 BIGHORN BASIN COAL SITES	Big Horn County, Fremont County, Washakie County, Hot Springs County, Fremont County
PROJECT 17H PRIORITY 1 & 2	Sweetwater County, Lincoln County, Uinta County
FREMONT COUNTY RESERVATION SITES	Fremont County Reservation Group

ONGOING NON-COAL PRIORITY 1 & 2 RECLAMATION PROJECTS	COUNTIES
CENTRAL/NW/SW NON-COAL	Park County, Hot Springs County, Washakie County, Fremont County, Converse County, Natrona County, Sweetwater County, Lincoln County, Sublette County
NORTHEAST NON-COAL	Campbell County , Crook County, Johnson County , Sheridan County , Weston County
SOUTHEAST NON-COAL	Albany County, Laramie County, Platte County
CARBON COUNTY CHEROKEE GROUP	Carbon County
CARBON COUNTY NON-COAL	Carbon County
17I STATEWIDE NONCOAL	Fremont County, Goshen County, Hot Springs County
17F NON-COAL	Fremont County , Park County
ONGOING URANIUM PRIORITY 1 & 2 RECLAMATION PROJECTS	**COUNTIES**
EAST & CENTRAL GAS HILLS	Fremont County, Natrona County
MCINTOSH PIT	Fremont
MISCELLANEOUS SMALL URANIUM SITES STATEWIDE	Albany County, Big Horn County, Campbell County, Carbon County, Crook County, Fremont County, Niobrara County, Washakie County, Weston County
WEST GAS HILLS	Fremont County
Notes: Priorities are designated following the Office of Surface Mining guidance; Priority 1 & 2 are high priority sites with human health and safety hazards. AML is reqiired by OSM to address all Priority 3 coal sites before non-coal sites. With funding committes to P3 coal AML may proceed on evaluation and planning, as well as reclamation on non-coal sites.	

State Mitigation Strategy – Subsidance

Grout mined-out areas in developed communiites	On-going costing approximately $10 million annually
Map mined-out areas	Completed
Abate underground coal mine fires	On-going as needed
Business Contact through the environmental review process	On-going
Remediate new subsidence as it occurs	On-going as needed

3.13 Avalanche

Wyoming is one of the top-ranking states for avalanche hazard because of its weather and mountainous terrain coupled with outdoor recreation. Skiers, snowboarders, and snowmobile operators are most commonly associated with avalanche hazards. However, motorists and others not engaging in recreation are also at risk of being caught in an avalanche. An avalanche is defined as a large mass of snow, ice, earth, rock, or other material in swift motion down a mountainside or over a precipice (Merriam-Webster).

Photos 3.13.1 - Jackson Peak Avalanche, November 2013

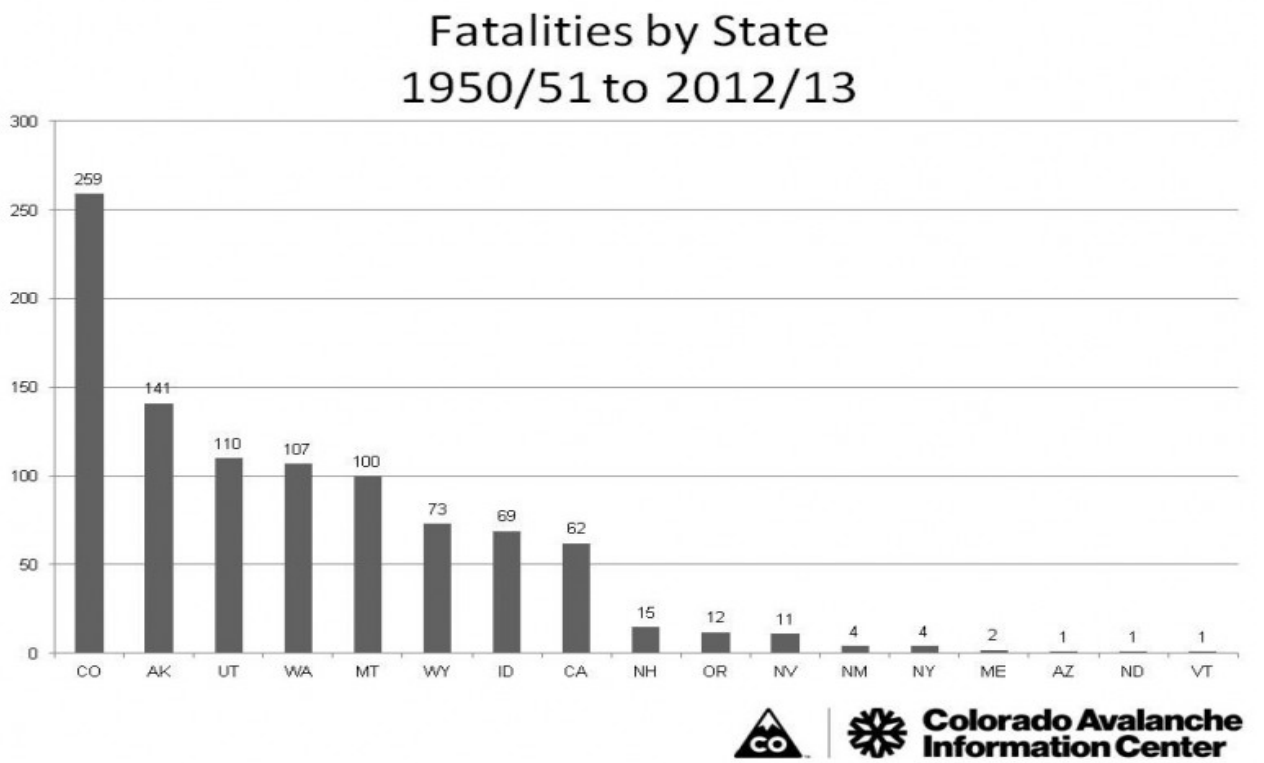
Bridger-Teton Avalanche Center Photos

Avalanche fatalities provide the best indicator for locations of where events occur and what populations are most threatened. According to the Colrado Avalanche Information Center statistics for the past 62 years (1950-2012), Wyoming ranks sixth among the eight states with the most avalanche fatalities (**Table 3.13.1**).

In the past ten years, Wyoming's ranking has improved slightly, with 26 of the 278 avalanche-related deaths occurring in Wyoming. This places Wyoming 7th in the list and represents 9% of avalanche deaths in the U.S. between the 2003/4 and 2012/13 snow seasons.

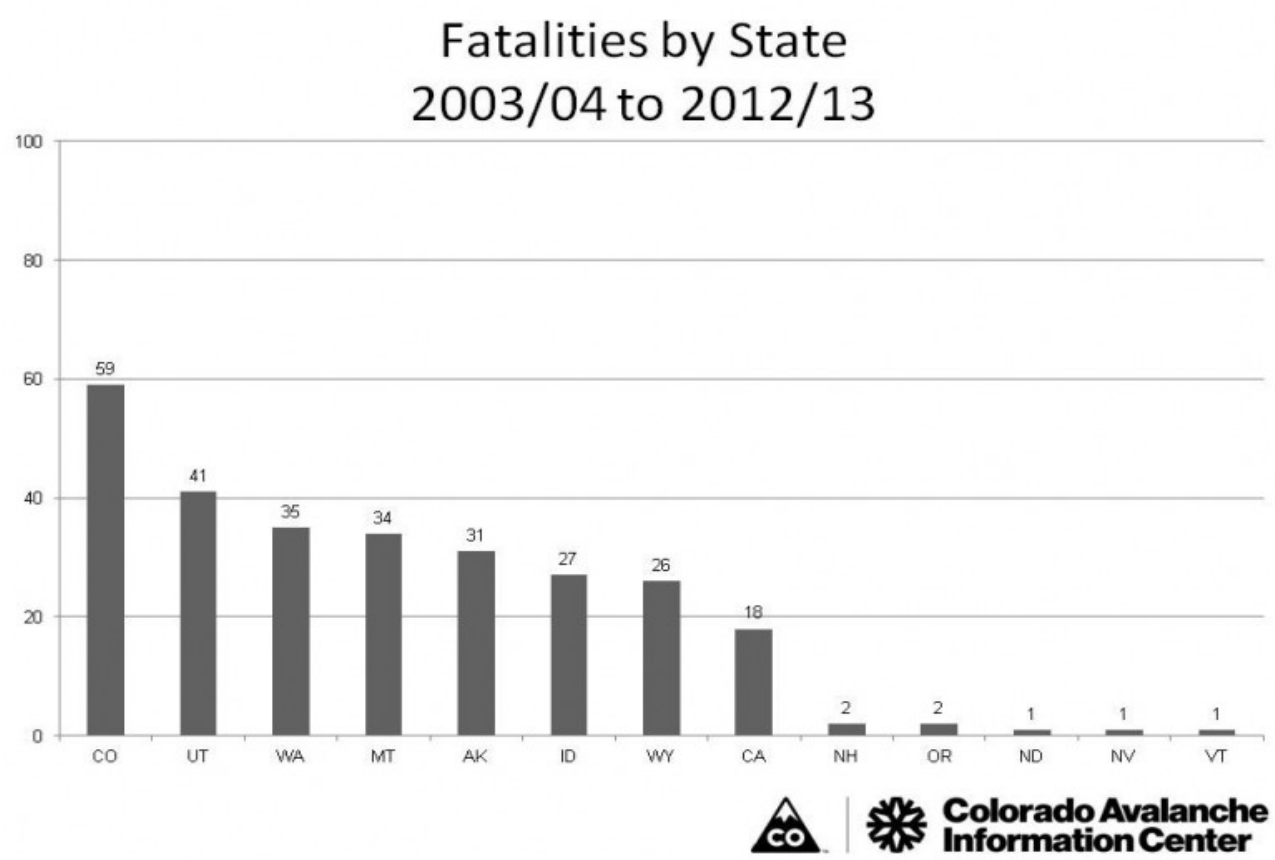
A historical list of avalanche events resulting in deaths is attached as **Appendix O**. There have been 11 avalanche fatalities in Wyoming since the last mitigation plan update three years ago, with a total of 88 recorded fatalities since 1918.

Table 3.13.1 – U.S. Avalanche Fatalities by State 1950-2012



http://avalanche.state.co.us/accidents/statistics-and-reporting Accessed 3/26/2014

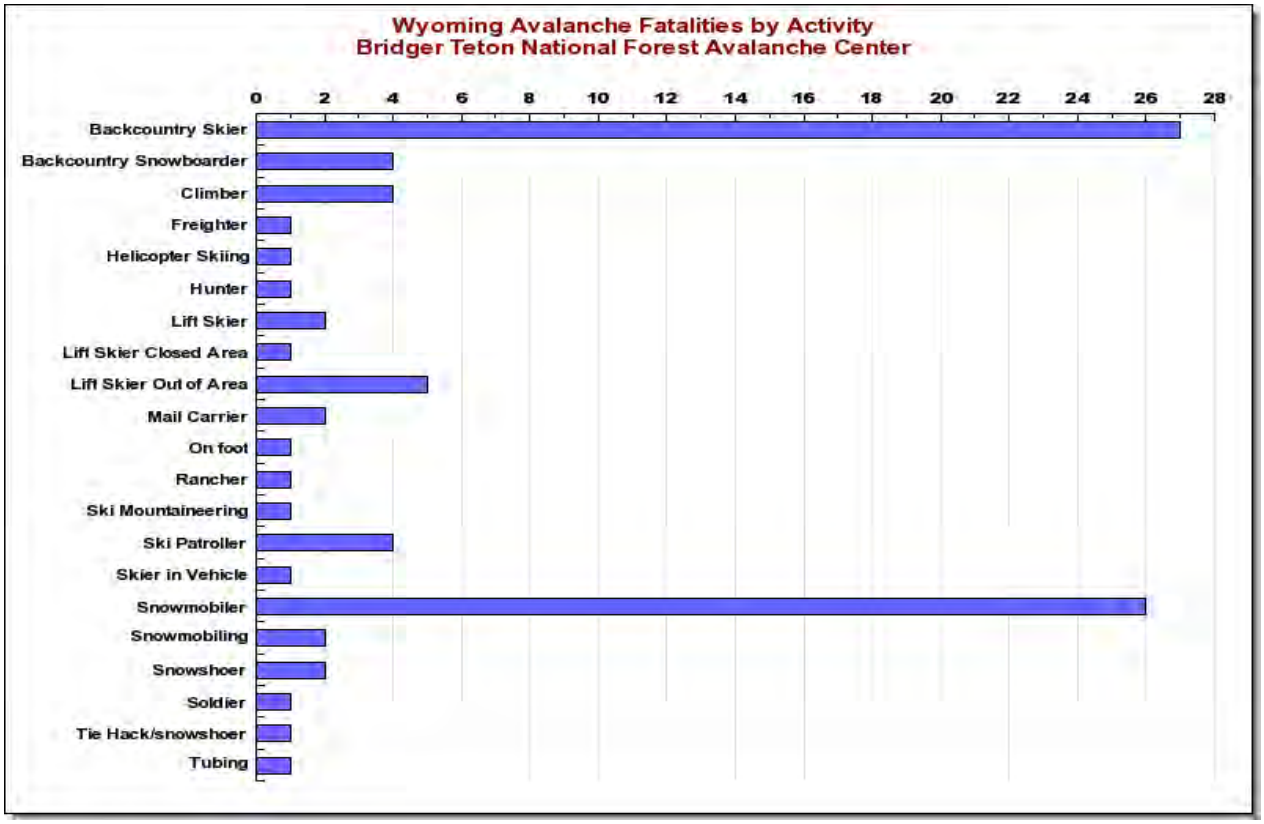
Table 3.13.2 – U.S. Avalanche Fatalities 2003-2012



Avalanche deaths occur primarily in the backcountry where access is limited and the recreating public enjoys recreational pursuits inbeautiful terrain. Typically deaths result from an avalanche triggered by those recreating in mountainous areas where the snow pack is unstable and on a steep slope. The two activities generating by far the greatest number of fatal avalances in Wyoming are skiing and snowmobiling. (**Table 3.13.3**)

Avalanches cause two primary impacts—road blocks and death or injury. Since 1994 there has been a trend of at least one fatality per year. Fatalities are the best-documented impact related to avalanches and are significant simply because of the nature of the hazard. Furthermore, there are costs associated with "search and rescue" and removal of the deceased.

Graph 3.13.3 – Wyoming Avalanche Fatalities by Activity

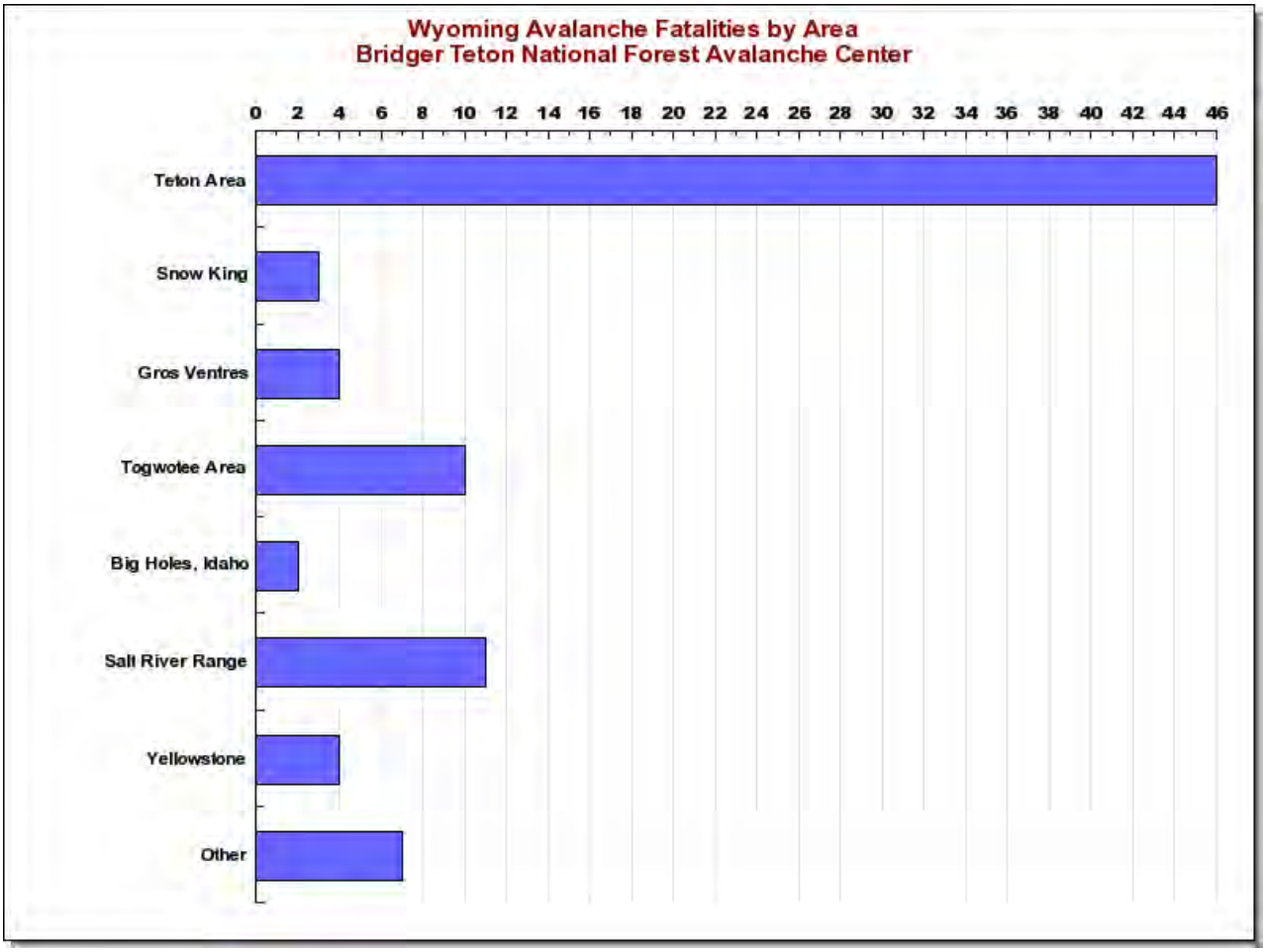


http://www.jhavalanche.org/fatalityGraph/type/activity Accessed 3/26/2014

Road blocks are another major concern where roads intersect an avalanche path. The major costs associated with road blocks are snow removal and traffic diversion, which both necessitate personnel and equipment. Another less frequent issue is the cost associated with rescuing motorists involved in an avalanche.

Table 3.13.4 shows the majority of fatalities occurred in western Wyoming, with most in the Teton area. The Teton area presents an increased population of outdoor enthusiasts; an increased population engaging in extreme winter sports; and the high angle, avalanche-prone character of the terrain.

Table 3.13.4 – Wyoming Avalanche Fatalities by Area

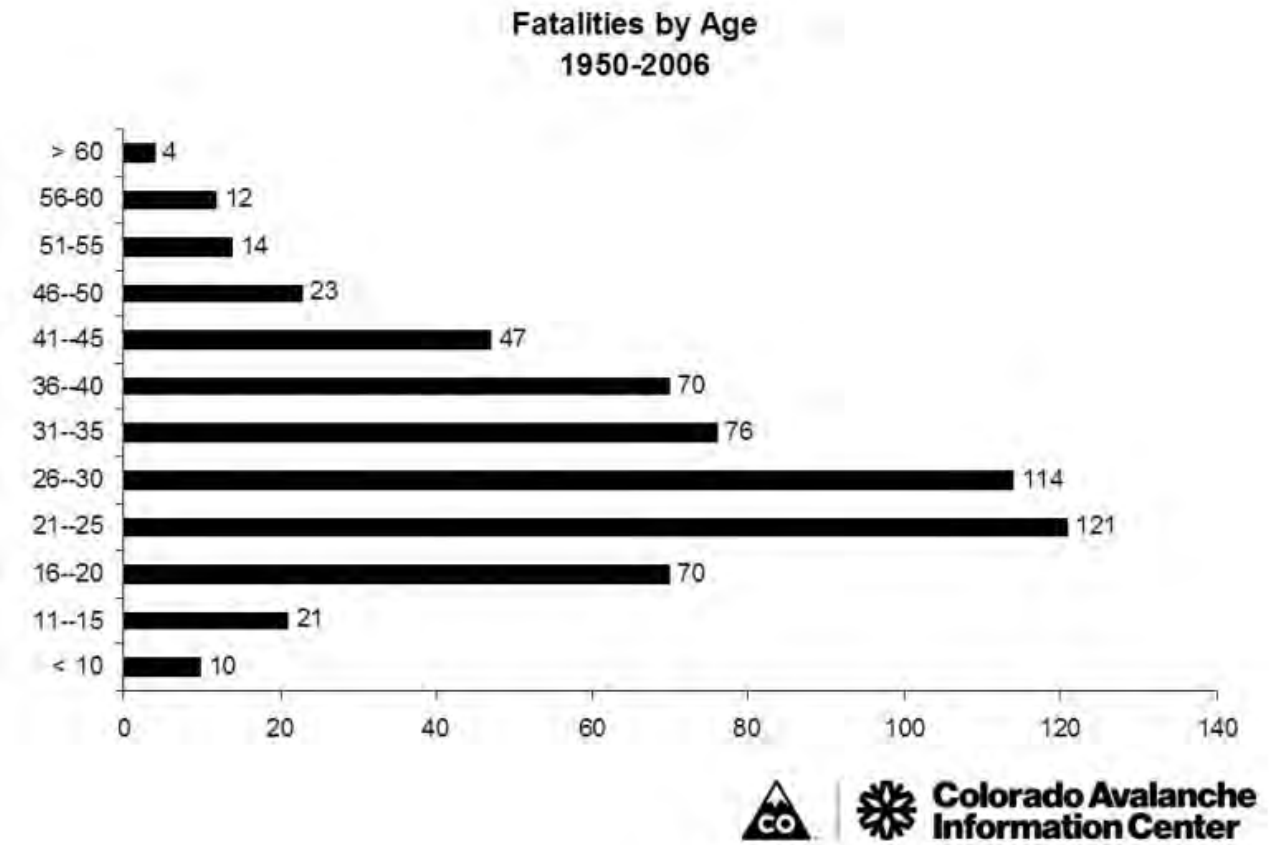


http://www.jhavalanche.org/fatalityGraph/type/area Accessed 3/26/2014

Table 3.13.5 shows the greatest number of avalanche fatalities in the U.S. occur in the 20-30 year age group. This age group tends to be more focused on strenuous, outdoor activities, and therefore it follows that this age group would be more susceptible to this risk.

Because avalanches are typically a back-country hazard in mountainous areas and do not typically occur in populated areas, there is limited risk to significant portions of the population. The one segment of the population most vulnerable to avalanche danger is individuals taking advantage of winter recreation opportunities in the mountains, typically skiers, snow boarders and snowmobilers. Skiers and snow boarders recreating within developed ski areas are less vulnerable to avalanche hazards, as ski area staff ensure known avalanche hazard areas within their boundaries are mitigated utilizing various methods. Those most vulnerable are those drawn to recreate outside developed ski areas where mitigation efforts may or may not be taken.

Table 3.13.5 – U.S. Avalanche Fatalities by Age



http://avalanche.state.co.us/accidents/statistics-and-reporting Accessed 3/26/2014

Wyoming's local mitigation plans reflect counties in mountainous western Wyoming consider snow avalanches a hazard to their residents, as one might expect. However, it is considered a low risk by each of those counties, despite loss of life over the past century. A conclusion may be drawn that large population areas are not typically subject to avalanche risk, leading to a low risk categorization by local jurisdictions. Many counties located on the plains do not address snow avalanches as a hazard within their plan which would be expected of counties without the steep slopes required for avalanche generation. Counties recognizing avalanches as a hazard within their borders have ranked avalanche risks based on the population impacted, probability of occurrence within their borders and the property impacted.

The table below extrapolates from local county mitigation plans the probability of an avalanche occurrence within their borders, based on population impacted, and property impacted, the risk perceived by each county relative to avalanche hazards. Teton County indicates historical damages of approximately $500,000. Lincoln County reflects potential losses are $2 million.

Local Plan Risk Assessments – Avalanche

COUNTY	Plan Y/N	Year Approved	Included in Plan	Rank-High, Medium, Low
ALBANY	Y	2010	Y	Low
BIG HORN	Y	2011	N	
CAMPBELL	Y	2011	N	
CARBON	Y	2009	Y	Low
CONVERSE	Y	2012	N	
CROOK	Y	2013	N	
FREMONT	Y	2012	N	
GOSHEN	Expired	2007	N	
HOT SPRINGS	N			
JOHNSON	Y	2013	N	
LARAMIE	Y	2013	N	
LINCOLN	Expired	2007	Y	Low
NATRONA	Y	2011	N	
NIOBRARA	Y	2010	N	
PARK	Y	2011	Y	Low
PLATTE	Expired	2004	N	
SHERIDAN	Y	2009	N	
SUBLETTE	Expired	2008	Y	Low
SWEETWATER	N			
TETON	Y	2010	Y	Low
UINTA	Y	2011	N	
WASHAKIE	Y	2011	N	
WESTON	N			
NORTHERN ARAPAHO TRIBE	N			
EASTERN SHOSHONE TRIBE	N			

In the case of development's impact on avalanche risk, this is one area where the risk actually seems to diminish as areas are developed. This is true, not because of development itself, but because of mitigation efforts undertaken to protect the population within developed areas. Avalanche is recognized as a hazard and mitigated in avalanche-prone locations throughout the state where development exists. Avalanche areas known to have the potential to interfere with highways and roads are typically mitigated prior to endangering citizens.

Ongoing Mitigation Efforts

Ski Areas

The Jackson Hole Mountain Resort has had an avalanche mitigation program since it opened in 1965. An avalanche-forecasting laboratory operates from October through April. The avalanche hazard is assessed and addressed every day during this period. Artillery, explosive hand charges, ski cutting, and area closures are employed as abatement efforts. This area pioneered the use of remote automated weather stations to continuously monitor the development of conditions that lead to the formation of avalanches and developed a state-of-the-art avalanche mitigation program that became an industry standard.

In the mid 1970's a significant increase in backcountry avalanche fatalities lead the national forest avalanche forecasters in the Bridger-Teton National Forest Avalanche Center (BTNFAC) laboratory to start issuing daily backcountry avalanche advisories.

The Snow King Ski Area and Grand Targhee Resort also use explosive charges, ski cutting, and area closures to mitigate the avalanche hazard at their resorts.

Highways

WYDOT has two full-time avalanche specialists on duty from November to April to monitor conditions and then initiate and oversee avalanche mitigation efforts on Teton Pass and in the Hoback and Snake River canyons. Their program uses artillery, hand charges, GAZ-EX, Avalanche Guard, snow sails, and road closures to mitigate the hazard from avalanches.

Four GAZ-EX units have been used on Teton Pass for about twenty years. These units have been permanently installed near the starting zones of two major avalanche paths that frequently impact the highway. They have a chamber that can be remotely filled with a mixture of propane and oxygen. A spark in this chamber then initiates an explosion that is directed from the chamber onto the snow surface in an attempt to trigger avalanches.

WYDOT also permanently installed two Avalanche Guard units on Teton Pass. These units contain explosive charges that can be remotely propelled from a secure box mounted on a vertical mast into avalanche starting zones.

A passive avalanche mitigation snow sail project was installed beginning in 2001 by WYDOT on the Mile 151 slide path that impacts Highway 89 south of Jackson. This project uses specially designed snow fencing to redistribute snow as it deposits in the starting zone in an attempt to abate the formation of dangerous slabs that cause avalanches. The starting zone of this path is in critical game habitat and therefore the use of explosives is an issue.

Helicopter Skiing

Based out of Jackson, the helicopter skiing operations access avalanche hazards on a daily basis and use route finding, snowpack stability evaluations, and ski cutting to mitigate the hazard. Explosive test charges are occasionally used to confirm stability evaluations.

Backcountry

Artillery and explosives are not used in the backcountry except on paths that could impact highways and ski areas, or as the occasional test shot to evaluate stability by helicopter guides.

"Most people trigger the avalanche that kills them." With this in mind the primary mitigation methods used in the backcountry are education, information dissemination, and ski cutting. A by-product of the increase in backcountry use has been some increase in stability by skier/rider compaction.

Avalanche education efforts are huge in western Wyoming. The BTNFAC and numerous private entities including the American Avalanche Institute, Jackson Hole Mountain Guides, and Exum Mountain Guides provide avalanche education courses to skiers, snowboarders, snowmobilers, snowshoers, guides, and workers who venture into avalanche terrain. These courses teach backcountry users to identify avalanche terrain, evaluate snowpack stability, and rescue techniques. Many backcountry users frequent avalanche terrain on a daily basis. The goal of this education is to better inform backcountry users on when not to go. The American Avalanche Association has developed standards for Level I, II, and III avalanche courses and has developed a certification program for professional instructors.

The BTNFAC issues daily specific avalanche advisories for three areas (the Teton area, the Continental Divide/Towgotee Pass area, and the Southwest Trails/Greys River area). The Gallatin National Forest Avalanche Center in Bozeman, Montana issues daily advisories for the West Yellowstone and Cooke City areas, which overlap into abutting portions of Wyoming. These daily advisories are available on the Internet and on a recorded phone message by 7:00 a.m. MST. They contain 24-hour snowfall, wind, and temperature data; area-specific weather forecast from the NWS; and a discussion of current conditions with respect to avalanche hazards including a rating of conditions on the international avalanche hazard scale.

The huge increase in skier and rider (snowmobilers and snowboarders) traffic in the backcountry and at ski resorts have had a significant impact on the stability of the snowpack. Skiers and riders disturb the snow and breakup the snowpack stratigraphy comprised of weak layers and sliding surfaces. These actions provide some increase in stability in frequently used areas. However avalanches still occur in these areas, especially during extended storm cycles.

Probability of Avalanche

Highly Likely = Value 4
128 Reported ÷ 52 years = 2.46 Avalanche events every year or a >100.0 % annual probability of an Avalanche event

Avalanche Risk Factor

Avalanche Risk Factor Value = 2.45 [(Probability: Highly Likely 4 x .30) + (Impact: 2 x .30) + (Spatial Extent: 1 x .20) + (Warning Time: 3 x .10) + (Duration: 1 x .10)]

State Mitigation Strategy – Avalanche

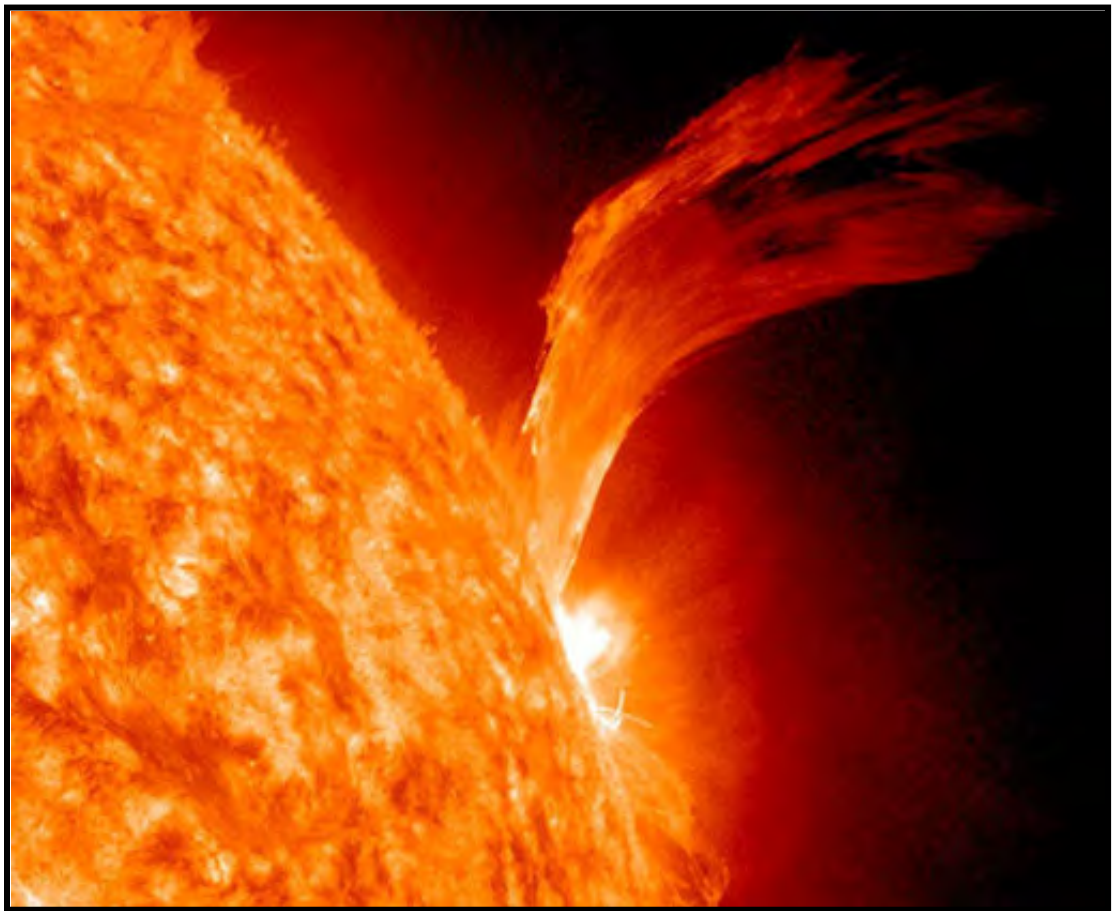
Develop & distribute education brochures on all hazards-including avalanche	Not started
Take advantage of educational meeting opportunities to discuss avalanche hazards, particularly in avalanche-prone areas	On-going as opportunities arise
Develop Public Service Announcements related to avalanche hazards	On-going as opportunities arise
Continue to support on-going mitigation activities listed above	On-going
Support local efforts to mitigate avalanche impact	

3.14 Space Weather

According to Wikipedia, "*Space Weather is the concept of changing environmental conditions in near-Earth space or the space from the Sun's atmosphere to the Earth's atmosphere… Space weather is the description of changes in the ambient plasma, magnetic fields, radiation, and other matter in space. Much of space wewather is driven by energy carried through interplanetary space by the solar wind from regions near the surface of the Sun and the Sun's atmosphere.*" [http://en.wikipedia.org/wiki/Space_weather Accessed 3/27/2014]

Space weather is a vast field of scientific research and application. For the purpose of this plan, this chapter will briefly review the impacts of solar weather from a layman's perspective rather than pursue an exhaustive study of the field. The focus will be on solar weather impacts to critical infrastructure. We will also briefly list the impact of historical solar weather events at the time they occurred and extrapolate potential impacts on electronics and other systems used throughout Wyoming. Lastly, potential mitigation actions will be discussed.

Photo 3.14.1 – September 2010 Solar Flare - NASA/SDO Photo



http://www.space.com/11506-space-weather-sunspots-solar-flares-coronal-mass-ejections.html Accessed 4/17/2014

Electrical Grid

The electrical grid is composed of many elements. Electrical network systems are known to be sensitive to space weather disturbances. Three cables, two hot and one ground, carry high voltage electricity while suspended on 100-foot towers. Those lines terminate at regional substations where the high voltages are converted to lower voltages. These lines then go to neighborhoods where the neighborhood transformer further reduces the voltage to the 220 or 110 volts which then supplies electricity to about a dozen homes.

When space weather disturbances cause Geomagnetically Induced Currents (GICs), the GICs can enter a transformer through the earth 'ground' connection. The addional current ultimately generates hot spots inside the transformer, where temperatures can increase very rapidly to hundreds of degrees in only a few minutes. These high temperatures can continue for the duration of a magnetic storm which can last for hours. High temperatures impact the insulation in the transformer, causing damage that is cumulative in nature, shortening the life of the transformer. GICs impact the larger, high voltage transmission network lines' substations in a similar manner, making the electrical grid subject to a widespread cascading failure in extreme disturbance events impacting multiple substations. An example of this type of failure is the collapse of the Hydro-Quebec Power Network on March 13, 1989 when GICs overloaded a transformer. The transformer failed, leading to a blackout impacting 6 million people for more than 9 hours.

Global Positioning System (GPS)

The Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on the earth where there is an unobstructed line of sight to four or more GPS satellites.

GPS satellites use radio signals to communicate from space. Those radio signals can be distorted by a disturbed ionosphere, causing a receiver to compute an inaccurate position or fail to compute any position at all. Space weather events can make GPS signals unreliable and impact society significantly. Commercial aviation uses a precise GPS navigation too called the Wide Area Augmentation System (WAAS). Every major space weather event impacts the WAAS, sometimes for only minutes. In some cases it has been disabled for days. Society has become more and more reliant on GPS tools to navigate stange locations. These tools can be made unreliable in a space weather event.

Long-Distance Radio Signals

The ionosphere bends radio waves in a maner similar to water in a swimming pool bending visible light. Radio waves in the 'shortwave band' are bent so much by the ionosphere that they are reflected back like a mirror reflects light. This bending and reflection of radio waves makes it possible for a shortwave radio signal to be transmitted around the curvature of the earth to a distant location. Shortwave radio is considered a critical backup communication system when newer satellite voice and data equipment is not available or is not functional.

Space weather events can create irregularities in the ionosphere which scatter the signals instead of reflecting them, making shortwave communication over long distances poor or impossible.

Electronics

Wyoming is similar to the rest of the United States, in that much of the economy is tied in some way to electronic equipment like computers, phones, vehicle operation systems, etc. Electronic equipment will be impacted by heat generated by GICs and interrupted electrical supply.

Notable space weather events

- *On the night of December 21, 1806, Alexander von Humboldt observed that his compass had become erratic during a bright auroral event.*
- *The Solar storm of 1859 causes widespread disruption of telegraph service.*
- *The Aurora of November 17, 1882 disrupts telegraph service.*
- *The May 1921 geomagnetic storm, one of the largest geomagnetic storms causes worldwide disruption of telegraph service and damage to electrical equipment.*
- *August 7, 1972 a large Solar Energetic Particles event occurred. If astronauts had been in space at the time, the dose would have been deadly or at least life-threatening. Fortunately, this large event happened between the Apollo 16 and Apollo 17 lunar missions.*
- *The March 1989 geomagnetic storm included the full array of space weather effects: Solar Energetic Particles, Coronal Mass Ejection, Forbush decrease, ground level enhancement, geomagnetic storm, etc..*
- *The 2000 Bastille Day event produces exceptionally bright aurora.*

- *April 21, 2002, the Nozomi Mars Probe was hit by a large Solar Energetic Particles event which caused large-scale failure. The mission, which was already about 3 years behind schedule, was eventually abandoned in December 2003.*

[http://en.wikipedia.org/wiki/Space_weather Accessed 3/27/2014]

Table 3.14.1 - Earth-Space Activities Disrupted by Solar Events

Solar-Geophysical Phenomena monitored by SWPC				
	Solar Phenomena	**Solar Radiation Hazards**	**Geomagnetic Activity**	**Solar Radio Interference**
Satellite operations				
Monitoring orbital variation			X	
Monitoring command & control anomalies		X	X	X
Ground-to-spacecraft communications			X	X
Aviation:				
Middle-latitude communication (VHF)				X
Polar-cap communication (HF)		X	X	
Navigation (VLF)		X	X	
High-altitude polar flights			X	
Electric Power Distribution			X	
Long-line telephone communications			X	
HF communication			X	
Pipeline operations			X	
Geophysical exploration			X	
Scientific satellite studies - Shuttle, Spacelab, solar physics, solar constant measurement, ozone variation, interplanetary missions	X		X	
Scientific rocket studies - Sun, magnetosphere, ionosphere, upper atmosphere	X		X	
Scientific ground studies - Sun, interplanetary medium, magnetosphere, troposphere; geomagnetic, seismological, biological	X		X	

Updated: October 1, 2007 http://www.swpc.noaa.gov/info/SolarEffects.html Accessed 3/27/2014

Mitigation Strategy – Space Weather

Monitor solar weather reports	
Develop shut-down procedures to prevent equipment damage	
Educate Public on Space Weather Hazard	

3.15 Tornado

Wyoming, lying just west of "tornado alley", is fortunate to experience fewer intense tornadoes than its neighboring states to the east. However, tornadoes remain a significant hazard in the state. Tornadoes are the most intense storm on earth, having been recorded at velocities exceeding 315 miles per hour (mph). The phenomena results in a destructive rotating column of air ranging in diameter from a few yards to greater than a mile, usually associated with a downward extension of cumulonimbus cloud. Tornadoes are classified by their intensity using the Fujita (F) Scale, with F0 being the least intense and F6 being the most intense. **(Table 3.15.1)**

Table 3.15.1 Fuijita Scale of Tornado Intensity

Fujita Scale	Wind Speed	Damage
F0	40-72	Light
F1	73-112	Moderate
F2	113-157	Considerable
F3	158-206	Severe
F4	207-260	Devastating
F5	261-318	Incredible
F6	319-379	Inconceivable

The weakest intensity, F0, tornadoes describe more than haf of Wyoming's past tornadoes. The strongest tornado in Wyoming was an F4 with winds between 207 and 260 mph. The tornado was the highest elevation F4 tornado ever documented. This tornado occurred in Teton County on July 21, 1987 and resulted in $500,000 in damages.

According to the Wyoming Climate Atlas, Wyoming ranks 25th in the number of annual tornadoes (10), 33rd in fatalities (six deaths per one million people), 36th in property damage ($49,339,505) (figure from WSGS), and 37th in injuries, in the U.S. from 1950 to 1994. (Excerpted from the Wyoming Climate Atlas) A record of Wyoming's tornadoes can be found in **Appendix P**.

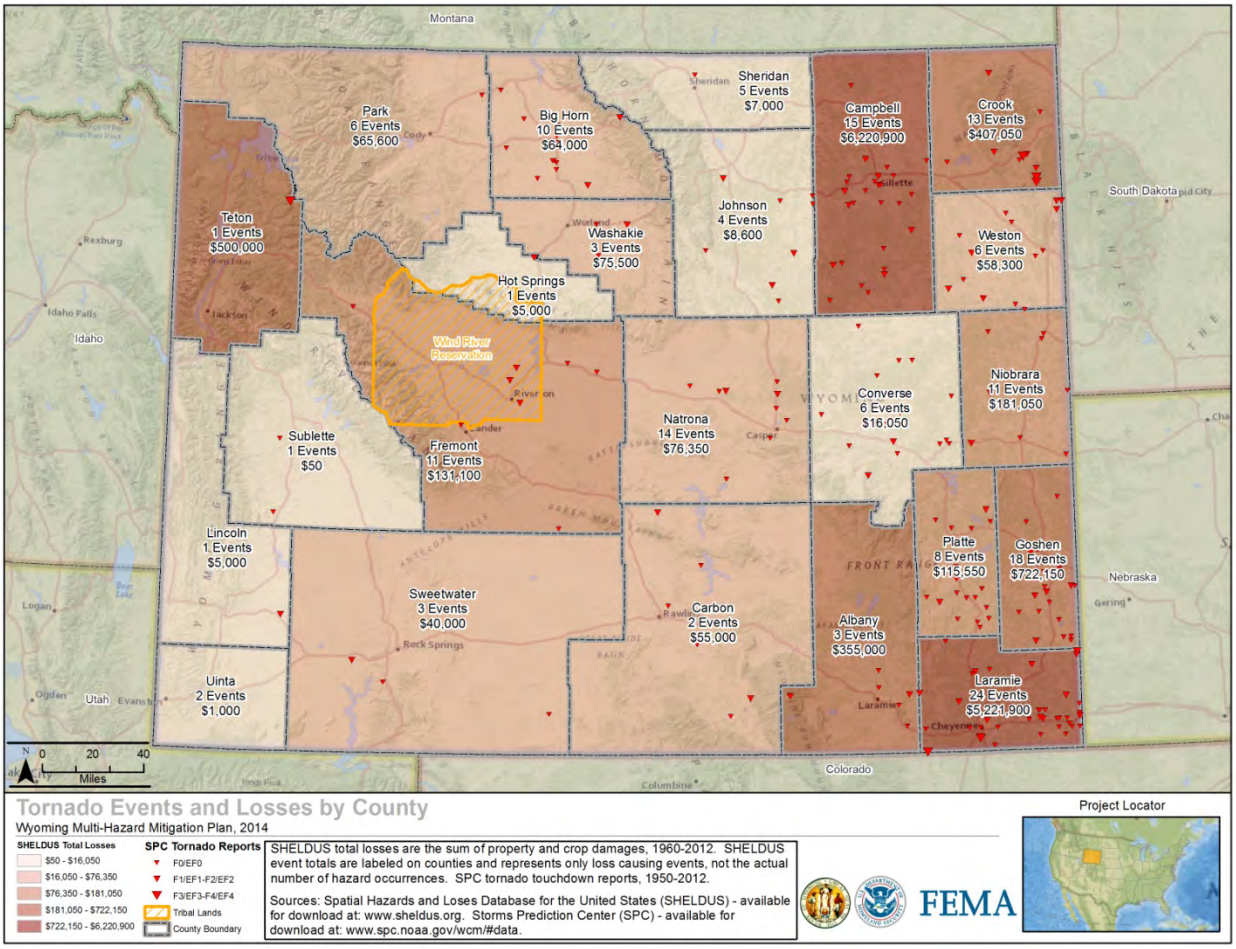
Tornado statistics, especially prior to the 1970's, must be viewed as incomplete since many twisters must have occurred without being witnessed. Wyoming's open rangelands experience little, if any, damage from these storms, so many go unreported. In the 1990's, the Internet and Doppler radar increased the public's awareness of tornadoes increasing the potential of more being observed and reported. However, the trend in annual tornadoes has decreased by one-third since 1976 and appears to have coincided with a

major hemispheric weather pattern shift, despite the increased reporting based on Doppler radar vortex (circulation) signatures. (Wyoming Climate Atlas).

Photo 3.15.2 –F2 Tornado in Wright, August 2005

By a large margin, 1979 was the year with the greatest damage, estimated at $42.8 million, with the influential factor being the Cheyenne-area tornado on July 16. The second worst year was 2005 with a total estimated damage of $5.0 million. This is a significant difference of $37.8 million. The damage in 1979 is not likely to occur, but nevertheless is possible and should be considered in this mitigation plan and in the State's Threat Identification and Risk Assessment (THIRA) and the State's Preparedness Report (SPR). The 1979 tornado damage was concentrated on property, rather than crops. Such an incident could occur again in the future. **Map 3.15.2** shows the number of recorded tornados and the estimated losses for each county.

Map 3.15.3 – Tornado Events and Losses by County



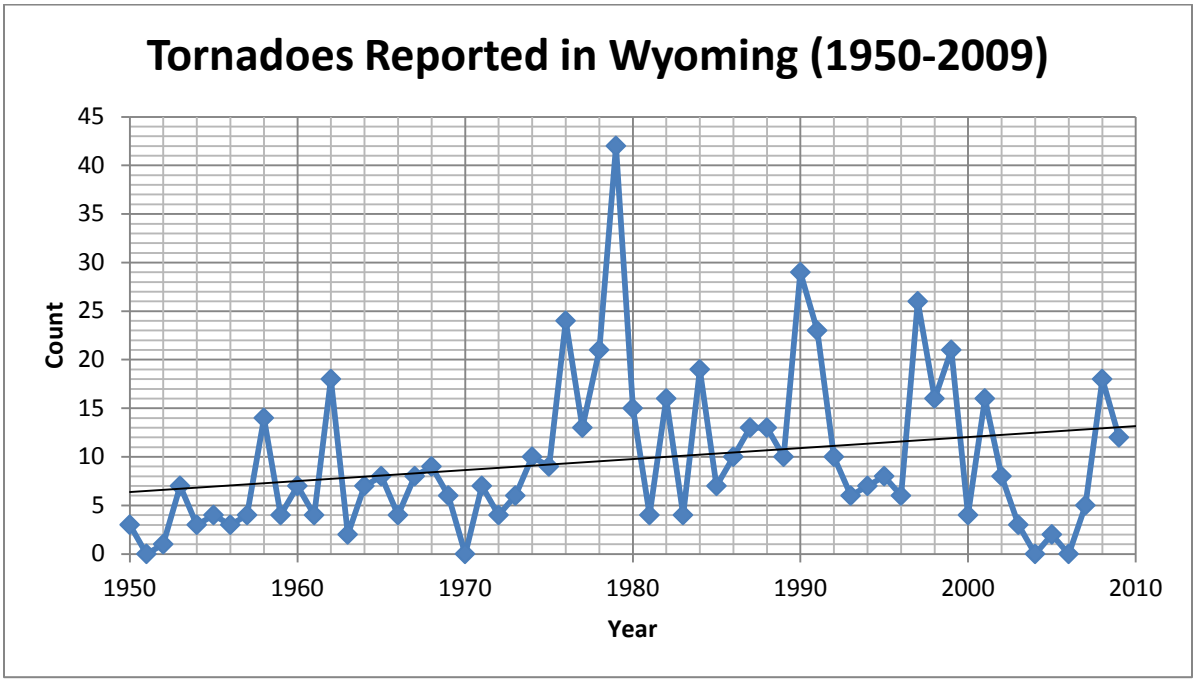
Property versus crop damage should be considered because property tends to be more critical to restore and time sensitive than crops. However, long-term effects of crop damage have potential to affect the public, but restoration is not as time sensitive as property damage.

Photo 3.15.4 – Damage from F2 Tornado in Wright – August, 2005

On the Tornado History Projects website there are 623 recorded tornado events in Wyoming from 1950 through 2012. According to the Tornado History Project, Wyoming tonados have killed four people and injured 102 in the same time period. The greatest distance traveled by a tornado in Wyoming is 52 miles. (http://www.tornadohistoryproject.com/tornado/Wyoming Accessed 3/2//2014) As one would expect, the concentration of recorded tornados occurred in the eastern portion of the state, where the plains are located.

Annual tornado statistics show a wide variation across the state. For example, 42 tornadoes were counted in 1979 while no tornadoes were reported in 1951 and 1970 (**Graph 3.15.5**). SHELDUS reports all Wyoming counties have experienced a tornado. Laramie County had the greatest number of tornadoes in the state (24) while Teton, Lincoln, Sublette and Hot Springs Counties recorded only one (**Map 3.15.3**). Laramie County has the largest population and, thus, tornadoes could be expected to cause greater damage to structures. The fact that extreme southeast Wyoming is closest to "tornado alley" explains the higher number of tornadoes. The average length of a tornado in Wyoming is 3.05 miles with an average width of 79 yards. On average there are six tornado days per year. (Excerpted from the Wyoming Climate Atlas)

Graph 3.15.5 – Tornadoes Reported in Wyoming 1950-2009

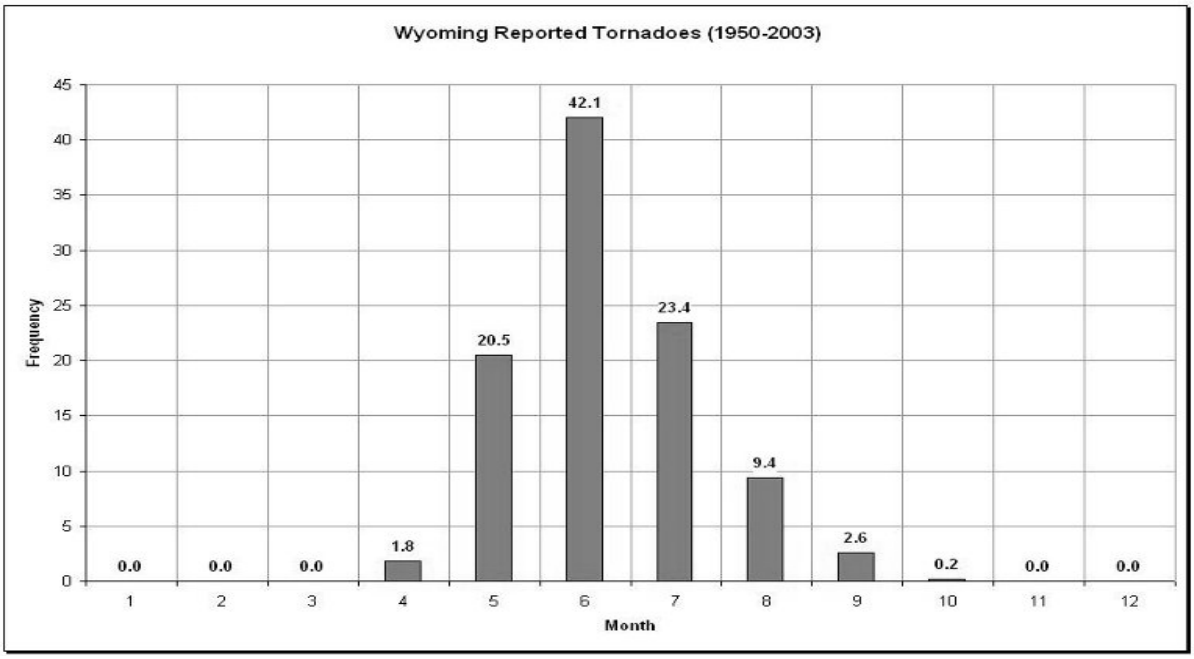


Statistically, Wyoming residents can expect tornadoes to occur between April to October, with the highest concentration of tornadoes in June (**Table 3.15.6**). Tornadoes are more likely to occur between 3 p.m. and 4 p.m. (**Table 3.15.7**)

Wyoming Government Property

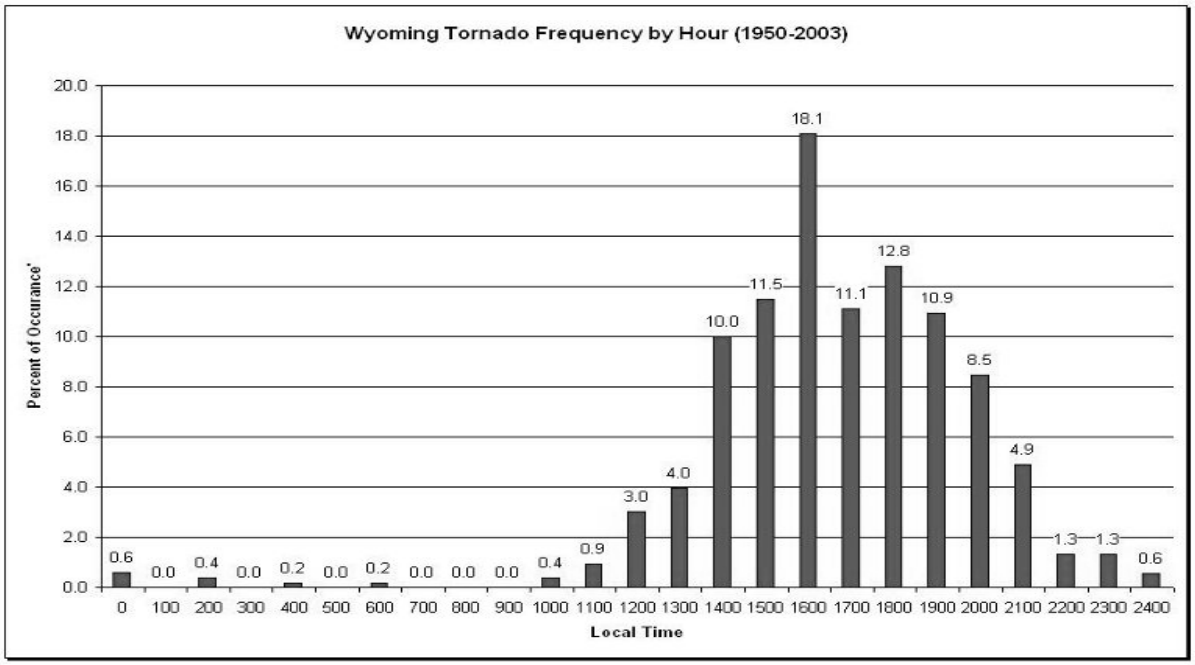
Historically Wyoming's government property has experienced 1 damaging tornado event totaling $4,251 in the 307-month period from August, 1985 through February, 2011. If we can assume past experience will continue into the future, the state can anticipate 1 damaging tornado event to its structures every 26 years. Given the number of anticipated tornado events, and based on past experience, damages of $166 can be anticipated annually ([$4,250.74 / 307 months] * 12 months each year = $166.20). Given the value of properties in locations around the state, any of which may be subject to tornados, past history may represent an accurate loss estimate or it may merely reflect historical good fortune.

Table 3.15.6 – Monthly Tornado Statistics 1950 – 2003



Wyoming Climate Atlas

Table 3.15.7 – Tornado Frequency by Hour 1950 – 2003



Wyoming Climate Atlas

Presidential Declaration

There has been one Presidential Disaster Declaration related to tornadoes in Wyoming. FEMA DR-WY-1599 was associated with the August 12, 2005, tornado in Wright, Wyoming located in Campbell County.

Although counties have been affected to lesser and greater extents by tornado intensity, frequency, and damage, they nevertheless have struck every county in Wyoming, thus proving to be a considerable danger. Historically, the most devastating tornado event in Wyoming was July 16, 1979 when the Cheyenne area received between $5 and $50 million worth of damage. [http://www.tornadohistoryproject.com/tornado/Wyoming/1979/July/table Accessed 3/28/2014] This is significant because Laramie County, the location of the state's capitol, has Wyoming's greatest population and is also the most likely to have the highest frequency and intensity of tornadoes.

Historical data demonstrates the most critical area of the state for tornado hazard is the eastern one third, with the five most threatened areas being Laramie, Campbell, Goshen, Crook, and Niobrara Counties. The four least threatened areas include Teton, Sublette, Hot Springs, and Lincoln Counties (**Map 3.15.3**).

Laramie, Goshen, and Campbell Counties should be viewed as most critical. The July 1979 tornado in the Cheyenne area, resulting in millions of dollars worth of damage, should be considered a worst-case scenario. The data suggests that Cheyenne's size and location places it at the highest risk for economic damage from tornado hazards.

The most recent tornadoes causing loss of life occurred in Big Horn County on June 26, 1959, in Cheyenne on July 16, 1979, and in Wright on August 12, 2005. One life was lost in the Big Horn County Cheyenne events, and two lives were lost in the Wright event. The Cheyenne event also resulted in 40 injuries.

Local Risk Assessments

Each county has ranked tornado risk within their borders based on the population impacted, probability of occurrence and the property impacted.

Below is a table outlining the local perception of tornado activity in their county and the impact it would have, based on past events. Information was gathered from local mitigation plans and extrapolates, based on population impacted, probability of occurrence within their borders, and property impacted, the risk perceived by each county relative to tornado hazards. You will note all counties rank tornadoes risk between a medium and high hazard within their borders. Potential losses quoted within the local plans vary widely, based on their past experience, population density and development within the county and its jurisdictions.

Table 3.15.8 – Local Risk Assessment - Tornado

COUNTY	Plan Y/N	Year Approved	Included in Plan	Rank-High, Medium, Low
ALBANY	Y	2010	Y	Medium
BIG HORN	Y	2011	Y	High
CAMPBELL	Y	2011	Y	High
CARBON	Y	2009	Y	Medium
CONVERSE	Y	2012	Y	Medium
CROOK	Y	2013	Y	Medium
FREMONT	Y	2012	N	

COUNTY	Plan Y/N	Year Approved	Included in Plan	Rank-High, Medium, Low
GOSHEN	Expired	2007	Y	Medium
HOT SPRINGS	N			
JOHNSON	Y	2013	Y	High
LARAMIE	Y	2013	Y	High
LINCOLN	Expired	2007	Y	Medium-High
NATRONA	Y	2011	Y	Medium-High
NIOBRARA	Y	2010	Y	High
PARK	Y	2011	Y	Medium
PLATTE	Expired	2004	Y	Medium
SHERIDAN	Y	2009	Y	Medium
SUBLETTE	Expired	2008	N	
SWEETWATER	N			
TETON	Y	2010	Y	Medium
UINTA	Y	2011	N	
WASHAKIE	Y	2011	Y	Medium
WESTON	N			
NORTHERN ARAPAHO TRIBE	N			
EASTERN SHOSHONE TRIBE	N			

Because of the devastating impact tornadoes can have on a community, the vulnerability of the community has an impact on the risk associated with tornado hazards. Additionally, development can impact the risk presented by tornadic activity. Increased population can mean greater damage in the event a tornado strikes. Tornado shelters and basements become more important the greater the population in order to help prevent loss of life in the event of a tornado. Additionally, those unfamiliar with the hazard may be drawn to watch events as they unfold rather than take shelter, putting them at greater risk of injury or death. Section 1.3 of this plan documents those counties with higher population increases and populations with greater vulnerability based on income levels, age, and other social vulnerability criteria.

Probability of Tornado

Highly Likely = Value 4
168 Reported ÷ 52 years = 3 Tornado events every year or a >100.0 % annual probability of a Tornado event

Tornado Risk Factor

Tornado Risk Factor Value = 3 [(Probability: Highly Likely 4 x .30) + (Impact: 3 x .30) + (Spatial Extent: 3 x .20) + (Warning Time: 3 x .10) + (Duration: 2 x .10)]

Mitigation Strategy

Tornado education	On-going activitiy
Establish tornado shelters, especially in heavily-populated areas	
Determine governmental buildings qualified for tornado shelters	
Enhanced radar coverage	On-going activity
Improve warning systems	On-going activity
Provide all-hazards weather radios to all residents	On-going activity

3.16 Wildland-Urban Interface Fire

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 defined by the National Interagency Fire Center (NIFC), a "wildland fire" is any non-prescribed, non-structure fire that occurs in the wildland.

Photo 3.16.1 – Sawmill Canyon Fire-Platte County, 2012

Photo courtesy of Wyoming State Forestry Division

Wyoming's Forest Action Plan identifies fire in the wildland-urban interface (WUI) as threat that is significant and expanding. Fire in the WUI impacts suppression strategies, tactics, costs, and also potentially firefighter and public safety. Lands in the WUI are often desirable for housing development due to amenities such as forests or other vegetation which in turn present a hazard to the development. The Forest Action Plan also identifies strategies and tactics to help reduce the risk of wildfire in the WUI. Increased areas of WUI are prompting policy makers and fire management organizations to respond to the need to mitigate wildfire risk.

Conditions on some landscapes are no longer within normal fire regimes or fire return intervals, the result of effective fire suppression, limited forest management, and climatic factors. For example, ponderosa pine stands often burn in an intense, stand replacing manner, rather than the lower intensity fires of the past. With more intense fires there is the risk of the loss of ecosystem components, such as large trees, plus risk of damage to other resources, such as water quality. For some landscapes, before fire can safely be returned, if desired, mechanical treatment would be necessary to reduce fuels to help control fire intensity.

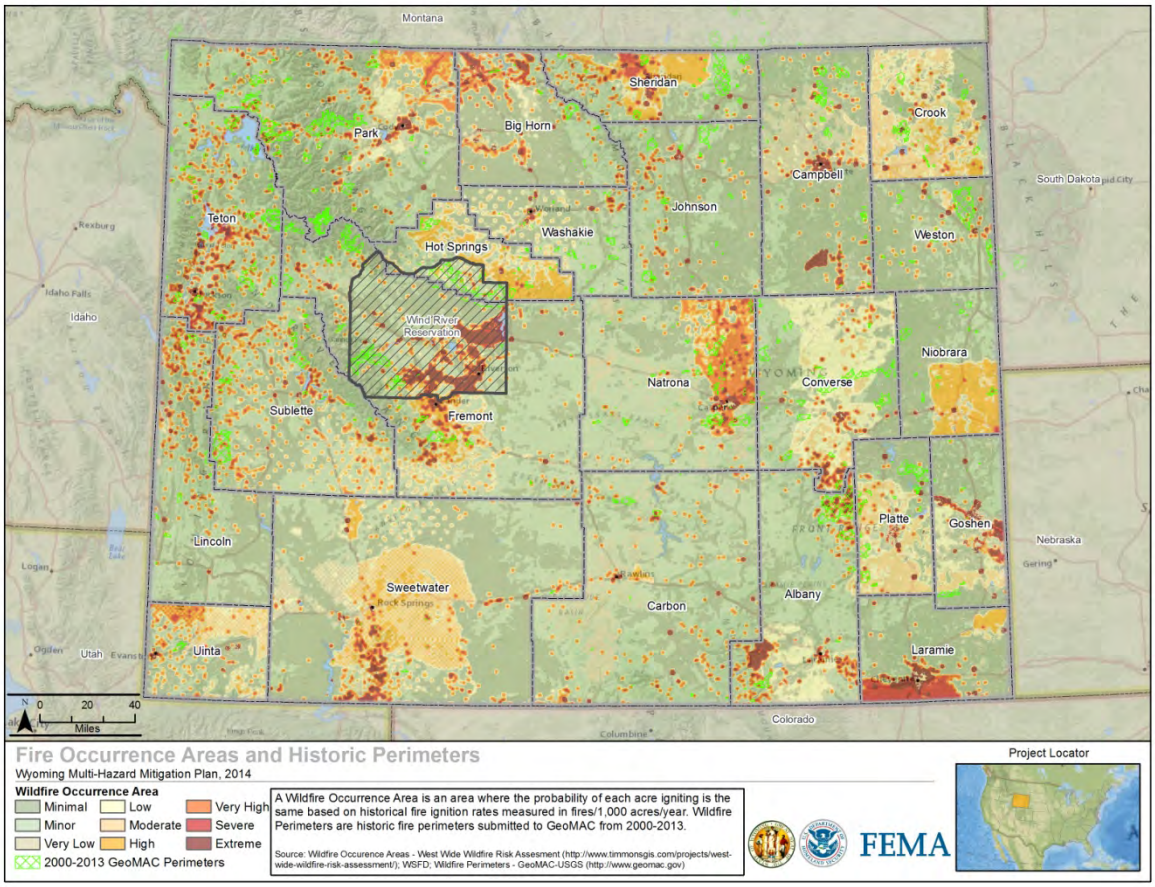
According to the Wyoming State Forestry Division, the majority of wildfires in the state are started naturally by lightning. This makes Wyoming dissimilar to more heavily populated states, as those states with higher populations find their wildfires are more likely to be human-caused. As the population in

Wyoming slowly increases, the number of human caused fires also slowly increases. Ninety-eight percent (98%) of all wildfires—both human and those caused naturally —in Wyoming are extinguished by firefighters within 10-acres of ignition.

Although different reports, assessments, plans, and programs have been developed by organizations at all levels of government, interagency coordination has proven to be extremely effective. Today Wyoming wildland fires are managed and supported to varying extents through a cooperative effort by the:

- U.S. Bureau of Land Management (BLM) Wyoming Fire Program
- Geospatial Multi-Agency Coordination (GeoMAC) Wildland Fire Support Maps
- Wyoming Fire Academy
- National Park Service (NPS) Fire Management Program
- U.S. Fish and Wildlife Service (FWS) Fire Management Branch
- National Interagency Fire Center (NIFC)
- U.S. Bureau of Indian Affairs (BIA) Fire and Aviation Management – NIFC
- USDA Forest Service (USFS) Fire and Aviation Management
- Wyoming State Fire Marshalls Office
- Wyoming Office of Homeland Security (WOHS)
- Wyoming State Forestry Division
- County and Local Fire Departments/Districts

Map 3.16.2 – Fire Occurrence Areas and Historic Perimeters



Before discussing wildland fire hazard in Wyoming some key terms should be identified. The term "wildland/urban interface" or WUI is widely used within the wildland fire management community to describe any area where man-made structures 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.

In the past, the principle wildland fire response plan for the state was the Wyoming Wildland Urban Interface Hazard Assessment produced by a joint venture of the Wyoming State Forestry Division, USFS, BLM, NPS, and other interested parties, with the BLM hosting the data. This is a geographic information system (GIS)-based mapping mission building 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 will result in a Risk, Hazard, and Value (RHV) map displaying areas of concern (red zones) for catastrophic wildland fires (**Map 3.16.6**). The Wyoming Wildland Urban Interface Hazard Assessment builds on the work of earlier hazard methodologies and provides new and updated data to further enhance accuracy and scale.

Photo 3.16.3 – Fontenelle Fire-Sublette County 2012

Photo courtesy of Wyoming State Forestry Division

Currently, the Wyoming Forest Action Plan and the Western Wildfire Risk Assessment are considered the primary strategic plans that address wildland fire management in the state. Additionally, the Wyoming

Interagency Cooperative Fire Management and Stafford Act Response Agreement outline areas of cooperation and coordination with respect to fire prevention, readiness, detection, fuels management, suppression, information sharing, communications, and reimbursement for shared resources. The agreement is produced through a joint venture of the U.S. Bureau of Land Management (BLM); National Park Service, Intermountain Region; Bureau of Indian Affairs, Rocky Mountain Region (BIA); Fish and Wildlife Service, Mountain Prairie Region; U.S. Department of Agriculture, Forest Service Rocky Mountain and Intermountain Regions; and the Wyoming State Board of Land Commissioners, Office of State Lands and Investments, Wyoming State Forestry Division. The agreement is implemented at the county and local level through Annual Operating Plans (AOP's). Community Wildfire Protection Plans (CWPP's) are also utilized, as well as other federal agency wildfire management plans.

History

As one of the most arid states in the U.S., Wyoming has experienced large fires historically. 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. Today, fires of equivalent magnitude can and have occurred.

2012 Fire Season

The 2012 fire season was in many ways the most severe fire season in Wyoming since 1988. An estimated 1,000 wildland fires burned over 600,000 acres of state, private, and federal lands. The fire season started early following a dry winter and spring, with drought intensifying since the late summer of 2011. The first large fire in the state requiring a Type II Incident Management Team was the Cow Camp Fire in Albany County that started on June 5th. The Cow Camp Fire consumed over 8,400 acres. There were 31 qualifying Emergency Fire Suppression Account (EFSA) fires in 13 different counties and 4 FEMA Fire Management Assistance Grant (FMAG) fires. In an average season, there are less than six EFSA qualifying fires and, at the most, one FEMA FMAG Fire. Initial attack and large fires subsided with the Sheepherder Hill Complex in Natrona County and the Horsethief Canyon Fire in Teton County in September. Initial attack continued through the month of November, with some counties, such as Crook County reporting wildfires in every month of 2012.

In the 2012 season, Wyoming firefighters witnessed unprecedented fire behavior and rates of spread. The results were 80 homes/cabins destroyed, 50 outbuildings destroyed, with costs to local and state government exceeding 40 million dollars. Eventually, all 23 counties in the state had fire restrictions in place, as well as most public federal lands. Despite the loss of values, improvements, range land, and timber, the safety record during the 2012 season was second to none. Early on in the season, heat related illnesses were experienced on some incidents. As the season progressed there were very few minor or major injuries. The commitment to training and firefighter and public safety was demonstrated on every incident. Over the course of the fire season, thousands of wildland firefighters from thirty one different states assisted in suppressing the fires. Lessons learned from the 2012 fire season include:

- Firefighting: Continue to fight fires and be adequately prepared for the next year.
- Rehabilitation and Restoration: Restore landscapes and rebuild communities damaged by the wildfires of 2012.

- Hazardous Fuel Reduction: Invest in projects to reduce wildfire risk.
- Community Assistance: Work directly with communities to ensure adequate community planning and protection.

Research following wildlland fires has provided some lessons learned:

- Fertile soil with good-water holding capacity and dense, diverse vegetation before the fire recovered quickly.
- Grasslands returned to pre-fire appearance within a few years.
- Many of the burned forests were mature lodgepole; this species is re-colonizing most of the burned areas.
- The first seedlings of Engelmann spruce, subalpine fir, Douglas-fir, and whitebark pine have emerged.
- Aspen reproduction has increased because fire stimulated the growth of suckers from the aspen's underground root system and left behind bare mineral soil that provides good conditions for aspen seedlings.
- Some of the grasses that elk eat were more nutritious after the fire.
- Bears graze more frequently at burned than unburned sites.
- Cavity-nesting birds, such as bluebirds, had more dead trees for their nests; birds dependent on mature forests, such as boreal owls, lost habitat.

Fuel types in Wyoming's WUI include many grasses, forbs, shrubs, trees, and forest residues. All of these types of vegetation can provide increased fire hazard near structures. Mitigating the risk of fire in the WUI can involve different practices depending on the fuels in the vicinity. It is also important to be aware that other fuels, such as firewood piles or other items in close proximity to a structure, can contribute to the risk that fire poses to a structure. Similarly, certain construction materials such as wood shingles can make a home more vulnerable to fire in the vicinity.

Table 3.16.4 is a chronological history of fires and the number of acres burned, highlighting both the figures for federal land, state and private lands, and their totals between 1960 and 2013.

Table 3.16.4 – History of Numbers of Fires and Acres Burned

Year	Intensity type	Amount		
		Federal land	State & private land	Total
1960[1]	Number of fires	159	39	198
	Number of acres burned	2,533	840	3,373
1961[1]	Number of fires	147	57	204
	Number of acres burned	1,193	16	1,209
1962[1]	Number of fires	116	20	136
	Number of acres burned	241	44	285

Year	Intensity type	Amount		
		Federal land	State & private land	Total
1963[1]	Number of fires	141	31	172
	Number of acres burned	1,367	764	2,131
1964[1]	Number of fires	143	24	167
	Number of acres burned	3,650	393	4,043
1965[1]	Number of fires	68	15	83
	Number of acres burned	228	94	322
1966[2]	Number of fires	261	243	504
	Number of acres burned	2,391	4,908	7,299
1967[2]	Number of fires	35	156	291
	Number of acres burned	325	4,490	4,815
1968[3]	Number of fires	163	132	295
	Number of acres burned	2,551	12,122	14,673
1969[3]	Number of fires	231	396	627
	Number of acres burned	2,980	25,981	28,961
1970[3]	Number of fires	241	413	654
	Number of acres burned	7,984	11,378	19,362
1971[3]	Number of fires	209	433	642
	Number of acres burned	3,406	67,567	70,973
1972[3]	Number of fires	183	438	621
	Number of acres burned	1,362	24,078	25,440
1973[3]	Number of fires	200	444	644
	Number of acres burned	2,911	10,047	12,958
1974[3]	Number of fires	301	772	1,073
	Number of acres burned	5,000	27,847	32,847
1975[3]	Number of fires	205	513	718
	Number of acres burned	6,101	15,177	21,278
1976[3]	Number of fires	349	589	938
	Number of acres burned	7,019	14,795	21,814
1977[3]	Number of fires	369	612	981

Year	Intensity type	Amount		
		Federal land	State & private land	Total
	Number of acres burned	6,045	16,885	22,930
1978[3]	Number of fires	301	559	860
	Number of acres burned	3,392	5,220	9,152
1979[3]	Number of fires	366	598	964
	Number of acres burned	12,100	16,294	28,394
1980[3]	Number of fires	333	603	936
	Number of acres burned	2,426	15,665	18,091
1981[3]	Number of fires	406	677	1,083
	Number of acres burned	30,326	6,757	37,083
1982[3]	Number of fires	205	555	760
	Number of acres burned	1,779	16,026	17,805
1983[3]	Number of fires	177	734	911
	Number of acres burned	2,294	25,136	27,430
1984[2]	Number of fires	169	607	776
	Number of acres burned	658	13,305	13,963
1985[2]	Number of fires	352	1,252	1,604
	Number of acres burned	11,227	56,185	67,412
1986[2]	Number of fires	202	546	748
	Number of acres burned	6,385	15,325	21,710
1987[2]	Number of fires	201	816	1,017
	Number of acres burned	7,872	21,123	28,995
1988[2]	Number of fires	504	1,456	1,960
	Number of acres burned	1,413,175	124,127	1,537,302
1989[2]	Number of fires	278	738	1,016
	Number of acres burned	4,331	25,088	29,419
1990[2]	Number of fires	353	492	845
	Number of acres burned	2,221	31,499	33,720
1991[4]	Number of fires	379	836	1,215
	Number of acres burned	16,106	61,944	78,050
	Number of fires	407	872	1,279

Year	Intensity type	Amount		
		Federal land	State & private land	Total
1992[4]	Number of acres burned	6,750	33,727	40,477
1993[4]	Number of fires	163	303	466
	Number of acres burned	4,283	4,628	8,911
1994[4]	Number of fires	584	1,027	1,611
	Number of acres burned	44,207	58,480	102,687
1995[4]	Number of fires	250	597	847
	Number of acres burned	2,846	12,697	15,525
1996[4]	Number of fires	516	1,506	2,022
	Number of acres burned	105,687	417,310	522,997
1997[4]	Number of fires	171	738	909
	Number of acres burned	8,420	20,016	28,436
1998	Number of fires	112[7]	446[6]	558[5]
	Number of acres burned	17,569[7]	5,373[6]	22,942[5]
1999	Number of fires	158[7]	574[6]	732[5]
	Number of acres burned	37,204[7]	47,097[6]	84,301[5]
2000[6]	Number of fires	339	909	1,248
	Number of acres burned	261,967	358,697	620,664
2001	Number of fires	486[7]	219[6]	705[8]
	Number of acres burned	138,696[7]	18,414[6]	157,110[8]
2002[6]	Number of fires	303	815	1,118
	Number of acres burned	60,007	163,227	223,234
2003[6]	Number of fires	283	727	1,010
	Number of acres burned	44,797	22,888	67,685
2004	Number of fires	185	655	850
	Number of acres burned	2,665	23,909	26,574
2005	Number of fires	190	697	887
	Number of acres burned	8,695	17,104	25,779
2006	Number of fires	289	1,008	1,297
	Number of acres burned	57,893	262,151	320,044

Year	Intensity type	Amount		
		Federal land	State & private land	Total
2007	Number of fires	254	816	1070
	Number of acres burned	50,878	52,304	107,505
2008	Number of fires	211	533	744
	Number of acres burned	88,908	51,456	140,364
2009	Number of fires	248	422	670
	Number of acres burned	939	5,778	6,717
2010 (Estimate)	Number of fires	321	541	562
	Number of acres burned	23,926	67,062	90,988
2011	Number of fires	643	355	998
	Number of acres burned	130,129	92,948	223,077
2012	Number of fires	802	547	1.349
	Number of acres burned	334,948	427,559	762,507
2013	Number of fires	448	281(Partial reporting, all fires not reported at this time	729 (Partial)
	Number of acres burned	43,844	1,511 (Partial reporting, all fires not reported at this time	45,355 (Partial)

[1] USDA Forest Service, Annual Fire Report for the National Forests
[2] USDA Forest Service, Summary of Forest Fire Statistics for the US (CD from USDA FS, Washington, DC)
[3] USDA Forest Service, Wildfire Statistics
[4] USDA Forest Service, Wildland Fire Statistics
[5] Wyoming State Forestry Division
[6] USDA Forest Service, Rocky Mountain Area and Coordination Center 1998-2003 Annual Report Figures
[7] Subtracted "State and Private" from "Total"
[8] Wyoming State Fire Marshal

Research completed by Headwaters Economics, dated 2010 found that:

- Of the 11 western states, Wyoming has the ninth largest area of undeveloped, forested private land bordering fire-prone public lands, and ranks last (11th) among western states in the amount of forested land where homes have already been built next to public lands.
- Wyoming has over 400 square miles of forested private land that borders public lands, of which 96 percent has not yet been developed.

- Housing in Wyoming's wildland urban interface consumes a whopping 7.6 acres per person, compared to the 0.5 acres per person average on other western private lands. These are larger residential lots than in any other western state's wildland urban interface.
- Wyoming has 4,604 residences in its wildland urban interface, of which 44 percent are seasonal homes or cabins.

Wyoming ranks eleventh (last) among western states in the number of homes built in forested areas next to public wildlands, and first in the percentage of those homes that are only seasonally occupied.

Overall, Wyoming has less developed wildland urban interface than most western states. 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. Combined, these three counties have more than 3,000 homes spread across 10 miles of wildland urban interface. Throughout Wyoming there remains potential for future home construction in more than 400 square miles of 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. (http://headwaterseconomics.org/pubs/wildfire/wy.php Accessed 6/4/2011)

Table 3.16.5 – Top 10 Counties Ranked by Existing & Potential Risk

Top 10 Counties in Wyoming Ranked by Existing Risk

Counties are ranked by the number of square miles of developed land in the wildland interface

County and State		Developed sq. mi.	Undeveloped sq. mi.	Percent Developed	Homes	% Second Homes
Teton County	Wyoming	5.6	29.9	16.0%	2,060	23.0%
Lincoln County	Wyoming	2.9	13.5	18.0%	684	21.0%
Albany County	Wyoming	1.8	30.3	6.0%	362	88.0%
Sheridan County	Wyoming	1.7	13.9	11.0%	336	70.0%
Carbon County	Wyoming	1.5	52.2	3.0%	164	95.0%
Park County	Wyoming	1.5	28.7	5.0%	385	58.0%
Natrona County	Wyoming	0.9	8.7	9.0%	230	76.0%
Sublette County	Wyoming	0.5	16.9	3.0%	71	76.0%
Fremont County	Wyoming	0.4	23.8	1.0%	69	81.0%
Crook County	Wyoming	0.3	59.6	1.0%	54	22.0%

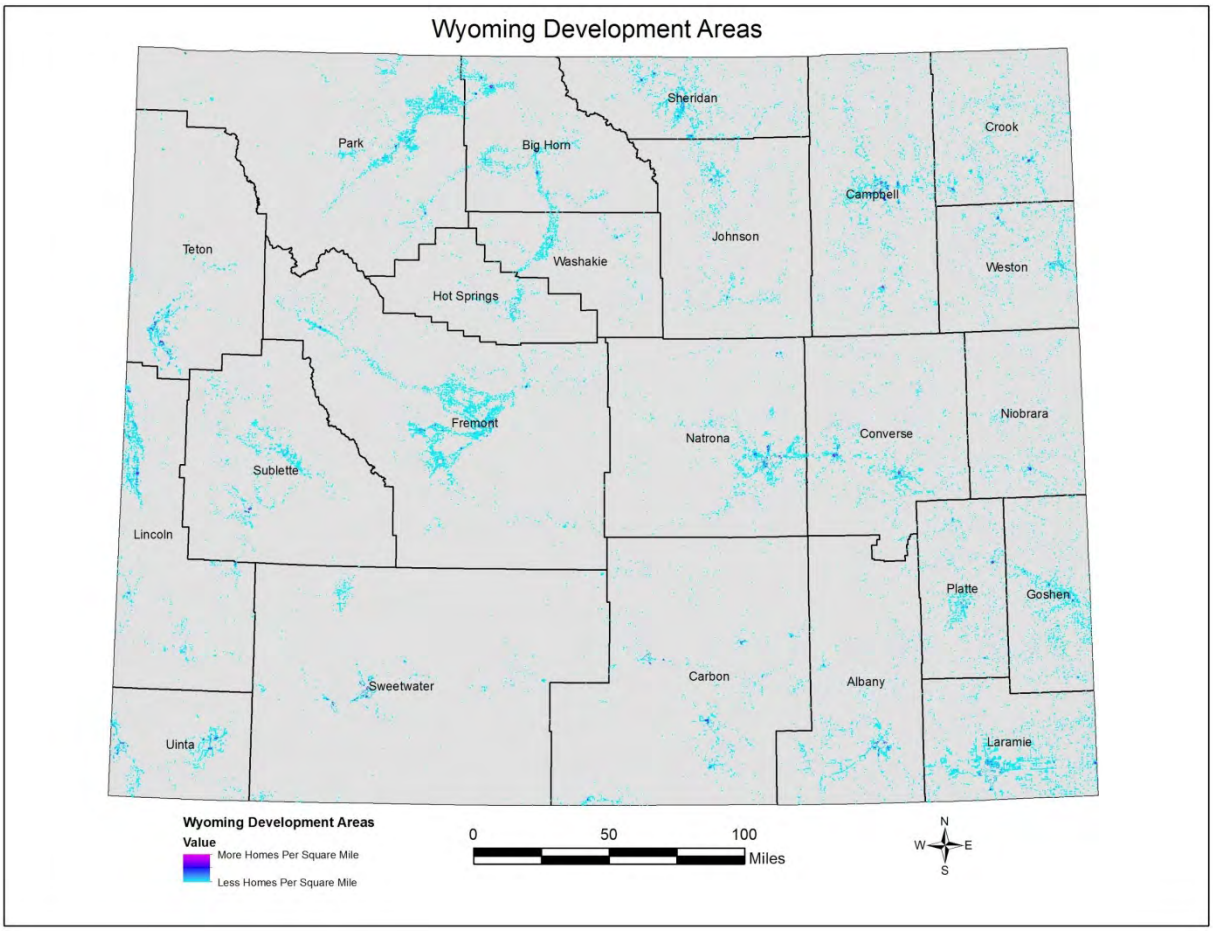
Top 10 Counties in Wyoming Ranked by Potential Risk

Counties are ranked by the number of square miles of undeveloped land in the wildland interface.

County and State		Developed sq. mi.	Undeveloped sq. mi.	Percent Developed	Homes	% Second Homes
Crook County	Wyoming	0.3	59.6	1.0%	54	22.0%
Carbon County	Wyoming	1.5	52.2	3.0%	164	95.0%
Converse County	Wyoming	0.3	34.9	1.0%	66	79.0%
Albany County	Wyoming	1.8	30.3	6.0%	362	88.0%
Teton County	Wyoming	5.6	29.9	16.0%	2,060	23.0%
Johnson County	Wyoming	0.3	28.7	1.0%	88	99.0%
Park County	Wyoming	1.5	28.7	5.0%	385	58.0%
Fremont County	Wyoming	0.4	23.8	1.0%	69	81.0%
Uinta County	Wyoming	0.0	23.8	0.0%	14	71.0%
Sublette County	Wyoming	0.5	16.9	3.0%	71	76.0%

http://headwaterseconomics.org/pubs/wildfire/wy.php **Accessed 6/4/2011**

Map 3.16.6 – Homes in the Wildland Interface

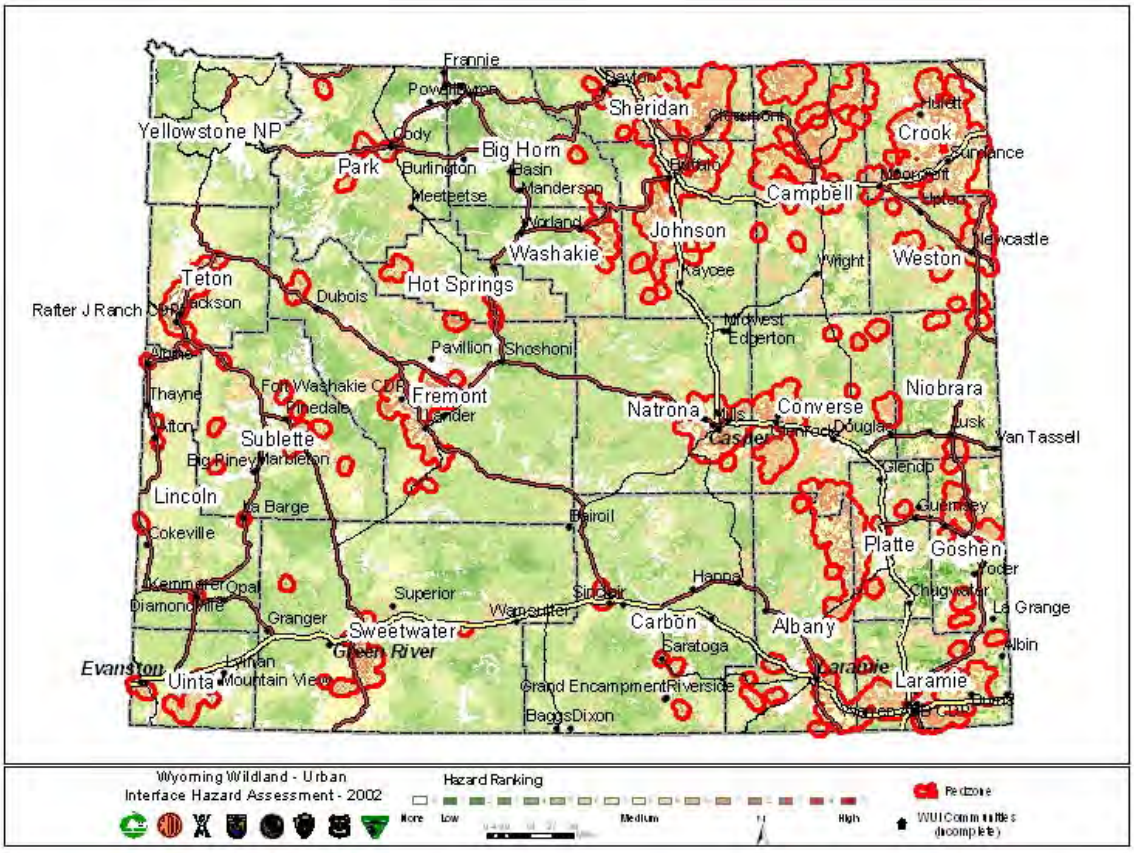


The Wildland Development Areas (WDA) data layer was developed to identify "where people live" in wildland areas that are threatened by fire from wildland fuels. Wildland Development Areas were compiled from the Where People Live (WPL) dataset which was developed using advanced modeling techniques based on the LandScan population count data available from the Department of Homeland Security, HSIP Freedom Dataset. The HSIP Freedom dataset is available at no cost to U.S. local, state, territorial, tribal and Federal government agencies.

The process excluded the core urban areas that are not in a neighborhood or area threatened by fire burning in wildland fuels. In the process, care was taken to leave relatively small, high-density structure areas, one housing unit on 1/3rd of an acre or more, in the Wildland Development Areas data layer when the area was small enough to be threatened by fire from wildland fuels.

The WPL and WDA datasets have been derived to represent the number of houses per square kilometer, consistent with Federal Register and USFS Silvis datasets. However, to aid in the interpretation and use of this data, the legends are presented in "houses per acre".

Map 3.16.7 Wyoming Wildland Urban Interface Hazard Assessment Red Zones (2002)



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.

Risk, hazard, and value are combined to produce the final output for the Hazard Assessment as depicted in the map above. Areas of highest hazard are buffered to establish the Red Zone layer, also depicted above.

Table 3.16.8 – Percent of Developed Wildland Interface

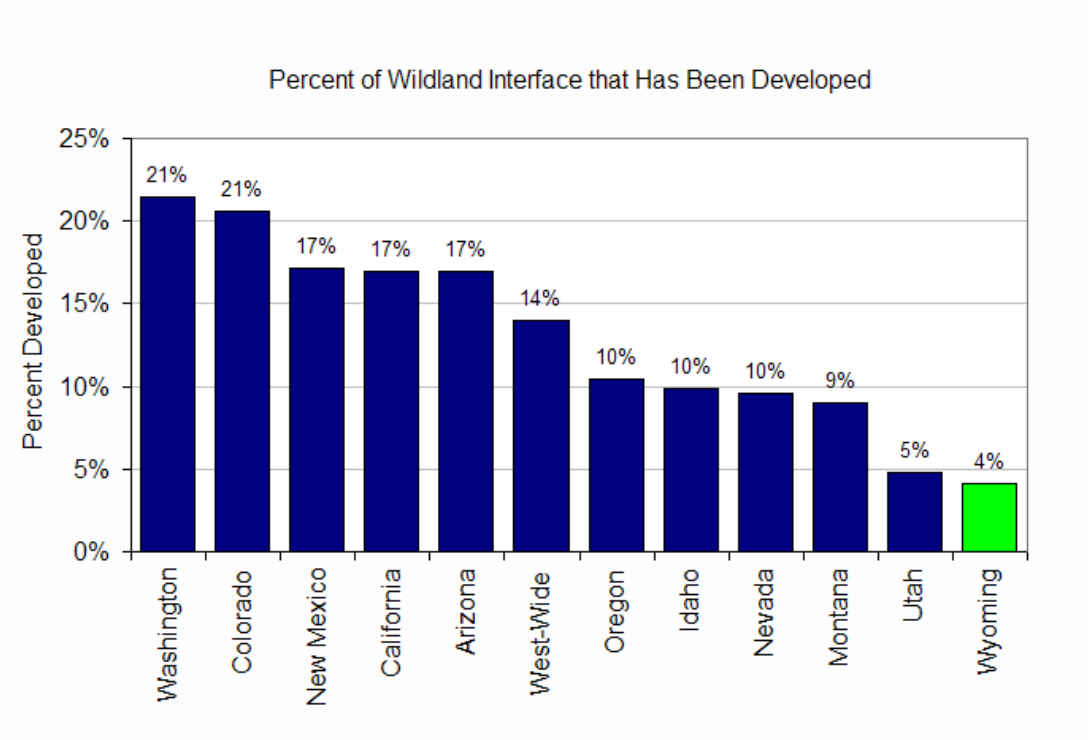
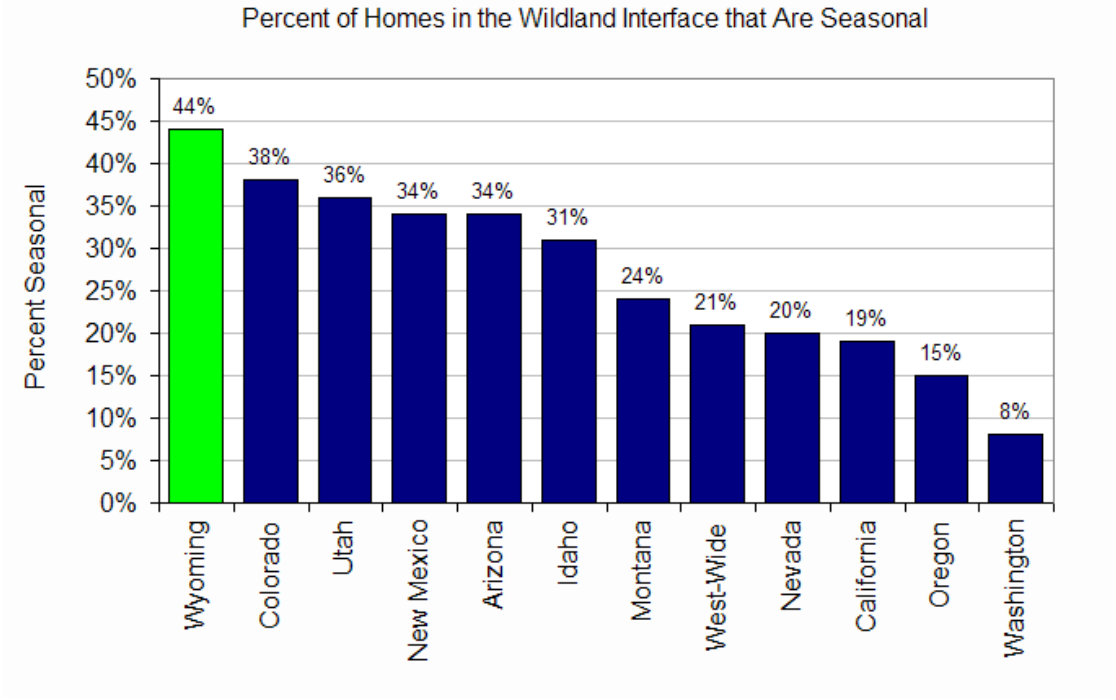


Table 3.16.7 – Percent of Seasonal Homes in Wildland Interface



When an analysis between annual precipitation rates and acreage burned is conducted, it reveals that there is a relationship between the variables. The average annual acres burned from 1960 to 2007 are 147,787.19, with a maximum acreage of 1,537,302 in 1988 and a minimum of 285 in 1962. Since 1999 Wyoming has been experiencing a significant drought yielding an average of 230,599 acres burned between 1999 and 2003—a considerable difference of 156,549 average acres from the 43-year span, 1960 to 2003—providing evidence for the precipitation/acreage burned relationship.

Table 3.16.9 displays a relationship between annual precipitation and the number of acres burned from wildland fires from 1960 to 2006. It is apparent that a precipitation decrease yields an increase in acreage burned. The most dramatic example is in 1988 where a total of 1,537,302 acres were burned and 8.55 inches of precipitation fell that year. Both figures are a record high and low, respectively, between the years 1960 and 2006.

Future impacts can be determined by weather analysis and prediction with drought and precipitation, and continuing studies with this relationship can be pursued further.

Table 3.16.9 Annual Precipitation & Acres Burned Relationship

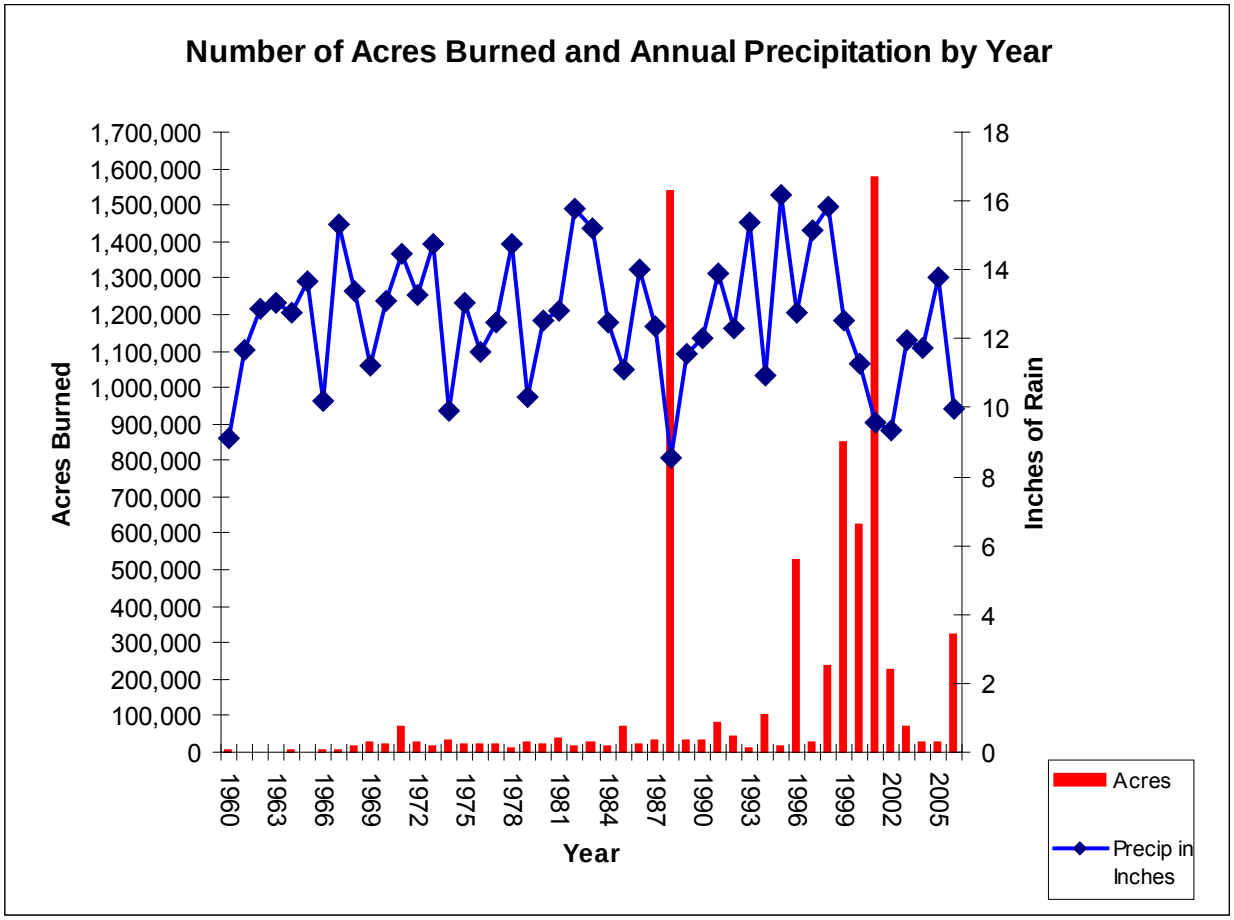


Figure 17.3—Relationship Between Annual Precipitation and Number of Wildland Acres Burned.

Wyoming Government Property

Historically, from August 1985 forward, there has been one wildland fire resulting in damage to state-owned property. The single event resulted in one monitoring station being burned and represents a loss of $1,687. If the past 25 years represents a loss record which can be expected to continue into the future, wildland fires are a minimal risk to state properties with an estimated annual loss of $67. Given the value of properties in locations identified as subject to wildland fires, past history may represent an accurate loss estimate given established mitigation efforts or it may merely reflect historical good fortune.

Local Mitigation Plan Risk Assessments

A review of the local plans reflects all counties consider wildland fire to be a hazard within their borders, as they each address the hazard within their local plans. Several counties have developed firewise communities within their borders, making mitigation efforts and fire prevention education a priority. This is particularly true of those counties within the mountain ranges of Wyoming. Counties addressing wildland fire have ranked wildland fire risks within their borders based on the population impacted, probability of occurrence within their borders and the property impacted.

Below is a table outlining information from local plans' wildland fire hazard sections. The table extrapolates, based on population impacted, probability of occurrence within their borders, and property impacted, the risk perceived by each county relative to wildland fire hazards. You will note all counties with mitigation plans consider the hazard to rank from medium-high to high within their borders. Most local plans do not state a specific number of incident occurrences or acres burned, but recognize there are multiple events each year, and reflect significant potential damage as a result of wildland fire.

Table 3.16.9 – Local Risk Assessment – Wildland Fire

COUNTY	Plan Y/N	Year Approved	Included in Plan	Rank-High, Medium, Low
ALBANY	Y	2010	Y	High
BIG HORN	Y	2011	Y	Medium-High
CAMPBELL	Y	2011	Y	High
CARBON	Y	2009	Y	Medium-High
CONVERSE	Y	2012	Y	High
CROOK	Y	2013	Y	High
FREMONT	Y	2012	Y	High
GOSHEN	Expired	2007	Y	High
HOT SPRINGS	N			
JOHNSON	Y	2013	Y	High
LARAMIE	Y	2013	Y	High
LINCOLN	Expired	2007	Y	High
NATRONA	Y	2011	Y	Medium
NIOBRARA	Y	2010	Y	High
PARK	Y	2011	Y	High
PLATTE	Expired	2004	Y	Medium-High

COUNTY	Plan Y/N	Year Approved	Included in Plan	Rank-High, Medium, Low
SHERIDAN	Y	2009	Y	High
SUBLETTE	Expired	2008	Y	High
SWEETWATER	N			
TETON	Y	2010	Y	High
UINTA	Y	2011	Y	
WASHAKIE	Y	2011	Y	High
WESTON	N			
NORTHERN ARAPAHO TRIBE	N			
EASTERN SHOSHONE TRIBE	N			

Probability of Wildland-Urban Interface Fire

Likely = Value 3
30 Reported ÷ 52 years = 58 % annual probability of a Wildland Fire event

Wildland-Urban Interface Fire Risk Factor

Wildland-Urban Interface Fire Risk Factor Value = 2.83 [(Probability: Likely 3 x .30) + (Impact: 3 x .30) + (Spatial Extent: 3 x .20) + (Warning Time: 3 x .10) + (Duration: 3 x .10)]

Ongoing Mitigation Projects

Mitigation of wildland fire hazard in Wyoming has been undertaken through various efforts of technology, public education and awareness, and projects to reduce or eliminate fuels. The Wyoming State Forest Action Plan and the Western Wildfire Risk Assessment are the primary statewide mapping projects to determine areas of wildfire-prone areas. Apart from statewide ventures, individual communities and counties are also working to address wildfire risk, prioritize fuels mitigation projects, and protect their areas from severe fires through the Firewise Program with assistance of the Wyoming State Forestry Division and the National Fire Plan. The primary mechanism for this is the county and local level Community Wildfire Protection Plans (CWPP's). Currently, twenty-two of the twenty-three Wyoming counties are covered by a CWPP or equivelant risk assessment. Many of the existing CWPP's are being revised, updated, or modified to address completed fuels mitigation projects, fire occurrence, development, and other new threats or opportunities.

Firewise is an educational project developed by the National Wildland/Urban Interface Fire Program, sponsored by the National Wildfire Coordinating Group (NWCG), and directed by the NWCG's

Wildland/Urban Interface Working Team to assist communities in wildfire-prone areas with awareness and project development to mitigate wildland fire hazard.

In Wyoming, five communities have been recognized as Firewise communities by the Firewise Program, but more are applying for this status. There are 41 states that have a total of 1,031 recognized communities, placing Wyoming at an approximate average with its five communities. Currently, Homestead Park in Fremont County, Story in Sheridan County, Union Pass in Sublette County, Canyon Creek in Washakie County, and Granite Springs Retreat in Laramie County have been recognized. Other potential Firewise communities according to the Wyoming State Forestry Division, include Star Valley Ranch in Lincoln County, Casper Mountain in Natrona County, and Esterbook in Converse County.

The Wyoming State Forestry Division (WSFD) website, wsfd.wyo.gov, has information on all aspects of forest management as well as the wildlandfire management page that has in depth information for the public. WSFD also assists Natrona County with funding for a website called Firewise Wyoming http://www.firewisewyoming.com which includes wildfire mitigation measures for homeowners residing in forested areas as well as useful links to associated organizations involved in wildland fire management. The Fuels Mitigation page has an interactive map on fuels mitigation projects that have occurred since 2010.

Fuels Mitigation projects on state and private lands in Wyoming are primarily funded by the National Fire Plan, and emphasize fuel reduction in wildland/urban interface areas. This is accomplished through means of mechanical removal of dead forest litter and thinning of trees. Conditions on some landscapes are no longer within normal fire regimes or fire return intervals, the result of effective fire suppression, limited forest management, and climatic factors. With more intense fires there is the risk of the loss of ecosystem components, such as large trees, plus risk of damage to other resources, such as water quality. For some landscapes, before fire can safely be returned, if desired, mechanical treatment would be necessary to reduce fuels to help control fire intensity.

The Wyoming State & Private Forestry Fact Sheet outlines investments made in wildfire mitigation in fiscal year 2013. Investments include nearly $2.5 million divided between the State Fire Assistance program, State Fire Assistance-National Fire Plan, Urban and Community Forestry, Volunteer Fire Assistance and Volunteer Fire Assistance-National Fire Plan. Three hundred fifty-six (356) state fire communities were assisted.

The 2013 Wyoming State Forestry Division's Annual Report outlined the following facts related to fuels mitigation in the state:

National Fire Plan (NFP) Projects were funded in FFY 2013 for a total of $1.2 million in 8 counties for program implementation and cost share to landowners.

$120,000 was invested in Community Assistance Funding for fuel breaks.

Over 10,000 homeowners were contacted with informational materials on Defensible Space and Firewise construction and landscaping practices

Over 3 miles of fuel breaks have been developed in key areas

Firewise/Defensible space workshops were held in multiple locations across the state

Three counties initiated or completed county-wide CWPP revisions in 2013.

In addition, the State has 164 Rural Fire Departments with 4,000 volunteers. There were over 250 Training classes held in 2013 with over 3,500 students. WSFD sponsors over 2,000 Red Cards for state employees and local firefighters. There are also over 400 pieces of Federal Excess Personal Property (FEPP) deployed across the state. Over the last year, in excess of $760,000 was procured through FEFP for parts and supplies. In 2013, 23 Fire Departments received $200,313 to equip, train and organize their departments through the Volunteer Fire Assistance Grant. State Fire Assistance Grant Funds were allocated to each of the 23 Wyoming counties in the amount of $10,286.00. The Wyoming State Helitack responded to 32 missions, including 25 wildland fires. The Honor Conservation Type II inmate Firefighting crews responded to 21 fires.

Wyoming continues to be proactive and strategic in addressing wildfire mitigation projects. The Preservation and Enhancement Fund, state legislative funding utilized for fuels mitigation and road maintenance projects in a competitive process, has expended, on average, $99,000 annually over the past six (6) years for mitigation throughout the state.

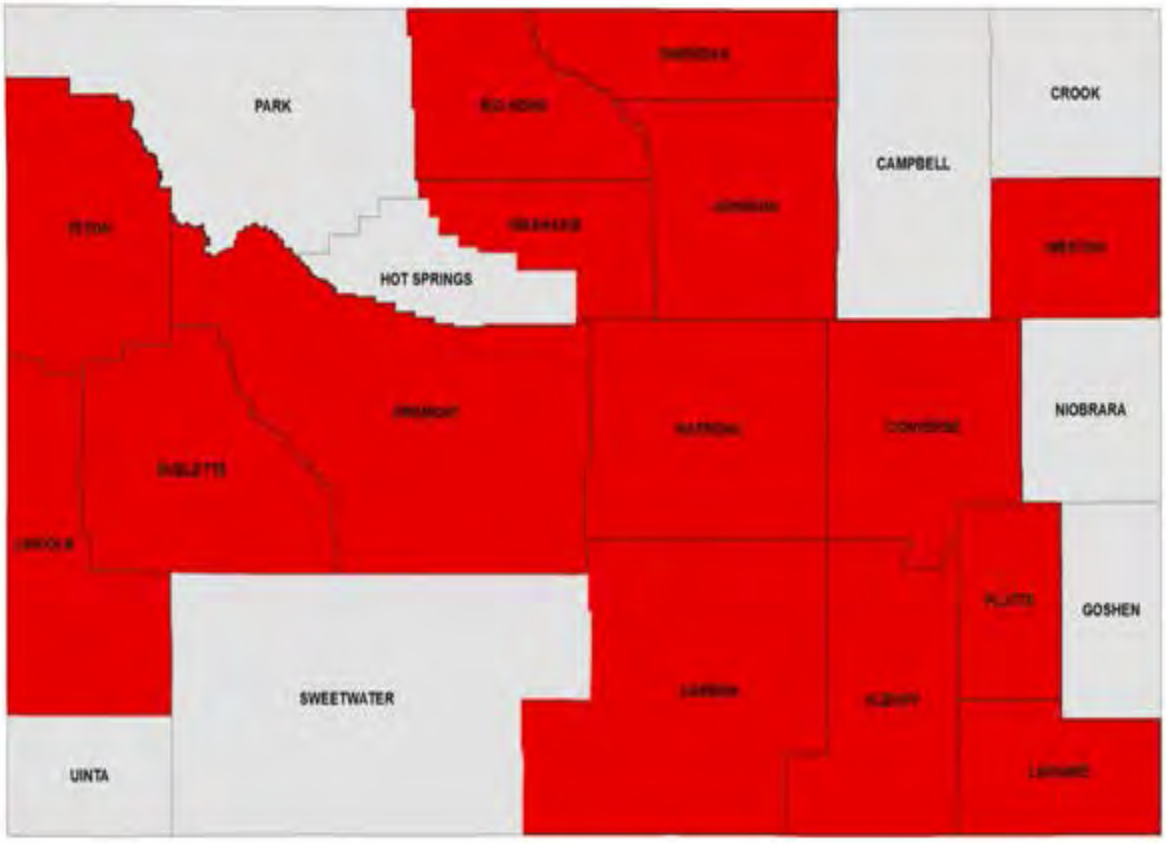
Wyoming, as part of the Council of Western State Foresters and the Western Forestry Leadership Coalition has developed a wildfire risk assessment for 17 western states. The assessment is known as the "Western Wildfire Risk Assessment." The GIS-based project will enable focused wildfire mitigation efforts.

Mitigation activities are also undertaken as a part of the Wyoming Statewide Forest Resource Strategy. The Statewide Forest Resource Strategy targets the preservation and enhancement of the economic value inherent to forests. A portion of the strategy is mitigation of wildfire through fuel reduction by coordinating defensible space and fuel break projects for maximum effect and resource benefit. Other strategies undertaken is the creation, completion and updating of Community Wildfire Protection Plans (CWPP), expanding local capabilities and community programs, increasing public wildfire prevention awareness through public service announcements and other non-traditional media outlets, and re-engaging the insurance industry.

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.

Such projects to mitigate wildfire hazard, specifically fuel removal and tree thinning, are occurring in 15 Wyoming counties. Wildland fire hazard is a more significant concern in forested areas than in the prairie because of the greater amounts of fuel. Consequently, counties where the majority of land is forest are more susceptible and require greater attention. In addition to decreasing fuel load, fire management organizations are increasing the awareness of forest home fire safety. This includes creating wildfire defensible zones and fire-resistant landscaping.

Map 3.16.10 – Counties (in red) with active WSWUI grants programs for cost-share projects on private lands in 2013



State Mitigation Strategy – Wildand-Urban Interface Fire

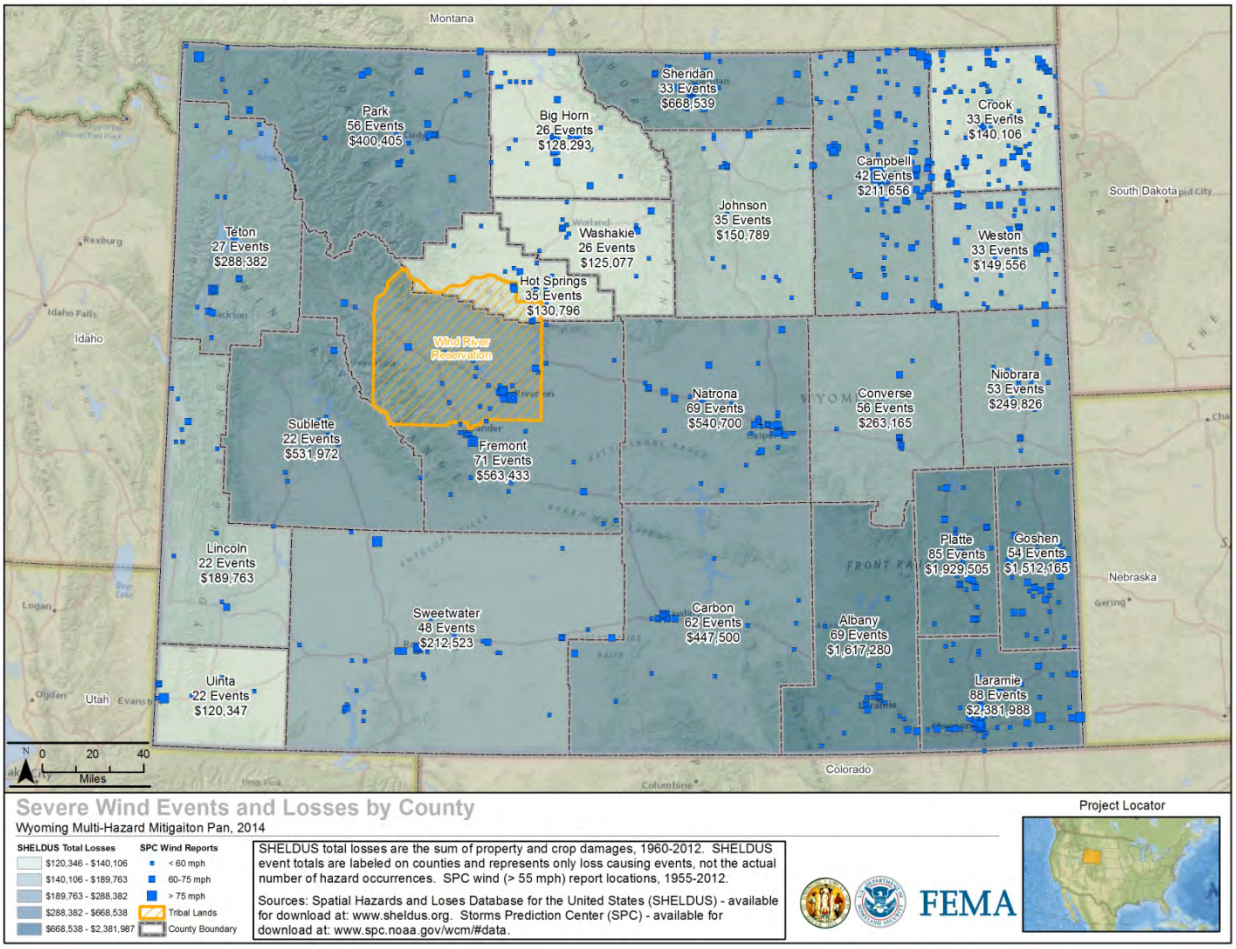
Increase number of firewise communities	
Improve livestock evacuation plans in event of fire	
Fuel load reduction projects	
Encourage Development of Defensible space around Structures and Infrastructure	
Encourage Fire-Resistant Landscaping	
Encourage Fire-Resistand Construction Techniques and Materials	
Retrofit at-Risk Structures with Ignition-Resistant Materials	
Increase Wildfire Risk Awareness	
Educate Property Owners about Wildfire Mitigation Techniques	

3.17 Wind

This plan update includes wind as a state-wide natural hazard for the first time. The 2011 Wyoming Mitigation Plan stated a goal for the 2014 update was to incorporate analysis of wind hazards in the state. During the 2011 mitigation plan update, damage from wind was prevelant in the insurance claims filed on state property. Therefore the question was asked if the inclusion of wind as a natural hazard would be appropriate to incorporate into the mitigation plan.

Data from the Wyoming State Property Risk Division revealed significant damage to state government property as a result of wind. In fact, wind ranks third in hazards generating damage to

Map 3.17.1 –Wind Events and Losses by County



state property. Wind, because of its constant presence in Wyoming, is just dealt with by the population and often overlooked as a hazard. In retrospect, wind is a damage-inducing hazard. Wyoming's wind is also becoming a positive economic factor as renewable wind energy is being developed around the state. Given the damage it causes and the economic impact, wind warrants a review.

SHELDUS reports only those high wind incidents causing losses. Incidents between 1960 and 2012 are reflected in the map above (**Map 3.17.1**) Wind events reported in SHELDUS number 1,067 events, or one third (33%) of the loss causing events in Wyoming. Though high in number of events, losses from wind events represent only 3% of costs to Wyoming residents from hazards, or just under $13 million.

The National Oceanic and Atmospheric Administration (NOAA) is another source reflecting number of high wind incidents and reported losses. From January 2011 through December 2013, there have been 989 high wind incidents, resulting in $247K reported losses, one death, and one injury. High wind event information obtained from the NOAA National Climatic Data Center Storm Events Database is summarized in three tables below. Further event details can be found in **Appendix F**.

Table 3.17.2 – High Wind Events 2011 through 2013

2011 - High wind Events	
Summary Info:	**317 Events**
Number of County/Zone areas affected:	35
Number of Days with Event:	70
Number of Days with Event and Death:	1
Number of Days with Event and Death or Injury:	1
Number of Days with Event and Property Damage:	8
Number of Days with Event and Crop Damage:	0

2012 - High wind Events	
Summary Info:	**417 Events**
Number of County/Zone areas affected:	45
Number of Days with Event:	60
Number of Days with Event and Death:	0
Number of Days with Event and Death or Injury:	0
Number of Days with Event and Property Damage:	2
Number of Days with Event and Crop Damage:	0

2013 - High wind Events	
Summary Info:	**255 Events**
Number of County/Zone areas affected:	36
Number of Days with Event:	37
Number of Days with Event and Death:	0
Number of Days with Event and Death or Injury:	1
Number of Days with Event and Property Damage:	3
Number of Days with Event and Crop Damage:	0

In the period between March 1, 1994 and November 30, 2011 there were 281 high wind events in Wyoming with wind speeds reaching 63 knots (F1 Tornado Equivalent). Between January 1, 1996 and November 30, 2011 there were 5 high wind events with wind speeds reaching 98 knots (F2 Tornado Equivalent). [http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms Accessed 3/2/2012] High wind events reaching 63 knots or greater resulted in property damage of more than $2.3 million. Details on these events can be found in **Appendix G**. It can be expected that not all damage was reported and rather was repaired by individuals with no report filed.

Table 3.17.3 – Local Risk Assessment – Wind

COUNTY	Plan Y/N	Year Approved	Included in Plan	Rank-High, Medium, Low
ALBANY	Y	2010	Y	Low
BIG HORN	Y	2011	N	
CAMPBELL	Y	2011	N	
CARBON	Y	2009	Y	Low
CONVERSE	Y	2012	Y	Medium
CROOK	Y	2013	N	
FREMONT	Y	2012	N	
GOSHEN	Expired	2007	N	
HOT SPRINGS	N		-	
JOHNSON	Y	2013	N	
LARAMIE	Y	2013	Y	High
LINCOLN	Expired	2007	Y	Medium
NATRONA	Y	2011	N	
NIOBRARA	Y	2010	Y	Medium
PARK	Y	2011	N	
PLATTE	Expired	2004	Y	Medium
SHERIDAN	Y	2009	N	
SUBLETTE	Expired	2008	N	
SWEETWATER	N		-	
TETON	Y	2010	N	
UINTA	Y	2011	Y	Low
WASHAKIE	Y	2011	N	
WESTON	N		-	
NORTHERN ARAPAHO TRIBE	N		-	
EASTERN SHOSHONE TRIBE	N		-	

Eight of Wyoming's 23 counties' local mitigation plans review wind hazard risks and impacts. Of those addressing wind, three rank wind as a low hazard, four feel wind is a medium hazard, and one considers wind to be a high hazard. Those who do not address the hazard may be taking the lead of the state's

previous years' mitigation plan or they may not view wind as a hazard in their county. The conclusion may be drawn that individual mitigation efforts are relatively effective, making wind of limited impact. Another conclusion may be that familiarity has developed complacency, as wind is frequently experienced throughout the state and Wyoming residents have grown 'comfortable' with wind as 'the norm.'

Probability of High Wind

Highly Likely = Value 4
1,067 Reported ÷ 52 years = 20 Wind events every year or a >100.0 % annual probability of a Wind event

High Wind Risk Factor

Wind Risk Factor Value = 2.80 [(Probability: Highly Likely 4 x .30) + (Impact: 2 x .30) + (Spatial Extent: 3 x .20) + (Warning Time: 2 x .10) + (Duration: 2 x .10)]

State Mitigation Strategy – Wind

Encourage construction methods which include structural strengthing to minimize wind damage	
Protect power lines and other infrastructure	
Retrofit residential, public and critical facilities structures to minimize wind damage	
Increase awareness of high wind risk (education)	

3.18 Windblown Deposits

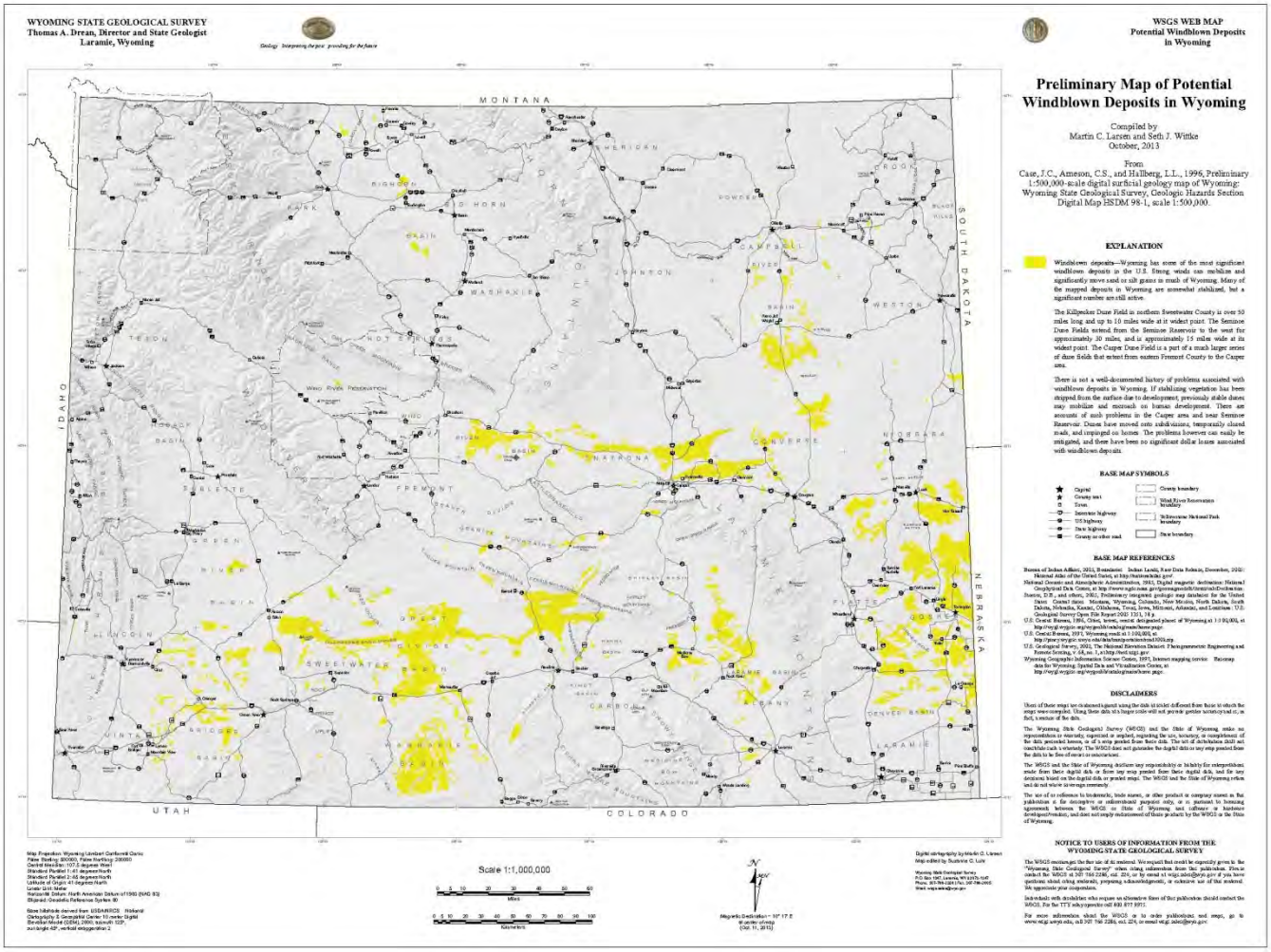
Wyoming has some of the most significant windblown deposits in the U.S. Strong winds can mobilize and significantly move sand or silt grains in much of Wyoming. Many of the mapped deposits in Wyoming are somewhat stabilized, but a significant number are still active.

Photo 3.18.1 – Killpecker Sand Dunes near Rock Springs, Wyoming

http://www.wyomingtourism.org/thingstodo/detail/Killpecker-Sand-Dunes/31316 Accessed 4/1/2014

The Killpecker Dune Field, in northern Sweetwater County, is more than 50 miles long and 10 miles wide at its widest point. The Seminoe Dune Field, extends from the Seminoe Reservoir to the west for approximately 30 miles, and is approximately 15 miles wide at its widest point. The Casper Dune Field is a part of a much larger series of dune fields that extend from eastern Fremont County to the Casper area (**Map 3.18.2**).

Map 3.18.2 – Preliminary Map of Potential Windblown Deposits



Map Courtesy of Wyoming Geological Survey

In Carbon County's mitigation plan their windblown deposit hazard is pictured near the Semino Reservoir (**Map 3.18.3**). Carbon County's location in the 'wind zone,' where a gap in the Rocky Mountains funnel and concentrate westerly winds, makes windblown deposits more likely to cause damage because of the force of the wind carrying the deposits. However, in Carbon County as in the rest of the state, there is no well-documented history of problems associated with windblown deposits.

Map 3.18.2 - Carbon County Windblown Deposits (Seminoe Dune Field)

7.5 minute quadrangle index and wind blown deposits

There is no well-documented history of problems associated with windblown deposits in Wyoming. If stabilizing vegetation is stripped from the surface because of some form of development, previously stable dunes may mobilize and encroach on human development. There are accounts of such problems in the Casper area. Dunes have moved onto subdivision properties, temporarily closed roads, and impinged on homes. The problems were easily fixed, and no significant dollar losses have been associated with windblown deposits. Further, there is no recent history of the recreating public requiring search and rescue in Wyoming dune areas utilizing public assets.

As development continues in Wyoming, more land is disturbed. Currently stabilized dunes may be disrupted, leading to nuisance problems with windblown deposits.

A handful of local multi-hazard mitigation plans address windblown deposits in their mitigation plans. They have ranked windblown deposits risks within their borders based on the population impacted, probability of occurrence within their borders and the property impacted.

Below is a table outlining information found in local mitigation plans' windblown deposit hazard chapters. The table extrapolates, based on population impacted, probability of occurrence within their borders, and property impacted, the risk perceived by each county relative to windblown deposit hazards. Only a few counties address the hazard within their plan and most consider the hazard presented by windblown deposits to rank as a low hazard within their borders.

Local Risk Assessment – Windblown Deposits

COUNTY	Plan Y/N	Year Approved	Included in Plan	Rank-High, Medium, Low
ALBANY	Y	2010	Y	Low
BIG HORN	Y	2011	N	
CAMPBELL	Y	2011	N	
CARBON	Y	2009	Y	Low
CONVERSE	Y	2012	N	
CROOK	Y	2013	N	
FREMONT	Y	2012	Y	Low
GOSHEN	Expired	2007	Y	Low
HOT SPRINGS	N			
JOHNSON	Y	2013	N	
LARAMIE	Y	2013	N	
LINCOLN	Expired	2007	N	
NATRONA	Y	2011	N	
NIOBRARA	Y	2010	Y	Medium
PARK	Y	2011	N	
PLATTE	Expired	2004	N	
SHERIDAN	Y	2009	N	
SUBLETTE	Expired	2008	N	
SWEETWATER	N			
TETON	Y	2010	N	
UINTA	Y	2011	N	
WASHAKIE	Y	2011	N	
WESTON	N			
NORTHERN ARAPAHO TRIBE	N			
EASTERN SHOSHONE TRIBE	N			

Those who move into Wyoming are typically unaware of the hazard presented by wind and windblown deposits. Because the level of damage has been historically low and the cost of damage is not expected to

increase, it is believed development within Wyoming has a limited impact on the risk presented by windblown deposits. Due to the limited nature of damage generated by windblown deposits, it is also believed the vulnerability of Wyoming residents is limited, as well.

Probability of Windblown Deposits

Unlikely = Value 1
3 Reported ÷Unknown # years = <1 % annual probability of a damaging Windblown Deposits

Windblown Deposits Risk Factor

Windblown Deposits Risk Factor Value = 1.7 [(Probability Unlikely 1 x .30) + (Impact 2 x .30) + (Spatial Extent 2 x .20) + (Warning Time 2 x .10) + (Duration 2 x .10)]

State Mitigation Strategy – Windblown Deposits

Encourage management of development in windblown deposit hazard areas	
Promote site & building design standards to minimize windblown deposit risk	
Locate utilities and critical facilities outside windblown deposit hazard risk areas	
Develop and implement windblown hazard management plan	

3.19 Winter Storm and Blizzard

Severe winter storms affect far more people in Wyoming than their summer counterparts, even though they are inherently less violent. Severe snowstorms are so extensive that they usually require a day or two to cross and completely exit the state. Blizzard conditions bring the triple threat of heavy snowfall, strong winds, and low temperatures. Poor visibility and huge snowdrifts are major hazards caused by blowing snow. These storms disrupt work, make travel difficult or impossible, isolate communities, kill livestock by the hundreds or thousands, and sometimes leave human fatalities in their wake.

Fortunately, the simultaneous combination of heavy snowfall, strong winds, and low temperatures are fairly rare, even in Wyoming. In some places, however, such as southeastern Wyoming, strong winds often lift snow crystals from the ground in quantities large enough to produce hazardous ground blizzards without accompanying snowfall.

Photo 3.19.1 – Hay trucks bringing aid to marooned ranches, Blizzard of 1949

Photo courtesy of Wyoming State Archives

Data show that Lake Yellowstone and Lander lead the state in frequency of major snowstorms with an average of about five such days per year. The time of year when they receive these storms, however is quite different. At Lake Yellowstone and throughout most of western Wyoming, major snowstorms strike—most often in the mid-winter months. In Lander and most other parts of the state (excluding the

high mountains), major snowstorms hit with greatest frequency in March and April. The springtime snowstorm peak is particularly destructive for ranchers because it coincides with calving and lambing seasons.

Winter storm history in Wyoming extends from 1871 to present. There have been several winter storms in Wyoming which caused great damage, loss of life, significant economic impact, and brought about change in livestock practices. A few of the most significant storms are described below.

The winter of 1886-1887 brought one of the most significant early storms recorded. The snow came early and grew very deep. Then, a freak thaw turned much of this to water. Cold weather moved back in, freezing the thawed liquid into a crust of ice, which prevented cattle from getting through to the forage underneath. These conditions, accompanied by a blizzard of unusual severity, caused a loss of more than 50 percent of the state's livestock. The snow was 6 feet deep on the level between Mountain Home and Woods Landing. On February 12, 1887 the storms were still raging over the state, and the snow was packed so hard that stages could drive over it. Trains were stalled on their tracks.

The most significant blizzard in Wyoming's history in human impact occurred from January 2, 1949 to February 20, 1949. Snowfall in parts of eastern and southeastern Wyoming measured up to 30 inches, with drifts 20 to 30 feet high. Within 24 hours of the storm initiation, all bus, rail, and air traffic was halted. There were thousands of stranded motorists and rail passengers. Three thousand three hundred (3,300) miles of state highway lay in the storm area. Seventeen people perished, along with 55,000 head of cattle (approximately 15% of the state's cattle) and more than 105,000 sheep. As the storm continued, Wyoming cities began to run out of food in the stores. Several other blizzards followed the first. It is estimated from field men's reports that 4,194 people received aid through the U.S. Department of the Interior operations, and help was given to 994 ranches (**Figure 19.1**). Seventeen people lost their lives during the storm, the greatest loss of life documented for a Wyoming winter storm. Total economic loss is estimated at more than $9 million (more than $88 million in 2013 dollars).

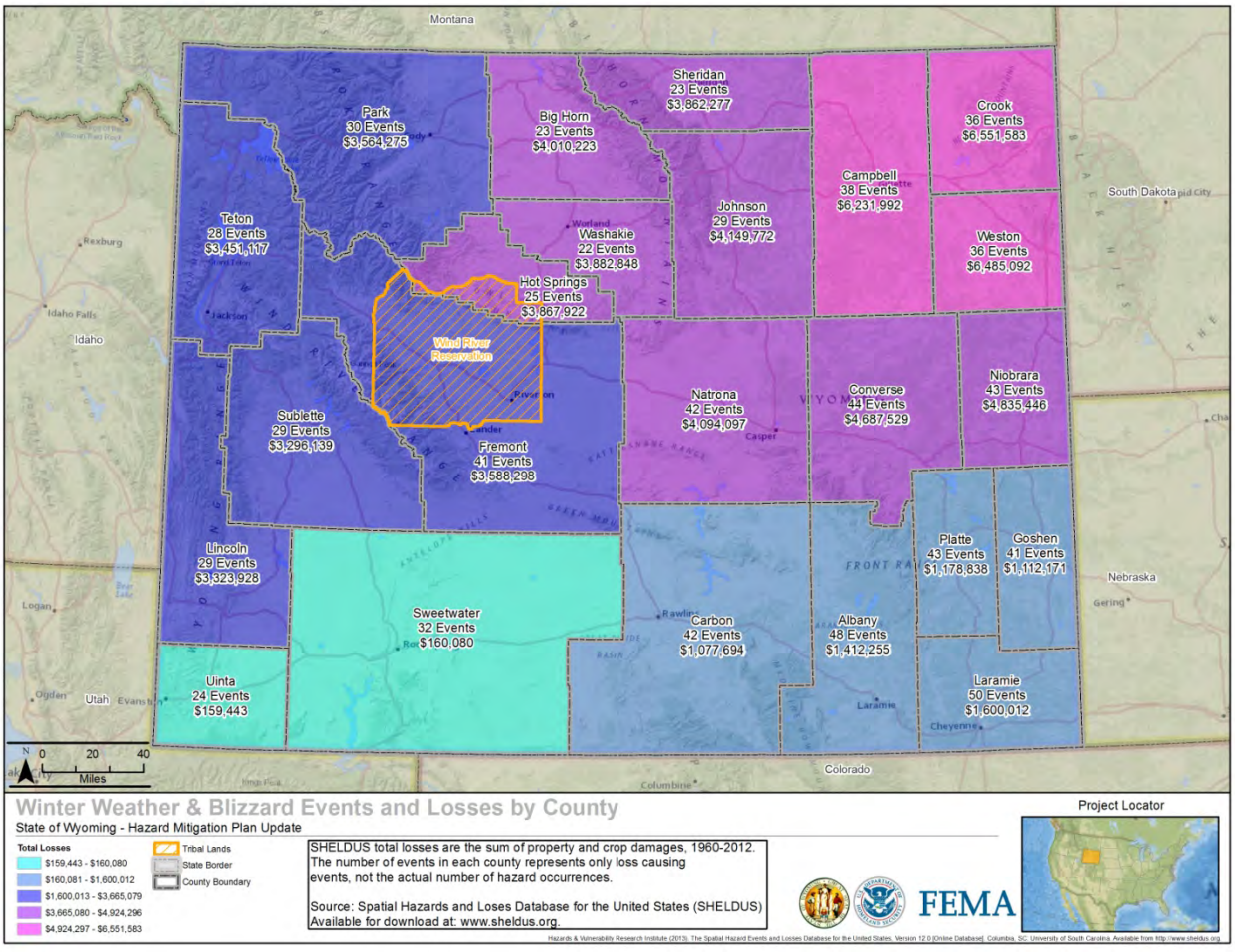
From April 25-27, 1984, the worst late spring blizzard ever to hit Wyoming battered the northern part of the state for three days. The northeast section was the hardest hit as snowfalls of 2 to 3 feet were whipped into 15 to 20 foot drifts by 65 mph winds. A rancher near Wright and one near Sundance died of exposure as they were stranded while hauling hay to their livestock. All of northeast Wyoming was effectively shut down for two days. Major damage occurred to the livestock industry as more than 200,000 sheep and cattle perished in the storm. Some ranchers lost up to 95 percent of their sheep, and up to 50 percent of their cattle. Contributing factors to the very high losses were: a large number of the sheep had recently been shorn; the livestock were well into the spring lambing and calving season; and finally, the storm started as cold rain that changed to wet snow which stuck to everything. In addition, the weight of the record-breaking snow damaged many roofs, and high winds of 50 to 65 mph blew down quite a few structures. Total economic loss was estimated at more than $100 million. The storm is the most costly in Wyoming's history.

On October 4-5, 1998, 8 to 12 inches of heavy, wet snow fell across eastern Converse County and Niobrara County. The heavy snow downed trees and power lines. Ice build up was up to 6 inches around many power lines. The build-up of ice around the power lines, along with 40 mph winds, caused 200 power poles to snap. Four thousand people were without power for up to 5 days in the Lusk, Manville, Van

Tassle, and Lance Creek areas. Interstate 80 between Cheyenne and Laramie was closed due to near zero visibilities.

On November 1, 2000, an intense winter storm brought high winds and heavy, wet snowfall to portions of northeastern Wyoming. In Crook and Weston counties, snowfall rates were one to two inches an hour. Snowfall totals in the plains were from 4 to 8 inches, while in the Bear Lodge Mountains, totals were from 8 to 24 inches. The Four Corners area in northeastern Weston County reported the most snowfall at 24 inches. High, sustained winds up to 40 mph with gusts to 60 mph caused blizzard conditions and toppled 600 power poles. Seven thousand people were without power; almost 15 miles of lines had to be replaced. The city of Moorcroft had more than 150 stranded semi-trucks after the interstate was shut down. In Campbell County, the temperatures were too warm for snow and rain fell throughout the day, but high winds were reported with gusts more than 50 mph at times. The highest gust in Campbell County was 64 mph at Echeta.

Map 3.19.1 – Winter Weather and Blizzard Events and Losses by County



A complete history of blizzards and winter storms that caused damage, loss of life, significant closure of highways, and/or impacts to the livestock industry can be found in **Appendix Q**. The data were derived from the monthly Storm Data and Climatological Data reports from National Oceanic and Atmospheric

Administration's (NOAA) National Climatic Data Center (NCDC). Other sources are unpublished reports from WOHS, newspaper accounts, and periodicals from public libraries.

Wyoming State Property

Historically Wyoming State Government property has experienced 28 damaging winter storm events totaling $220,000 in the 307-month period from August, 1985 through February, 2011. If we can assume past experience will continue into the future, the state can anticipate 1 damaging winter storm event to its structures each year ([28 events / 307 months = .09 each month] * 12 months = 1.08 events annually). Given the number of anticipated annual damaging winter storm events, and given past experience, damages of $8,592 can be anticipated annually ([$219,803.73 / 307 months] * 12 months = $8,591.64).

Presidential and State Emergency/Disaster Declarations

There have been two Presidential Disaster Declarations related to winter storms in Wyoming. FEMA DR-WY-1268 was associated with the October 4-5, 1998, storm in Niobrara and Converse Counties. FEMA DR-WY-1399 was associated with the November 1, 2000 storm in Crook and Weston Counties.

State-Level Emergencies (Winter Storm)

Date	Case #	Duration (days)	Location	Event Type	Resource Used	Cost to WOHS (supported by docs)	Cost to WOHS - Est. (personnel, vehicle etc	Total Costs	Notes
2/7/2007	07-0002	1	Albany County	Snow Removal	Nat'l Guard	$ 11,233.36	$ 200.00	$ 11,433.36	
2/4/2008	08-0003	4	Niobrara County	Snow Removal	Nat'l Guard	$ 13,510.09	$ -	$ 13,510.09	Guard front-end loaders & dump trucks

Photo 3.19.2 – Clearing Snow from Wyoming Highway 130 on June 10, 2011

Winter storms usually cover a significant part of the state, and as such are difficult to describe regionally.

Local Risk Assessments

A review of local plans shows all consider winter storms and blizzards a hazard within their borders. All local plans address blizzards and winter storms. The counties' plans have ranked winter storm and blizzard risks within their borders based on the population impacted, probability of occurrence within their borders and the property impacted.

Below is a table outlining information from the local plans' winter storms hazard sections. The table extrapolates, based on population impacted, probability of occurrence within their borders, and property impacted, the risk perceived by each county relative to winter storms hazards. You will note all counties with mitigation plans consider the hazard to rank from medium-high to high within their borders. Most do not state a specific number of incident occurrences but recognize there are multiple storms each year, and reflect significant potential damage as a result of winter storms.

Table 3.19.3 – Local Risk Assessment- Blizzard & Winter Storm

COUNTY	Plan Y/N	Year Approved	Included in Plan	Rank-High, Medium, Low
ALBANY	Y	2010	Y	Medium-High
BIG HORN	Y	2011	Y	Medium
CAMPBELL	Y	2011	Y	High
CARBON	Y	2009	Y	Medium-High
CONVERSE	Y	2012	Y	Medium
CROOK	Y	2013	Y	High
FREMONT	Y	2012	Y	High
GOSHEN	Expired	2007	Y	High
HOT SPRINGS	N			
JOHNSON	Y	2013	Y	High
LARAMIE	Y	2013	Y	High
LINCOLN	Expired	2007	Y	Medium-High
NATRONA	Y	2011	Y	Medium
NIOBRARA	Y	2010	Y	Medium-High
PARK	Y	2011	Y	Medium
PLATTE	Expired	2004	Y	Medium-High
SHERIDAN	Y	2009	Y	High
SUBLETTE	Expired	2008	Y	Medium-High
SWEETWATER	N			
TETON	Y	2010	Y	High
UINTA	Y	2011	Y	
WASHAKIE	Y	2011	Y	Medium
WESTON	N			
NORTHERN ARAPAHO TRIBE	N			
EASTERN SHOSHONE TRIBE	N			

Because winter storms are so prevalent in Wyoming, vulnerable populations can be significantly impacted. Impacts include inability to get from one location to another because of closed roads, making pharmacies and grocery stores inaccessible. Electrical outages are also prevalent during winter snow storms and blizzards, limiting or eliminating household heating and cooking capability. Preparation for winter storms is needed to ensure successful weathering of the situation. Some winter storm preparations to be considered by residents include the creation and maintenance of adequate water and food within a 72-hour kit both in vehicles and at home, backup power generation capabilities, and backup household heating options. Winter storms are best weathered by sheltering in place during the storm, and attempting to go out only after the storm has ended.

Rural areas tend to be more susceptible to power outages in winter storms and power outages in rural areas tend to be of greater duration than those in more populated areas. Rural locations are more likely to have livestock and farming economic factors, which can be significantly impacted by winter weather. Blizzards and winter storms have resulted in livestock deaths and livestock rescue efforts including hay drops by helicopter and snow removal efforts to give ranchers access to their livestock to minimize losses.

Winter storms and blizzards are particularly impactful on people unfamiliar with the hazard. This makes those areas of increased development more vulnerable and subject to risk from the hazard, assuming a percentage of those moving to developing areas are unfamiliar with winter storms, specifically the need to make preparations ahead of the storm and the need to shelter-in-place through a blizzard or winter storm. The 2010 census documents those counties with the greatest increase in population. In areas of high development with an influx of families, education is critical to help prepare the community for the hazard. Other important mitigation efforts include advance warning through media and all-hazard radios.

Probability of Winter Storm and Blizzard

Highly Likely = Value 4
798 Reported ÷ 52 years = 15 Winter Storm and Blizzard events every year or a >100.0 % annual probability of a Winter Storm and Blizzard event

Winter Storm and Blizzard Risk Factor

Expansive Soils Risk Factor Value = 3.08 [(Probability: Highly Likely 4 x .30) + (Impact: 2 x .30) + (Spatial Extent: 4 x .20) + (Warning Time: 2 x .10) + (Duration: 3 x .10)]

State Mitigation Strategy – Winter Storm & Blizzard

Encourage residential & governmental structural retrofit to withstand low temperatures (add insulation) and snow loads	
Protect Power Lines from winter storm impacts through multiple mitigation actions including pole replacement and burying power lines	
Reduce winter storm impacts to roadways, including greater use of living and traditional snow fences	
Increase Public awareness of severe winter storms	
Improve outreach to vulnerable populations	
Encourage public preparations for winter weather, including development of a 3-day kit	
Encourage installation of fire and carbon monoxide monitors and alarms	
Add additional webcams to roadways for better road condition monitoring	
Improve livestock evacuation planning and livestock food stockpiling	

3.20 Hazard Ranking - Conclusions

Requirement §201.4(c)(2)(ii): *[The State risk assessment **shall** include an] overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments as well as the State risk assessment. The State **shall** describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events. State owned critical or operated facilities located in the identified hazard areas shall also be addressed … .*

Based on the risk factor analys, the natural hazard with the highest risk potential is flood which has a value of 3.10. Others ranking high are tornado and winter storm/blizzard. All hazards identified in this plan have the potential to cause disastrous impacts. Following is the risk factor analysis table showing all hazards analyzed for perceived risk:

Table 3.2.1 - Risk Factor Results

#	Hazards	Probability	Impact	Spatial Extent	Warning Time	Duration	Risk Factor Rating
1	Dam Failure	3.00	2.579545	2.6	2.8888889	2.577778	2.74
2	Drought	3.00	1.727273	3.622222	1.3555556	3.8	2.66
3	Earthquake	3.00	2.777778	2.75	3.6363636	2.422222	2.89
4	Expansive Soil	1.00	1.318182	1.906977	2.6097561	2.309524	1.57
5	Flood	4.00	2.6	2.777778	2.5555556	3.066667	3.10
6	Hail	4.00	1.755556	2.377778	3.2666667	1.444444	2.67
7	Terrorism		2.818182	2.125	3.6931818	2.227273	1.86
8	HazMat Incident-Fixed Facility		2.211111	1.688889	3.6222222	2.122222	1.58
9	HazMat Incident-Transportation		2.366667	1.833333	3.6444444	2.155556	1.66
10	Landslide		1.704545	1.431818	3.4418605	2.136364	1.36
11	Lighning	4.00	1.454545	1.533333	3.4	1.266667	2.41
12	Liquefaction	1.00	1.571429	1.418605	3.2439024	1.534884	1.53
13	Mine Subsidence		1.5	1.325581	2.6585366	2.209302	1.20
14	Avalanche	4.00	1.627907	1.44186	3.3023256	1.44186	2.45
15	Solar Weather		1.318182	2.604651	2.3488372	1.790698	1.33
16	Tornado	4.00	2.677778	2.288889	3.4888889	1.886364	3.00
17	Wildland Fire	3.00	2.522222	2.8	2.9111111	3.266667	2.83
18	Wind	4.00	1.688889	3.111111	2.4444444	2.311111	2.80
19	Windblown Deposits		1.5	2.372093	2.3809524	2.023256	1.36
20	Winter Storm & Blizzard	4.00	2.3	3.5	2.0222222	2.863636	3.08

The conclusions drawn from the qualitative and quantitative assessments, combined with final determinations from the planning team, were fitted into three categories for a final summary of hazard risk for Wyoming based on High, Moderate or Low risk designations.

Table 3.19.2 - Wyoming Hazard Risk Conclusions

Risk Level	Hazards
HIGH RISK (3.0 or higher)	Flood, Tornado, Winter Storm & Blizzard
MODERATE RISK (2.0 – 2.9)	Dam Failure, Drought, Earthquake, Hail, Lightning, Avalanche, Wildland Fire, Wind
LOW RISK (0.1 – 1.9)	Expansive Soil, Terrorism,Hazmat Incident-Fixed Facility, Hazmat Incident-Transportation, Landslide, Liquifaction, Mine Subsidence, Solar Weather, Windblown Deposits

4. Vulnerability

People are vulnerable to both natural and human-caused hazards. Vulnerability is further exaserbated by socio-economic factors. Data available through the 2010 Census was used to develop Wyoming's social vulnerability status, both at the census block level and at the county level.

The table below (**Table 4.1**) compares Wyoming counties to one another, ranking them according to social vulnerability. There is a level of uncertainty in the creation of an index, both with the margin of error in Census data as well as with the creation of an index. Caution should be taken by the user.

Table 4.1 – County Rank - Social Vulnerability

County	County FIPS	Social Vulnerability Score	County Rank
Fremont	56013	1.89	1
Laramie	56021	1.46	2
Albany	56001	1.23	3
Washakie	56043	1.21	4
Natrona	56025	1.19	5
Goshen	56015	1.18	6
Hot Springs	56017	1.16	7
Johnson	56019	1.14	8
Sweetwater	56037	1.09	9
Big Horn	56003	1.08	10
Weston	56045	1.05	11
Carbon	56007	1.00	12
Uinta	56041	0.98	13

County	County FIPS	Social Vulnerability Score	County Rank
Crook	56011	0.91	14
Converse	56009	0.91	15
Campbell	56005	0.89	16
Platte	56031	0.89	17
Park	56029	0.88	18
Sheridan	56033	0.83	19
Sublette	56035	0.82	20
Niobrara	56027	0.69	21
Lincoln	56023	0.61	22
Teton	56039	0.11	23

Social Vulnerability Index Methodology

Index Creation

A copy of the Social Vulnerability Spreadsheet, calculated by Census Block is located in this plan as Appendix T. Wyoming's social vulnerability was calculated in the following manner:

19 census variables were pulled from the U.S. Census Bureau and the American Community Survey for the State of Wyoming at the census block group level. Values were normalized for population, households (excluding *Median Housing Value*, *Median Contract Rent*, and *Household Median Income*) depending on the variable. For example, *Total Population Under 5* was divided by *Total Population* and *Total Number of Households with No Vehicles* was divided by *Total Households*. A maximum-minimum transformation was then performed to reduce the data between the values of 0-1. The values were then summed (added or subtracted based upon the cardinally of the variable as shown below) to create an additive vulnerability index. Positive variables increase social vulnerability; negative variables decrease social vulnerability. Each census block group results in a score which creates a range of social vulnerability, highest to lowest. There is a level of uncertainty in the creation of an index, both with the margin of error in Census data as well as with the creation of an index. Caution should be taken by the user.

Census Variables with Cardinality

Census 2010

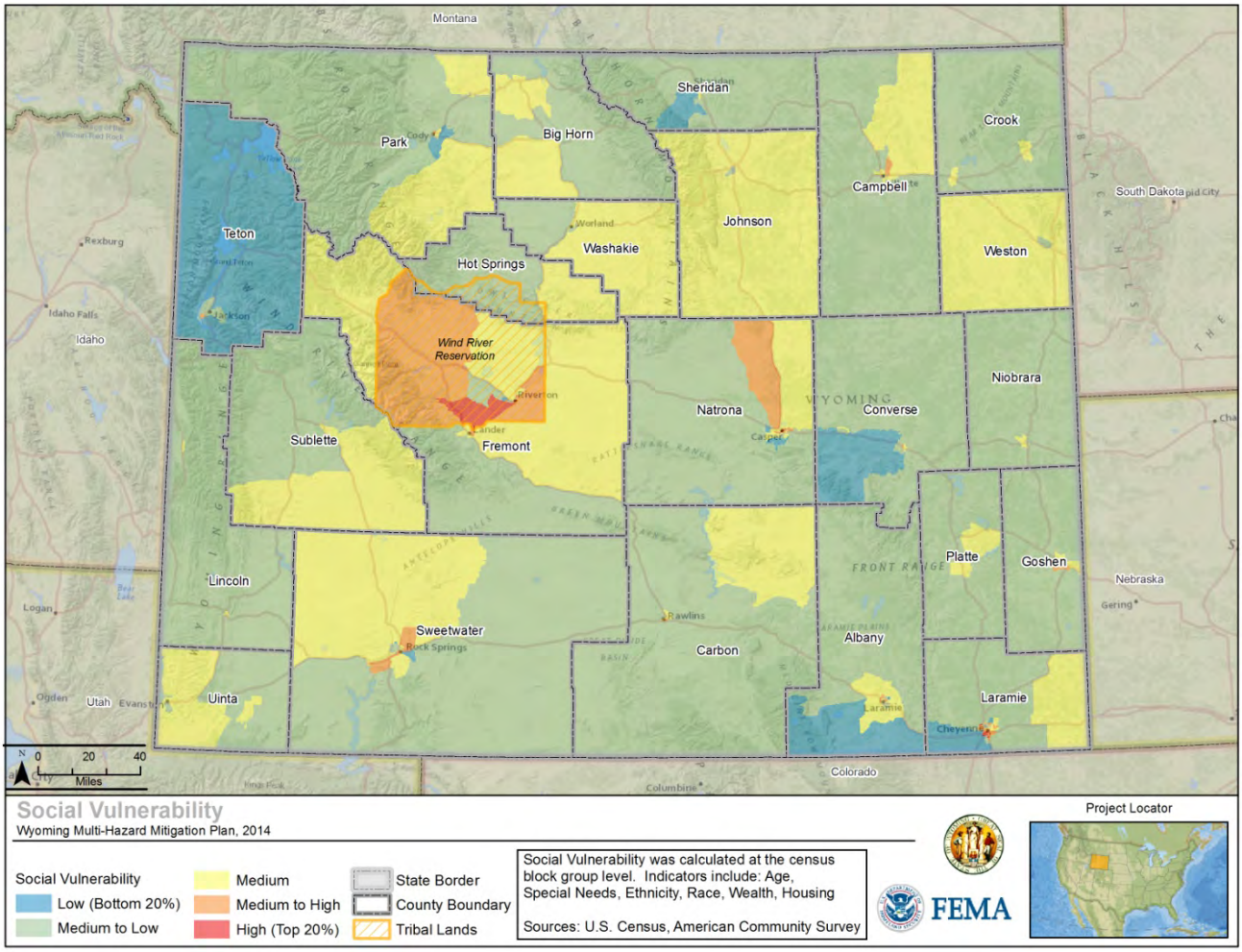
1. Total Population (+)
2. Total Households (+)
3. Total White (-)
4. Total Black (+)
5. Total Asian (-)
6. Total Native American (+)
7. Total Other Races (+)
8. Total Hispanic (+)
9. Total Population Under 5 (+)
10. Total Population Under 16 (+)
11. Total Population Over 65 (+)

American Community Survey

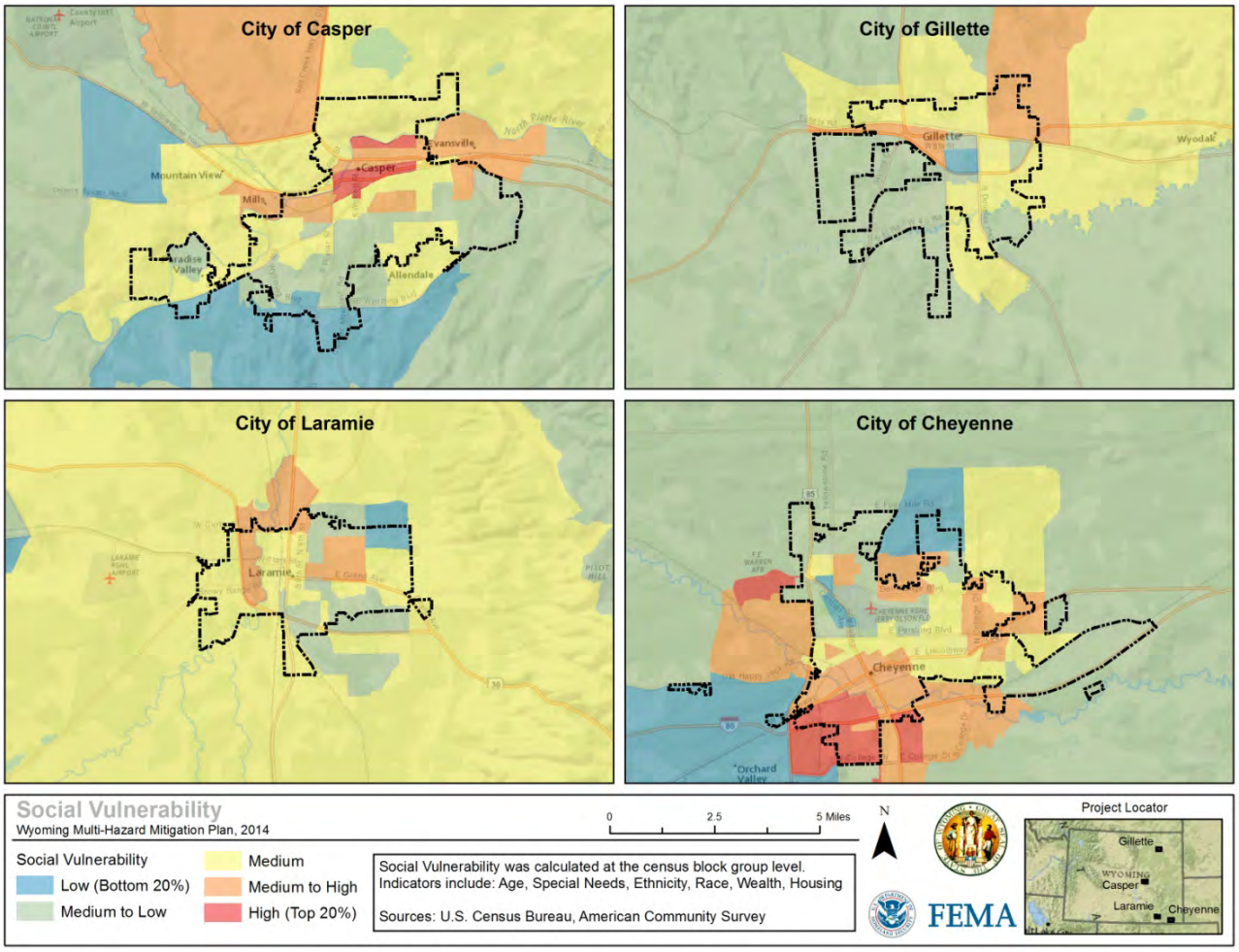
12. Total Renters (+)
13. Median Housing Value (-)
14. Median Contract Rent (-)
15. Total Mobile Homes (+)
16. Total Households Linguistically Isolated (+)
17. Total Households in Poverty (+)
18. Household Median Income (-)
19. Total Households with No Vehicles (+)

Map 4.2 below documents social vulnerability across the state. **Map 4.3** extracts the vulternability data of four major communities in Wyoming and pictures locations within the community which may be more vulnerable to hazards based on socio-economic factors.

Map 4.2 – Wyoming Social Vulnerability



Map 4.3 – Social Vulnerability Casper, Cheyenne, Gillette, Laramie



5. Capability Assessment

5.1 State Capability Assessment

Requirement §201.4(c)(3)(ii): *[The State mitigation strategy **shall** include a] discussion of the State's pre-and post-disaster hazard management policies, programs, and capabilities to mitigate the hazards in the area, including: an evaluation of State laws, regulations, policies, and programs related to hazard mitigation as well as to development in hazard-prone areas [and] a discussion of State funding capabilities for hazard mitigation projects…* .

State Hazard Mitigation Capabilities

The State of Wyoming mitigates natural hazards through a number of statutes and programs which are funded by state and federal governments. Within the state, several agencies and programs implement mitigation through their assistance to local government. The information below represents the State Hazard Mitigation Team's best effort to identify State Agencies, programs, laws and other capabilities that play a significant role in protecting life, property and infrastructure.

State Statutes Applicable to Hazard Mitigation

Wyoming Statute includes a number of measures that although not directly related to hazard mitigation effect the state's ability to influence land use decisions that impact vulnerability. In most cases, these statutes allow county and local governments to establish local rules and regulations.

1. The Surface Water Drainage Utility Act, Wyoming Statute § 16-10-101 *et seq., addresses the authority of local governments to create storm drain systems.*

2. The Wyoming Relocation Assistance Act of 1973, Wyoming Statute § 16-7-101 *et seq. provides procedures for the relocation of residents when lands are appropriated by local, state, and federal governments.*

3. The Powers of County Commissioners, Wyoming Statute § 18-5-101 states: *Each board of county commissioners may provide for the physical development of the unincorporated territory within the county by zoning all or any part of the unincorporated territory.*

4. County Planning and Zoning Commissions, Wyoming Statute § 18-5-101 *et seq*. are authorized to: *Promote the public health, safety, morals and general welfare of the county, each board of county commissioners may regulate and restrict the location and use of buildings and structures and the use, condition of use or occupancy of lands for residence, recreation, agriculture, industry, commerce, public use and other purposes in the unincorporated area of the county. However, nothing in W.S. 18-5-201 through 18-5-207 shall be construed to contravene any zoning authority of any incorporated city or town and no zoning resolution or plan shall prevent any use or*

occupancy reasonably necessary to the extraction or production of the mineral resources in or under any lands subject thereto.

5. The Board of Land Commissioners, Wyoming Statute § 36-2-101 *et seq*., states: *The governor, secretary of state, state treasurer, state auditor, and superintendent of public instruction, being constituted a "board of land commissioners" by the provisions of section 3, article 18, of the constitution of the state of Wyoming, shall as such board, have the direction, control, leasing, care and disposal of all lands heretofore or hereafter granted or acquired by the state for the benefit and support of public schools or for any other purpose whatsoever, subject to the limitations contained in the constitution of the state, and the laws enacted by the legislature. The board shall have the power and authority to take such official action as may be necessary in securing title to land grants, or any other lands acquired by the state.*

6. The Wyoming Homeland Security Act, Wyoming Statute § 19-13-101 *et seq*. states:

   "Homeland security" means the preparation for and the carrying out of all emergency functions essential to the recovery and restoration of the economy by supply and resupply of resources to meet urgent survival and military needs, other than functions for which military forces are primarily responsible, necessary to deal with disasters caused by enemy attack, sabotage, terrorism, civil disorder or other hostile action, or by fire, flood, earthquake, other natural causes and other technological, industrial, civil and political events. These functions include without limitation the coordination of fire-fighting services, police services, medical and health services, rescue, engineering, attack warning services, communications, radiological events, evacuation of persons from stricken areas, emergency welfare services (civilian war aid), emergency transportation, existing or properly assigned functions of plant protection, temporary restoration of public utility services, mitigation activities in areas threatened by natural or technological hazards, and other functions related to civilian protection, together with all other activities necessary or incidental to the preparation for any carrying out of the foregoing functions.

   Each political subdivision through the homeland security program will cause to be prepared a local homeland security plan which will include actions essential to the recovery and restoration of the economy by supply and re-supply of resources to meet urgent survival and military needs and to provide for the ongoing management of resources available to meet continuing survival and recovery needs.

In summary, Wyoming statute makes provision for mitigation activity, particularly at the local level. The State, through the Homeland Security Act is authorized to act in pursuit of economic recovery and restoration, which includes mitigation. No state statute restricts development in hazard prone areas. Any such restrictions, including floodplain development and development in wildfire prone areas, are authorized and generated at the local level.

Agency Overview

The state plays an important role in creating opportunities, coordinating and supporting mitigation actions. At the state level, mitigation is achieved through a number of departments in a variety of ways.

Departments within state government are responsible, within their statutory authorities, to provide assistance and support to local jurisdictions when the local jurisdictions are unable to cope with a disaster or emergency situation. Upon implementation of the State Operations Plan (SOP), they are responsible for the implementation of their assigned emergency support functions (ESFs). Multiple agencies are involved in mitigation in their areas of responsibility. For example, the Wyoming Forestry Division develops fire plans and implements projects addressing Wildland Urban Interface (WUI) areas subject to fire hazards.

The Wyoming Office of Homeland Security employs one full-time employee dedicated to mitigation for the state. The State Hazard Mitigation Officer (SHMO) coordinates and implements Hazard Mitigation Assistance Grants, which currently include the Pre-Disaster Mitigation (PDM), the Hazard Mititgation Grant Program (HMGP) and Flood Mitigation Assistance Grant (FMA). Additionally, the SHMO Maintains the Wyoming Multi-Hazard Mitigation Plan and Hazard Mitigation Administrative Plans. The SHMO assists local jurisdictions by reviewing their local mitigation plans, facilitating mitigation training for state and local officials and developing mitigation partnerships. Implementation of mitigation actions throughout the state is slow, but steady with progress made as time and funding allow.

The real power to initiate and implement mitigation action items lies with local jurisdictions. They are intimately aware of trouble areas which impact their communities. 'Grass root' demand for change is a significant driver in Wyoming mitigation. While some mitigation projects are spearheaded at the state level, local jurisdictions are the focal point of most mitigation project and grant application development. Time and funding are also limited at the local level, however, and limit mitigation progress.

The WOHS annually completes a Threat and Hazard Identification and Risk Assessment (THIRA), identifies gaps in capacity and capability, and prepares the State Preparedness Report (SPR). In addition to the mitigation grants, the Wyoming Office of Homeland Security (WOHS) administers several grant programs including the Homeland Security Grant Program (HSGP), Emergency Management Performance Grant (EMPG), Hazardous Materials Emergency Preparedness Grant (HMEP), Community Assistance Program Grant (CAP), Waste Isolation Pilot Plant Grant (WIPP), and Public Safety Communications Commission Grant (PSCC). Each of these grants is strategically utilized to maintain and close gaps in Wyoming's capacity to prevent, protect, mitigate, respond, and recover from disasters and emergencies.

Further, the WOHS provides administrative support for the Search and Rescue Committee, the State Emergency Response Commission (SERC), and the School Safety Commission. A Senior Advisory Committee is in the process of being established to assist in establishing a more complete whole community approach to emergency management process. County Coordinators and WOHS meet quarterly to coordinate efforts, discuss areas of concern, exercise and train together.

Selection and Funding of Local and State Mitigation Projects

Requirement §201.4(c)(3)(iii): *[State plans **shall** include an] identification, evaluation, and prioritization of cost-effective, environmentally sound, and technically feasible mitigation actions and activities the State is considering and an explanation of how each activity contributes to the overall mitigation strategy. This section **should** be linked to local plans, where specific local actions and projects are identified.*

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities…

Mitigation projects/measures considered for funding must be in conformance with the goals and objectives stated in this plan, and a local plan, where applicable. Applications for federal funding must follow requirements outlined in respective program guidance and the following criteria which is included in 44 CFR 206.434:

- Project applicants must have FEMA-approved mitigation plans;
- Local projects must be in conformance with the local jurisdiction's mitigation plan;
- Must be cost effective (a benefit-cost ratio of 1:1 or better);
- Must be feasible and practical;
- Must be environmentally sound;
- Must contribute to a long-term solution, including repetitive loss properties;
- Measures that, if not taken, will have a severe detrimental impact on the applicant, such as potential loss of life, loss of essential services, damage to critical facilities, or economic hardship on the community.

Grant applications for PDM and FMA grant programs will be reviewed by the WOHS to determine compliance with eligibility criteria. Applications will then be reviewed and ranked by a committee made up of at least three qualified state agency representatives. They will assign values to each of the criteria identified in 44 CFR 206.434. Cost effectiveness, based on a cost-benefit analysis, is one of the most important criteria and will be weighted accordingly. The HMGP grant is administered similarly, as outlined in the HMGP Administration Plan.

In addition, ranking of projects for grant funding will include preference for those communities with the highest risks based on both local and state hazard assessments and those with the most intense development pressures. Consideration may be given for any measure or proposed project, from any county in the state, which is designed to reduce risk or future damage, hardship, loss, or suffering from disaster so long as it meets the eligibility criteria established in 44 CFR, 206-434. Proposed projects/measures do not necessarily have to relate directly to the type of disaster for which a presidential declaration is issued and may be for all or part of the state of Wyoming.

Administering FEMA Grant

When a funding opportunity becomes available from FEMA in the form of grant guidance, all local jurisdictions and state agencies receive notification informing the jurisdiction or agency of the funding opportunity. Notification to additional, interested individuals and entities are also made. The notice includes an overview of the grant guidance explaining eligible and ineligible projects, as well as a reference to online grant guidance. Application deadlines are explained as well as the expected method of application, including Notices of Intent. Suggested FEMA protocols are followed for PDM, FMA and HMGP-funded plans, including adhering to the Wyoming HMGP Administrative Plan.

To be eligible to apply for a Pre-Disaster Mitigation (PDM) Program, Flood Mitigation Assistance (FMA) or a Hazard Mitigation Grant Program (HMGP) project grant, an applicant must have a FEMA-approved mitigation plan (or be a jurisdiction that has signed and adopted another jurisdiction's plan). WOHS will encourage counties to increase their number of planning partners as a means of identifying and adding well-defined projects, including multi-purpose and multi-funded projects, to their plans. The counties which have FEMA-approved plans are documented in Section 2.2, **Table 2.2.1**. County plans are generally multi-jurisdictional. Mitigation projects accomplished from 2010 forward are documented in **Table 5.1** below. All historical FEMA hazard mitigation projects are documented in **Appendix U**.

Table 5.1 – Mitigation Projects Implemented 2010 – Present

Big Horn	2 Total Projects							
Disaster Number	**Project Number**	**Project Title**	**Program Area**	**Status**	**Date Approved**	**Date Awarded**	**Date Completed**	**Date Closed**
1923	0005	Big Horn County Sheriff CAD System & Enhanced 911	HMGP	Approved	05/14/2012	~	~	~
4007	0002	BIG HORN COUNTY-WIDE WARNING & NOTIFICATION SYSTEM	HMGP	Approved	11/09/2012	~	~	~
Carbon	2 Total Project							
Disaster Number	**Project Number**	**Project Title**	**Program Area**	**Status**	**Date Approved**	**Date Awarded**	**Date Completed**	**Date Closed**
4007	0004	TOWN OF SARATOGA RIVER BANK ARMORING NEAR PEDESTRIAN BRIDGE TO VETERANS ISLAND	HMGP	Approved	04/19/2013	~	~	~
4007	0006	SARATOGA RIVER BANK ARMORING NEAR TOWN'S PUBLIC WORKS FACILITY	HMGP	Approved	04/19/2013	~	~	~
Crook	1 Total Project							
Disaster Number	**Project Number**	**Project Title**	**Program Area**	**Status**	**Date Approved**	**Date Awarded**	**Date Completed**	**Date Closed**

1923	0002	CROOK COUNTY MULTI-JURISDICTIONAL MULTI-HAZARD MITIGATION PLAN	HMGP	Approved	05/14/2012	~	~	~
Fremont	1 Total Project							
Disaster Number	**Project Number**	**Project Title**	**Program Area**	**Status**	**Date Approved**	**Date Awarded**	**Date Completed**	**Date Closed**
4007	0008	WYO DEPT OF TRANSPORTATION-FREMONT CNTY WIND RIVER BANK ARMORING & STABILIZATION	HMGP	Approved	01/23/2013	~	~	~
Johnson	1 Total Project							
Disaster Number	**Project Number**	**Project Title**	**Program Area**	**Status**	**Date Approved**	**Date Awarded**	**Date Completed**	**Date Closed**
4007	0001	Johnson County Multi-Jurisdictional Multi-Hazard Mitigation Plan Update	HMGP	Approved	11/09/2012	~	~	~
Laramie	2 Total Projects							
Disaster Number	**Project Number**	**Project Title**	**Program Area**	**Status**	**Date Approved**	**Date Awarded**	**Date Completed**	**Date Closed**
~	PDMC-PL-08-WY-2011-001	Cheyenne/Laramie County MultiHazard Mitigation Plan	PDM	Obligated	09/16/2011	09/23/2011	~	~
~	FMA-PJ-08-WY-2004-001	City of Cheyenne Henderson Basin Flood Control Improvement Project	FMA	Obligated	05/26/2005	01/12/2010	~	~
Lincoln	1 Total Project							
Disaster Number	**Project Number**	**Project Title**	**Program Area**	**Status**	**Date Approved**	**Date Awarded**	**Date Completed**	**Date Closed**
~	PDMC-PL-08-WY-2005-004	Pre-disaster Mitigation Plan for Lincoln Co., WY	PDM	Obligated	07/18/2005	04/16/2010	~	~
Park	1 Total Project							

Disaster Number	Project Number	Project Title	Program Area	Status	Date Approved	Date Awarded	Date Completed	Date Closed
~	PDMC-PL-08-WY-2010-002	Park County Multi-jurisdictional Hazard Mitigation Plan	PDM	Obligated	08/23/2010	08/25/2010	~	~
Sheridan	2 Total Projects							
Disaster Number	**Project Number**	**Project Title**	**Program Area**	**Status**	**Date Approved**	**Date Awarded**	**Date Completed**	**Date Closed**
4007	0007	SHERIDAN COUNTY- TONGUE RIVER BANK ARMORING PROJECT	HMGP	Approved	02/26/2013		~	~
4007	0009	SHERIDAN COUNTY KOOI ROAD MITIGATION-TONGUE RIVER BANK STABILIZATION	HMGP	Approved	01/23/2013		~	~
Statewide	1 Total Project							
Disaster Number	Project Number	Project Title	Program Area	Status	Date Approved	Date Awarded	Date Completed	Date Closed
~	PDMC-PL-08-WY-2005-008	Update and Expansion of Wyoming Multi-Hazard Mitigation Plan	PDM	Obligated	07/26/2005	04/16/2010	~	~
Unita	1 Total Project							
Disaster Number	**Project Number**	**Project Title**	**Program Area**	**Status**	**Date Approved**	**Date Awarded**	**Date Completed**	**Date Closed**
~	PDMC-PL-08-WY-2008-001	Uinta County Update Multi-Hazard Multi-Jurisdiction Mitigation Plan	PDM	Obligated	09/05/2008	12/14/2010	~	~
Washakie	1 Total Project							
Disaster Number	**Project Number**	**Project Title**	**Program Area**	**Status**	**Date Approved**	**Date Awarded**	**Date Completed**	**Date Closed**
~	FMA-PL-08-WY-2010-001	Washakie County Flood Mitigation Plan	FMA	Obligated	09/02/2011	09/07/2011	~	~

5.2 Local Capability Assessment

Requirement §201.4(c)(3)(ii): *[The State mitigation strategy **shall** include] a general description and analysis of the effectiveness of local mitigation policies, programs, and capabilities.*

Local Hazard Management Capabilities

Local mitigation implementation capacity varies from county to county based on population, economy, level of risk, funding, and staffing levels. The individual most likely to be responsible for development and implementation of the local mitigation plan is the County Coordinator. These individuals are frequently responsible for other activities, including implementation of the U.S. Department of Homeland Security grant programs. County Coordinators may not have sufficient resources to carry out mitigation programs, including development of multi-hazard mitigation plans.

PDM grant funds have been a catalyst for several counties to complete and pursue FEMA approval of their mitigation plans. Counties without approved plans have been and will continue to be encouraged to apply for PDM funds for planning purposes. Additional funding options for mitigation planning include HSGP and EMPG grants. Several counties have completed or are working on plans with county funds. A few counties indicate they do not have funds for matching a PDM planning grant. The state provides no funding to local governments for matching federal grants.

An effective way for local jurisdictions to address hazard mitigation is through land use policies and regulations and the enforcement of building codes. Land use policies and zoning regulations remain unpopular in Wyoming and if of zoning regulation is pursued, it is challenging at best. **Table 5.2.1** summarizes existing mitigation capacity of each county and some cities. The information was derived from local plans as well as personal communications.

Table 5.2.1 – Local programs and Capabilities

County	Location	Program or Hazard	Description
Albany	Laramie	Hazardous Materials	Enforcement of uniform fire and building codes regulating hazardous materials storage and use.
Albany	Laramie	Flood	Planning regulations keeping new construction out of identified floodplains.
Albany	Laramie	MMMS	Community actively participated in MMMS mapping effort, expanding expertise.
Albany	Laramie	Land Use Policy	The City of Laramie adopted a Comprehensive Plan in 2007
Albany	Countywide	Land Use Policy	Albany County adopted a Comprehensive Plan in 2008
Big Horn	Countywide	Flood	Produced more localized flood hazard maps. Requested FEMA to update FIRMs. Big Horn EMA produced a worst case scenario for major dam failure and resulting floods.
Big Horn	Countywide	MMMS	County actively participated in MMMS mapping effort, expanding expertise.
Big Horn	Countywide	PDM	County Multi-Hazard Mitigation Plan completed.
Big Horn	Greybull	FMA	Flood Mitigation Assistance Plan completed.

County	Location	Program or Hazard	Description
Campbell	Gillette	Land Use Regulation	Gillette has zoning and subdivision regulations
Campbell	Countywide	Drought	Development of the Madison Well Field and Pipeline project to bring water to Gillette in response to 1970's water supply shortages.
Campbell	Countywide	Flood	New storm drainage channels and reduction of development in 100-year floodplain areas. Creation of greenway parks in Wright to carry storm run-off into detention areas.
Campbell	Countywide	Hazardous Materials	Mining companies, the LEPC and emergency response agencies developed a public educational program on hazardous material safety and the mines funded an automated phone warning system for response to emergencies.
Campbell	Countywide	Overall	Creation of a joint county/municipal emergency operations plan beginning in June 2000.
Campbell	Countywide	MMMS	County actively participated in MMMS mapping effort, expanding expertise.
Campbell	Countywide	PDM	County Multi-Hazard Mitigation Plan Completed
Converse	Countywide	Drought	1. Education on the benefits of ongoing water conservation, including education on use of drought-tolerant plantings. Funding through State Mitigation Fund. 2. Develop or increase water storage capabilities for livestock industry. State funds available.
Converse	Countywide	Flooding	Acquisition of property within the floodplain and transition of those areas into green spaces. Funding through Community Development Block Grant, Disaster Recovery Initiative, Emergency Management Preparedness & Assistance Grant, Flood Mitigation Assistance Program, Hazard Mitigation Grant Program, National Flood Mitigation Fund, Public Assistance, State Disaster Preparedness Grants.
Converse	Countywide	FMA	Flood Mitigation Plan completed
Converse	Countywide	MMMS	County participating in MMMS mapping effort, expanding expertise.
Converse	Countywide	Hazardous Materials	1. Protect residents from hazardous materials spills that occur at either fixed facilities or by transportation of the materials. Funding through State Mitigation Fund. 2. Training and equipment for local emergency responders to enhance their ability to respond to Hazardous Materials incidents. Receive funding from the following grants: Homeland Security Grant, Community Development Block Grant, Disaster Recovery Initiative, Hazard Mitigation Grant Program, and Hazardous Waste Management State Program Support.
Converse	Countywide	Tornado	1. Enforcement of building codes (to include use of hurricane clips). 2. Severe Weather Spotter training for the public. 3. Public education for tornado awareness and what to do in case of a tornado. Funding through State Mitigation Fund.
Converse	Countywide	Wildfire	Public education for rural residents about the use of Defensible Space as a means of protecting their property. Also educating public on fire resistant vegetation and landscaping and fire resistant construction materials. Funding from State Mitigation Fund, resources from BLM, County Extension Office, and Univ. of Wyoming.
Converse	Countywide	Winter Storms	1. Public education for winter storm preparedness and emergency supplies. Funding through State Mitigation Fund. 2. Enhance tree-trimming programs near utility lines and other vulnerable areas. Funding through County and Municipal resources.

County	Location	Program or Hazard	Description
Crook	Countywide	Wildland Fire	Worked with USFS, BLM, and WSF to better respond to, and mitigate wildfires.
Crook	Countywide	Severe Weather	Work with Road and Bridge and WYDOT to maintain road conditions during storms.
Crook	Countywide	Hazardous Materials	Hazardous Materials Training for emergency personnel.
Crook	Countywide	Stormwater Drainage	Several communities have drainage master plans.
Crook	Countywide	Wildfire	Participation in Western States Wildland Urban Interface Grant Program.
Crook	Countywide	Wildfire	Participation in Wyoming Emergency Fire Suppression Account.
Crook	Countywide	Floods	Funds are available for relocation or elevation of structures in the floodplain.
Crook	Hulett, Moorcroft, Sundance	MMMS	Communities actively participated in MMMS mapping effort, expanding expertise.
Fremont	Countywide	PDM	Completed County Multi-Hazard Mitigation Plan
Fremont	Countywide	Drought	Created Fremont County Drought Task Force
Fremont	Countywide	Flood	Encourage local citizens who live in floodplains to continue flood mitigation projects. The flood emergency response plan was revised in 2000 to better reflect flood- prone areas. Dubois and Lander each prepared Flood Mitigation Plans.
Fremont	Countywide	Hazardous Materials	Continue cooperative effort with businesses and industries that store and use chemicals. The county coordinator provides technical and program support to the Fremont County Hazardous Material Regional Response Team.
Fremont	Countywide	Wildland Fire	Prepared Disaster Mitigation Plan for Wildland Fire Mitigation. Project Objectives include: 1. Training in hazard assessment techniques and computer software. 2. Wildland/Urban Interface and defensible space education to all interested landowners. 3. Create demonstration sites in each major subdivision. 4. Conduct Fuel Hazard Assessments/Evaluations in major subdivisions. 5. Complete Community Action Plans in three areas of the county. 6. Assist landowners with Fuel Hazard Reduction projects around homes.
Fremont	Countywide	PDM	County Multi-Hazard Mitigation Plan completed
Fremont	Countywide	MMMS	County actively participated in MMMS mapping effort, expanding expertise.
Fremont	Riverton, Hudson, Dubois	FMA	Flood Mitigation Assistance Plans completed. Additional flood mitigation drainage work required for Riverton.
Goshen	Countywide	Disorder/Riot	Regular training for law enforcement personnel.
Goshen	Countywide	PDM	County Multi-Hazard Mitigation Plan completed
Goshen	Countywide	Flood	County, and the towns of Lingle and Torrington are members of National Flood Insurance Program. Plans are kept at the County Emergency Operations Center which projects times and areas of flood inundation from upstream dam breaks, along with computer generated maps of the probable inundation areas. Phone lists are kept at the County Emergency Operations Center for notification of persons along affected creeks and rivers.
Goshen	Countywide	Hail Storms	Good communication and coordination exists between National Weather Service and dispatch and response personnel.
Goshen	Countywide	Hazardous Materials	LEPC meets regularly to review Hazardous Materials facility reports and emergency response plans. First responders continue to obtain better

County	Location	Program or Hazard	Description
			Hazardous Materials response equipment and training as funds allow.
Goshen	Countywide	Power Failure	Critical services have generators (City/County Dispatch, Hospital, and Emergency Operations Center).
Goshen	Countywide	Terrorism	Schools and law enforcement developing plans for buildings, bus routes, other contingencies.
Goshen	Countywide	Tornado	Torrington Dispatch relays potential warnings from the National Weather Service to the Goshen Emergency Agency, and then to the affected fire districts and municipalities.
Goshen	Countywide	Wildland Fires	Fire warden and fire chiefs of 12 fire districts in County maintain response arrangements that allow for concentrations of large numbers of personnel and equipment in specific areas.
Goshen	Countywide	Winter Storms	Increased snowplow fleet from 3 to 8 units.
Goshen	Countywide	Winter Storms	EM participates in winter awareness week and conducts communication fan-outs for severe weather warnings.
Goshen	Torrington	FMA	Flood Mitigation Assistance Plan completed
Hot Springs	Countywide	All Hazards	Educating the public on thunderstorms, tornadoes, windstorms, hailstorms, severe winter storms, extreme summer weather, earthquakes, landslides, land subsidence, snow avalanches, floods, dam failure, drought, wildfires, structural fires, and terrorist activities
Hot Springs	Countywide	All Hazards	EMWIN is in place for early warning systems regarding various hazards.
Hot Springs	Countywide	Drought and Wildland Fire	Drought and Wildfire Action Committee
Hot Springs	Countywide	Hazardous Materials	Obtaining full TIER II reports.
Hot Springs	Countywide	Terrorism	School resource officer has been put in place in the Hot Springs County School system to oversee and prepare school for terrorist threats.
Johnson	Countywide	PDM	County Multi-Hazard Mitigation Plan completed
Johnson	Kaycee	NFIP	Kaycee actively participated in flood mapping effort, expanding expertise.
Laramie	Cheyenne	Flood	Allison Draw Drainage Master Plan
Laramie	Cheyenne	Flood	Analysis of Capitol Basin Storm Drain system.
Laramie	Cheyenne	Flood	Crow Creek Drainage Basin Master Plan
Laramie	Countywide	Flood	Utilized Wyoming Risk and Vulnerability FY 2000 Instrument.
Laramie	Cheyenne	Flood	Dry Creek Basin Master Plan
Laramie	Cheyenne	Flood	Henderson and East Lincolnway Drainage Basins Master Plan
Laramie	Cheyenne	Flood	Holliday Drainage Basin
Laramie	Countywide	Public Awareness	Continued public education
Laramie	Cheyenne	Flood	Implementation of the Master Drainage Plan of the F.E. Warren AFB.
Laramie	Cheyenne	FMA	Flood Mitigation Assistance Plan completed
Laramie	Cheyenne	PDM	City Multi-Hazard Mitigation Plan completed
Laramie	Cheyenne	Flood	Crow Creek PDM-funded Flood Control Project
Laramie	Cheyenne	Flood	Dry Creek PDM-funded Flood Control Project
Laramie	Cheyenne	Flood	Henderson Basin FMA-funded Flood Control Project
Laramie	Countywide	FMA	Flood Mitigation Assistance Plan completed
Laramie	Cheyenne	Land Use Policy	Laramie County and the City of Cheyenne have partnered on a Cheyenne Area Master Plan (2006)
Laramie	Countywide	Drought	Water restrictions.
Laramie	Countywide	Earthquake	Building codes in place.
Laramie	Countywide	PDM	County Multi-Hazard Mitigation Plan completed
Lincoln	Countywide	Flood	Flood plan
Lincoln	Countywide	Flood	Dam failure plan

County	Location	Program or Hazard	Description
Lincoln	Countywide	Hazardous Materials	Fixed Hazardous Materials plan
Lincoln	Countywide	Hazardous Materials	Transported Hazardous Materials plan
Lincoln	Countywide	Landslides	Landslide plan
Lincoln	Countywide	Earthquake	Earthquake plan
Lincoln	Countywide	Severe Weather	Public education of weather-related hazards.
Lincoln	Countywide	Terrorism	Designated shelters for man-made hazards.
Lincoln	Countywide	PDM	County Multi-Hazard Mitigation Plan completed
Lincoln	Countywide	MMMS	County actively participated in MMMS mapping effort, expanding expertise.
Lincoln	Countywide	Power Failure	Created list of portable generators.
Lincoln	Countywide	Zoning	Ordinances and regulations to discourage development in hazardous areas.
Lincoln	Kemmerer	FMA	Flood Mitigation Assistance Plan completed
Natrona	Casper	Flood	Platte River Parkway project to reduce the number of structures in the 100-year floodplain.
Natrona	Casper	FMA	Flood Mitigation Assistance Plan completed
Natrona	Countywide	Warning System	Emergency Alert System and cable interrupt
Natrona	Countywide	Drought	Public education and awareness with water conservation. Development of Drought Task Force. Water restrictions during critical drought periods.
Natrona	Countywide	Earthquake	Public education and awareness. CERT training, lamination film for windows, strapping of gas water heaters, securing book cases and other wall hangings, securing computers/monitors on desks, 72-hour kits.
Natrona	Countywide	Flooding	For flooding, the review of ordinances and resolutions for builders, homeowners, and land use is accomplished. Containment dams in drainages, installing storm drain systems to a higher capacity or installing where none existed.
Natrona	Countywide	GIS	GIS with extensive layering, including floodplain identification. Mapping has been accomplished for addressing of rural residence for the Public Safety Communications Center's E911 system.
Natrona	Countywide	Hazardous Materials	Ongoing review of ordinances and resolutions as well as enforcement of federal regulations. The Uniform Fire Code is also adopted as related to use, storage, and disposal of hazardous materials. Pipelines are identified and mapped.
Natrona	Countywide	Severe Weather	Severe weather is mitigated by public education and awareness such as Winter Weather Awareness Weeks, Spring Severe Weather Awareness Weeks, Community Emergency Response Team (CERT) program, and public service announcements via radio, television, and newspaper.
Natrona	Countywide	Wildland Fire	Maps of fire-prone areas and exposure valuations. Wildland fire areas identified and mapped by severity potential by the USDA Forest Service and locally by the Wyoming FireWise committee. Interagency cooperation established.
Natrona	Countywide	Wildland Fire	Wyoming FireWise has established funding through federal grants for wildland fire mitigation.
Natrona	Countywide	PDM	County Multi-Hazard Mitigation Plan completed
Natrona	Countywide	MMMS	County actively participated in MMMS mapping effort, expanding expertise.
Niobrara	Countywide	PDM	County Multi-Hazard Mitigation Plan completed
Park	Countywide	PDM	County Multi-Hazard Mitigation Plan completed
Park	Northwest College	PDM	Draft Northwest College Disaster-Resistant University Plan completed

County	Location	Program or Hazard	Description
Park	Countywide	MMMS	County actively participated in MMMS mapping effort.
Platte	Countywide	PDM	County Multi-Hazard Mitigation Plan completed
Sheridan	Sheridan	Flood	Flood plan completed
Sheridan	Countywide	Flood	Flood plan completed
Sheridan	Countywide	Fire	Public Education for Fire Safety
Sheridan	Countywide	PDM	Draft County Multi-Hazard Mitigation Plan
Sublette	Countywide	Codes or Code Adoptions	Enforce building codes.
Sublette	Countywide	Extreme Cold	Cattle warnings if temperatures are low enough.
Sublette	Countywide	Earthquake	Fixing structurally unsound buildings.
Sublette	Countywide	Tornados	Educating public on keeping yards picked up to avoid flying debris.
Sublette	Countywide	Wildland Fire	Educating public on mitigation tactics to prevent the start of a fire and protect their homes from fire.
Sublette	Countywide	Wildland Fire	Pre-attack and evacuation plans are in place in the event of a fire.
Sublette	Countywide	Health	Education and training for first responders and the County Health Department. Full-scale Tularemia exercise involving County Health Department. Sublette County Sheriff's Office, Sublette County EM, Local EMTs, Fire Departments, Public Works, Vet Clinics, and local government officials..
Sublette	Countywide	Extreme Cold	During periods of extreme cold private homes and businesses insulate pipes, watch and listen to weather reports, and some have installed generators for power during outages.
Sublette	Countywide	Hazardous Materials	For hazardous materials spills, development of regional response team, education of first responders, establishment of city evacuation plans and rally points, city street and road improvements, lowering traffic speed limits, and increased traffic patrol by local law enforcement.
Sublette	Countywide	Tornados	High wind are mitigated by enforcing building codes, fixing structurally unsound buildings, and educating the community on importance of keeping yards picked up to avoid damage to person or property from flying debris.
Sublette	Countywide	Wildland Fire	Forest Service fuel mitigation grants are available.
Sublette	Countywide	PDM	Draft Multi-Hazard Mitigation Plan completed
Sweetwater	Countywide	NFIP	Actively pursuing participation in the NFIP.
Teton	Countywide	PDM	County Multi-Hazard Mitigation Plan completed
Teton	Jackson Hole	Land Use Policy	Jackson Hole partnered with Teton County on a Comprehensive Plan in 2011
Teton	Countywide	MMMS	County actively participated in MMMS mapping effort, expanding expertise.
Teton	Countywide	All Hazards	Public education for all hazards.
Teton	Countywide	All Hazards	"Plan for the worst hope for the best" video.
Teton	Countywide	Wildland Fire	Attendance at Wyoming Fire School.
Teton	Countywide	All Hazards	Teamed up with Red Cross to distribute 72-hour emergency kits to community members.
Teton	Countywide	Wildland Fire	Fire Suppression Grants
Teton	Countywide	FMA	Flood Mitigation Assistance Plan completed
Teton	Countywide	All Hazards	Project Impact has offered funding of a safe schools analysis.
Teton	Countywide	Earthquake	Requirement of new construction to comply with seismic zone 3 standards.
Uinta	Countywide	PDM	County Multi-Hazard Mitigation Plan completed
Uinta	Countywide	Land Use Policy	Uinta has a Comprehensive Plan

County	Location	Program or Hazard	Description
Uinta	Countywide	MMMS	County actively participated in MMMS mapping effort, expanding expertise.
Uinta	Countywide	FMA	Flood Mitigation Assistance Plan completed.
Washakie	Worland	FMA	Flood Mitigation Assistance Plan completed.
Washakie	Countywide	Earthquake	Control is through local plans and building codes.
Washakie	Countywide	Flooding	Flood prediction from analyses from the Bureau of Reclamation who operate Boysen Reservoir and the National Weather Service. Control of flooding by sand bagging and land use management.
Washakie	Countywide	Hazardous Materials	Control of Hazardous Materials spills by local plans, zoning, and training of response and management forces.
Washakie	Countywide	Tornado	Control is through local plans and building codes.
Washakie	Countywide	PDM	County Multi-Hazard Mitigation Plan completed
Washakie	Countywide	MMMS	County actively participated in MMMS mapping effort, expanding expertise.
Weston			Unknown, will be researched for future updates

Building Codes

The State of Wyoming has adopted the International Building Code. **Table 5.2.2** summarizes the code status of Wyoming Counties. The counties or incorporated jurisdictions indicated with an "L" have also adopted the code and have responsibility for enforcement. The jurisdictions marked with an "S" have not separately adopted the code and enforcement of the code is under the jurisdiction of the State.

The Wyoming Conference of Building Officials (WCBO) is the state chapter of the International Code Council. The WCBO allows small communities, whose budgets may not allow for extensive training, to join forces with other jurisdictions to effectively plan and develop their community. The WCBO works in cooperation with the Wyoming Association of Municipalities (WAM) to represent the code position of the local municipality or jurisdiction in the Wyoming State Legislature. The WCBO also works closely with the Wyoming State Fire Marshal's Office in the area of building and fire codes.

Table 5.2.2 – Local Jurisdiction Building Code Status

COUNTY	FIRE	BLDG	ELEC	STATE BLDG	ELECTRICAL HEALTH
ALBANY COUNTY	S	S	S	S	S
Laramie	L	L	L	S	L
Laramie Airport Proper	L	L	L	S	S
BIG HORN COUNTY	S	S	S	S	S
Basin	S	S	S	S	S
CAMPBELL COUNTY	L	L	L	S	S
Gillette	L	L	L	L	L
Wright	L	L	S	S	S
CARBON COUNTY	S	S	S	S	S
Rawlins	S	L	S	S	S
CONVERSE COUNTY	S	S	S	S	S
Douglas	S	L	S	S	S
CROOK COUNTY	S	S	S	S	S
FREMONT COUNTY	S	S	S	S	S
Lander	L	L	L	S	L
Riverton	L	L	L	S	L
GOSHEN COUNTY	S	S	S	S	S
HOT SPRINGS COUNTY	S	S	S	S	S
Thermopolis	S	L	S	S	S
JOHNSON COUNTY	S	S	S	S	S
LARAMIE COUNTY	L	L	L	L	S
Cheyenne	L	L	L	L	S
LINCOLN COUNTY	S	S	S	S	S
Diamondville	S	S	S	S	S
NATRONA COUNTY	L	L	L	L	S
Bar Nunn	L	L	L	S	S
Casper	L	L	L	L	L
Edgerton	L	L	L	S	S
Evansville	L	L	L	S	S
Midwest	L	L	L	S	S
Mills	L	L	L	S	S
NIOBRARA COUNTY	S	S	S	S	S
PARK COUNTY	S	S	S	S	S
Cody	L	L	L	S	L
Powell	S	L	L	S	S
PLATTE COUNTY	S	S	S	S	S
Wheatland	L	L	L	S	L
SHERIDAN COUNTY	S	S	S	S	S
Sheridan	L	L	L	L	L
SUBLETTE COUNTY	S	S	S	S	S

Effectiveness of Local Mitigation Policies, Programs, and Capabilities

The Wyoming Office of Homeland Security considers all local mitigation policies and programs effective, taking into account local capabilities. Most counties are understaffed and some county Emergency coordinators are part-time. Many jurisdictions do not have readily available funds for match.

The International Building Code is the most recent iteration of building codes designed to protect lives in the case of a disaster, and is considered the most effective mitigation measure. As shown in the table above, not all jurisdictions in Wyoming have adopted building codes, much less the most current code. Buildings in those jurisdictions may not have the same disaster resistance as buildings in jurisdictions with adopted building codes. The Wyoming Department of Fire Prevention and Electrical Safety encourages local jurisdictions to adopt building codes, as do many County Coordinators.

Zoning is not a popular concept in most of Wyoming. City and county planners, local building departments, and county homeland security coordinators do promote hazard awareness in areas where zoning does not exist. Counties have been supplied with maps of natural hazards, and most of those maps are included in county multi-hazard mitigation plans.

Development in Hazard Prone Areas

As a Home Rule state, planning and zoning are generally the responsibility of local governments. The State of Wyoming has no overall authority for planning and zoning with the exception of state lands. These factors place limitations on the state's ability to initiate, implement, or administer mitigation programs, particularly those which would address development in hazard prone areas. Comprehensive hazards data have been supplied to all counties in Wyoming by the Wyoming Office of Homeland Security and the Wyoming State Geological Survey. In addition, all counties have been supplied with hazards analyses and vulnerability assessments for pertinent natural hazards. State agencies have been supplied with the Wyoming Multi-Hazard Mitigation Plan, and key agencies were involved with the creation of this plan update.

Natural and man-made hazards are identified as part of the state and local review of Environmental Assessments, Environmental Impact Statements, and Industrial Siting applications for significant construction projects proposed in Wyoming. If the known hazards are not addressed in the documents, the parties responsible for preparing the document are required to address the hazards. Review comments related to any development in hazard prone areas are provided to appropriate parties and jurisdictions during the process of Environmental Assessment, Environmental Impact Statement, and Industrial Siting application reviews conducted by the State of Wyoming. The review process ensures natural and man-made hazards are recognized and addressed for all significant construction projects.

Pre-disaster mitigation programs

Federally funded pre-disaster mitigation programs include FEMA's Pre-Disaster Mitigation (PDM) program, Flood Mitigation Assistance Program (FMA), Community Assistance Program (CAP), Community rating System (CRS), Dam Safety Program, Map Modernization Program, and the National Flood Insurance Program. The Federal Highway Administration funds the Federal Aid Highway Program,

and the U.S. Department of Agriculture funds the National Fire Plan. **Table 5.2.3** identifies federally funded pre-disaster mitigation programs, which the state administers. Funding varies from year to year as it's contingent on Congressional authorization. Administration authority is identified for each program. Other than major corporations which might support a local program within their county or near vicinity, no statewide local program funding has been identified. Funding sources listed in **Table 5.2.4** are not intended primarily for mitigation activities but could be considered for use by grant applicants for multi-objective projects.

Table 5.2.3 – Pre-Disaster Mitigation Programs Administered by the State

Name	Description and evaluation	Agency Administration (Grantor, Grantee)
Community Assistance Program (CAP)	*Provides funding to state to assist communities in complying with National Flood Insurance Program (NFIP).* Due to frequent changeover in local flood plain managers, this program provides resources for maintaining contact with these individuals through site visits. In addition an annual floodplain manager's workshop provides education and updates. The program effectively helps the state to acquire input on local jurisdiction needs.	FEMA, WOHS
Community Rating System (CRS) (Part of NFIP)	*This system is part of the NFIP. It is a voluntary incentive program that recognizes and encourages community floodplain management activities, which exceed minimal NFIP requirements, resulting in discounted NFIP insurance premium rates to property owners. Activities include flood loss reduction, accurate insurance rating, and awareness of NFIP.* As a result of this program, the following communities have reduced insurance rates five to fifteen percent: Casper, Cheyenne, Douglas, Laramie County, and Sheridan. The state is actively working with these communities to improve their CRS ratings and efforts are underway to enroll additional communities in the program. Participants are supportive of the program.	FEMA, WOHS
Dam Safety Program	*Provides funding to the state to promote dam safety through emergency action plans, exercises, and inspections.* State uses contractors to photograph dam sites and record GIS coordinates. Funds are being used to inspect new dams constructed in coalbed natural gas generating areas. The State supports the Dam Safety Program through several legislatively supported positions. The state legislature has authorized the State Engineer's Office (SEO) to promulgate rules requiring state's high- and significant-hazard dam owners to develop emergency action plans.	FEMA, SEO
Federal Aid Highway Program	*Provides funding to the state for maintaining the interstate and state highway system. Numerous mitigation projects and programs are funded.*	FHA, WYDOT

Name	Description and evaluation	Agency Administration (Grantor, Grantee)
	Numerous projects are funded, including state maintenance, highway safety improvement, congestion, bridge safety studies, and hazard mitigation.	
Flood Mitigation Assistance Program (FMA)	*Provides pre-disaster funding to state for repetitive flood loss property reduction through relocation or acquisition.* Wyoming currently has nine repetitive loss properties, most of which are in Cheyenne or Laramie County. Currently, a FMA-funded project in Cheyenne, Wyoming should reduce impacts to one repetitive loss property.	FEMA, WOHS
Risk Map Program	*Provides funds for updating Flood Insurance Rate Maps.* This program provides valuable assistance in digitally updating flood insurance rate maps within the state. The state has chosen to participate in the program at medium level.	FEMA, WOHS
National Flood Insurance Program (NFIP)	*Provides pre-disaster flood insurance. There are approximately 85 Wyoming communities that participate in this program, which represents an increase from the last plan update.* This is a high priority program within the state. There are several jurisdictions in the state, which haven chosen not to participate, and efforts will be made to encourage their participation to help protect and insure property owners.	FEMA, WOHS
National Fire Plan (NFP)	*Provides pre-disaster funding for wildland fire mitigation and hazard planning. Assists land owners with fuel reduction.* The state supports continued participation in the program. It provides valuable assistance to the state in fuel load reduction providing protection to property and resources.	U.S. Dept. of Agriculture, State Forestry Division
Pre-Disaster Mitigation Grants PDM)	*Provides pre-disaster funding for mitigation planning and projects.* This program assisted 7 jurisdictions in developing local mitigation plans and developing and funding a flood control project.	FEMA, WOHS

Requirement §201.4(c)(3)(iv): *[The State mitigation strategy **shall** include an] identification of current and potential sources of Federal, State, local, or private funding to implement mitigation activities.*

Table 5.2.4 – Potential Mitigation Funding Sources

Name	Description	Federal Agency
AmeriCorps	Provides funding for volunteers to serve communities, including disaster prevention.	Corporation for National & Community Service
Community Development Block Grant (CDBG)	States sometimes receive a CDBG Supplement, following a disaster, intended for mitigation projects in the affected areas.	U.S. Department of Housing and Urban Development (HUD)
Clean Water Act Section 319 Grants	Provides grants for a variety of activities related to non-point source pollution runoff mitigation.	Environmental Protection Agency (EPA)
Economic Development Administration Grants and Investments	Invests and provides grants for community construction projects, including mitigation activities.	U.S. Department of Commerce
Emergency Watershed Protection	Provides funding and technical assistance for emergency measures to protect impaired watershed easements.	U.S. Department of Agriculture - Natural Resources Conservation Service (USDA-NRCS)
Environmental Quality Incentives Program	Provides funding and technical assistance to farmers and ranchers to promote agricultural production and environmental quality as compatible goals.	USDA-NRCS
Housing and Urban Development Grants	Provides a number of grants related to safe housing initiatives.	HUD
North American Wetland Conservation Fund	Provides funding for wetland conservation projects.	U.S. Fish and Wildlife Services (FWS)
Natural Resources Conservation Service Programs	Provides funding through a number of programs for the conservation of natural resources.	USDA-NRCS
Partners for Fish and Wildlife	Provides assistance to states in the planning for the development, utilization, and conservation of water and related land resources.	FWS
Planning Assistance to States	Provides assistance to states in the planning for the development, utilization, and conservation of water and related land resources.	U.S. Army Corps of Engineers (USACE)
Rural Development Grants	Provides grants and loans for infrastructure and public safety development and enhancement in rural areas.	USDA, Rural Development
Rural Fire Assistance Grant (RFA)	Funds fire mitigation activities in rural communities.	U.S. Forest Service - National Interagency Fire Center
SBA Pre-Disaster Mitigation Loan Program	Provides low-interest loans to small businesses for mitigation projects.	U.S. Small Business Administration
Small Flood Control Projects	U. S. Army Corps of Engineers has authority to construct small flood control projects.	USACE
Streambank & Shoreline Protection	U. S. Army Corps of Engineers has authority to construct streambank stabilization projects.	USACE
Wetland Program Development Grants (WPDG)	Provides funding for studies related to water pollution prevention.	EPA

National Flood Insurance Program

The Wyoming Office of Homeland Security administers the NFIP for Wyoming, and is continually encouraging communities to join the program through community assistance visits. Some jurisdictions are not participating in the National Flood Insurance Program (NFIP), and as such may not have local ordinances to govern the construction of buildings in flood prone areas. Local homeland security coordinators, city and county planners, and local citizens are also active in encouraging NFIP participation. **Table 5.2.5** lists counties and communities participating in NFIP.

Table 5.2.5 – Jurisdictions Participating in the NFIP

County and community names	County and community names	County and community names
Albany County	Shoshoni	Cody
Laramie	Goshen County	Meeteetse
Big Horn County	Fort Laramie	Powell
Basin	Lingle	Platte County
Greybull	Torrington	Chugwater
Lovell	Hot Springs County	Guernsey
Manderson	East Thermopolis	Wheatland
Campbell County	Kirby	Sheridan County
Gillette	Thermopolis	Clearmont
Wright	Johnson County	Dayton
Carbon County	Buffalo	Ranchester
Baggs	Kaycee	Sheridan
Dixon	Laramie County	Sublette County
Elk Mountain	Burns	Big Piney
Medicine Bow	Cheyenne	**Sweetwater County***
Rawlins	Pine Bluffs	Green River
Riverside	Lincoln County	Rock Springs
Saratoga	Afton	Teton County
Converse County	Cokeville	Jackson
Douglas	Diamondville	Uinta County
Glenrock	Kemmerer	Bear River
Crook County*	Opal	Evanston
Hulett	Star Valley Ranch	Lyman
Moorcroft	Natrona County	Mountain View
Sundance	Casper	Washakie County
Fremont County	Evansville	Tensleep
Dubois	Mills	Worland
Hudson	**Niobrara County***	**Weston County***
Lander	Lusk	Newcastle
Riverton	Park County	* County does not participate in NFIP

Repetitive Loss Program

The National Flood Insurance Program provides insurance for properties located in floodplains. In conjunction with this program, FEMA administers the Repetitive Loss Program, which focuses on properties having sustained repetitive losses. Both the Pre-Disaster Mitigation (PDM) Grant Program and the Hazard Mitigation Grant Program (HMGP) provide funding for property acquisition, structure relocation, or flood-proofing measures as a means of preventing repetitive losses. In Wyoming, there are nine repetitive loss properties.

Repetitive Loss Properties Analysis

There are 9 repetitive loss properties in the state. Four of the nine properties are insured. The repetitive loss properties are located in Saratoga, Goshen County, Cheyenne, Laramie County, and Park County. A summary of repetitive loss properties and losses follows in **Table 5.2.6**:

Table 5.2.6 – Wyoming Repetitive Loss Summary

	AE, A1-30, AO, AH, A	VE, V1-30, V	B, C, X	TOTAL
RL Buildings (Total)	6	0	3	9
RL Buildings (Insured)	4	0	0	4
RL Losses (Total)	16	0	6	22
RL Losses (Insured)	8	0		8
RL Payments (Total)	$222,373.43	$.00	$58,400.32	$280,773.75
Building	$222,373.43	$.00	$43,758.40	$266,131.83
Contents	$.00	$.00	$14,641.92	$14,641.92
RL Payments (Insured)	$130,140.12	$.00	$.00	$130,140.12
Building	$130,140.12	$.00	$.00	$130,140.12
Contents	$.00	$.00	$.00	$.00

Post - FIRM SFHA RL Buildings:	1
Insured Buildings with 4 or More Losses:	0
Insured Buildings with 2-3 Losses > Building Value:	0
Total Target RL Buildings:	0

Post-disaster mitigation programs

The state manages one federal fund related to post-disaster hazard mitigation, FEMA's Hazard Mitigation Grant Program (HMGP) summarized in **Table 5.2.7**. The state program is guided by the Wyoming Hazard Mitigation Grant Program Administrative Plan. After a Presidential Disaster Declaration, funds are made

available for hazard mitigation projects and planning. The Hazard Mitigation Grant Program may provide Wyoming with an amount equal to 15 percent of the total disaster grants awarded by FEMA after the declaration. The funds may be used to fund up to 75 percent of eligible mitigation measures identified in the Wyoming Multi-Hazard Mitigation Plan, with the state or local government providing the remaining cost-share from non-federal sources.

Upon notification by FEMA that HMGP funds will be made available, WOHS conducts applicant briefings around the state. The briefing includes an overview of the program, eligibility criteria, application process, selection process, environmental requirements, cost/benefit analysis requirements, cost share requirements, and financial control/grant management information. Once project or planning applications are received, WOHS will review applications for completeness and activate a selection and ranking committee to review and rank applications if more than one application is received. Selected applications will be forwarded to FEMA, and Grant Award Agreements prepared for FEMA-approved applicants. **Table5.1** presented earlier in this chapter summarizes HMGP and HMA activity in Wyoming from 2010 forward. More detail on the award, monitoring, and project closeout process is available in the Wyoming Hazard Mitigation Grant Program Administrative Plan.

Table 5.2.7 – Post Disaster Mitigation Programs

Name	Description and evaluation	Agency Administration (Grantor, Grantee)
Hazard Mitigation Grant Program (HMGP)	*Provides post-disaster funding to state and local jurisdictions for eligible projects.* Currently, several HMGP planning and projects are underway, as a result of the Presidential Declaration for the flooding disasters in 2010 (DR-1923) and in 2011 (DR-4007). Funding and match concerns limit the number of HMGP applications received. In addition, limited staff available at the local level to track and manage grants affected the number of applications.	FEMA, WOHS

6.1 Mitigation Actions

Requirement §201.4(c)(3)(iii): *[State plans **shall** include an] identification, evaluation, and prioritization of cost-effective, environmentally sound, and technically feasible mitigation actions and activities the State is considering and an explanation of how each activity contributes to the overall mitigation strategy. This section **should** be linked to local plans, where specific local actions and projects are identified.*

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities…

Below is a compilation of mitigation strategies from each of the hazard assessments:

Mitigation Strategy – Dam Failure

Refine computer models to determine potential damage to dams from earthquakes.	Not started. VERY low priority.
Drill test cores on older hydraulic fill dams in western Wyoming to determine liquefaction or piping potential of the dam.	Not started. VERY low priority. Unlikely to be pursued.
Identify homes built in inundation areas of dam failures.	Progress has been made and is ongoing for high and significant hazard dams.
Update hazard rating of all dams statewide.	Continuous, ongoing project.
Develop and train a team to respond to landslide dams to prevent failure.	Not started. Low priority. Limited mitigation value. Determined to be response, rather than mitigation.
Increase height of dams to compensate for sediment behind dams.	Removed from the list. Sediment may be removed as necessary. Increased dam height is rarely considered.
Spillway modifications to reflect current analysis on design storms.	Ongoing.
Provide all-hazards weather radios to all residences in Wyoming.	Removed from the list.
Identify and inspect shelters in hazard prone areas.	American Red Cross is working with WOHS and VOAD to develop and maintain a current list of identified shelters. Shelters have been identified and validated (3-deep) in all counties. The list is re-validated at least annually.
Provide hazards info to shelters, emergency facilities in public buildings, campgrounds, and phone books.	Removed from the list.

Develop reseeding plans for losses due to all hazard events.	Removed from the list.
GIS training for local jurisdictions with emphasis on hazards recognition and analysis for application to mitigation planning.	Local GIS capability is encouraged. Training is accomplished at the local level, as needed and as funding is available.
Investigate opportunities for developing or improving warning systems as a means to reduce loss of life, damage to property, and economic losses.	Removed from the list. This is an ongoing, response planning activity, and not a mitigation activity.
Education programs encompassing multi-hazard insurance for business, resident and government application.	Ongoing mitigation activity. Annual workshop series and tabletop exercises are conducted each year.
Education programs encompassing multi-hazard mitigation for business, resident and government application.	Ongoing mitigation activity. Annual workshop series and tabletop exercises are conducted each year.
Planning studies regarding transportation of essential and/or key personnel during all hazard events.	Removed from the list. This is a response planning activity and not a dam hazard mitigation activity.
Continue outreach to counties on identifying cost effective and feasible mitigation projects.	Ongoing. Outreach accomplished through County Coordinators.
Promote Continuity of Operations and Continuity of Government, statewide.	Continuity of Operations is an ongoing activity.
Maintain and continue to expand hazards databases that were generated for the State Hazard Mitigation Plan. Seek new sources of information.	Removed from the dam safety mitigation list. Not a dam hazard mitigation activity.
Identify, document, and advertise all volunteer agency's locations and contact information.	Removed from the list. This is a response and recovery planning activity and is not a dam hazard mitigation activity.

State Mitigation Strategy: Drought

Educate residents on water saving techniques & encourage water-saving techniques as a lifestyle	Ongoing activity
Maintain drought emergency plan	Ongoing activity. State drought plan is in place.
Monitor water supply	Ongoing local & state-level activity
Encourage drought tolerant landscaping	Ongoing activity
Educate agricultural community on crop insurance and education programs encompassing multi-hazard insurance for business, resident and government application	Ongoing activity
Develop reseeding plans for losses due to all hazard events.	Removed. Recovery activity.
Seek additional opportunities for water storage	Remains on the list.
Improve monitoring of drought conditions	Ongoing activity through NOAA, local weather reporting, and Snowtel locations around the state
Deployment of solar powered well pumps in drought ridden areas.	Low priority activity

Water conservation projects	Ongoing activity
Weather mitigation modification (cloud seeding expanded research)	Removed.
Education programs encompassing multi-hazard mitigation for business, resident and government application	Ongoing activity

State Mitigation Strategy: Earthquake

Conduct HAZUS analyses to determine effects building code adoption may have on reducing loss estimates.	Remains a potential project, not yet begun.
Conduct study on phasing in of earthquake provisions of code for state funded and/or inspected buildings.	Removed. Studies are not mitigation activities.
Development of enhanced soil layer for use in HAZUS.	Completed. Enhanced soil layer was used for the 2004 and updated for the 2011 HAZUS projects.
Study on retrofit feasibility of government owned buildings, essential facilities, culverts, and bridges.	Modified. Studies are not mitigation activities. (see below)
Retrofit state and local government-owned buildings, essential facilities, culverts, and bridges as funding allows for those determined to be cost effective.	List of critical infrastructure for visual assessments requested from local emergency managers. Visual assessments begun in Teton County. The intent is to develop a 'wish list' to be prioritized for future mitigation.
Retrofit pipelines with flexible connectors where they intersect with active faults.	Modified to reflect mitigation activity rather than a 'study.'
Education on earthquakes and on seismic provisions of the building code.	Education activities remain on-going. Wyoming-specific flyer developed and inserted into newspapers in western Wyoming in 2012. Wyoming participated in the ShakeOut for the first time in 2013.
Analysis of effects of earthquakes on public buildings and shelters.	Removed. Studies are not mitigation activities.
Retrofit State Capitol and Herschler Building.	Removed. Included in project above.
Provide all-hazards weather radios to all residences in Wyoming.	On-going activity. All-hazards weather radios have been purchased as funding allows and distributed to schools and other critical facilities. They have also been distributed as incentives to participate in preparedness activities.
Identify and inspect shelters in hazard prone areas.	This activity is nearly completed…

	and will continue as an on-going activity. However, it is not a mitigation activity, and is removed from the list.
Research feasibility and costs of adding new frontage roads /detour routes to I-80, I-90, and I-25 to prevent significant delay in traffic flow and resultant economic loss and possible loss of life.	Removed
Provide hazards information to shelters, emergency facilities in public buildings, campgrounds, and phone books.	Removed
Provide emergency phones at strategic locations with direct lines to emergency dispatch services.	No longer useful. Traveling public typically has cell phones. Modified to reflect current cell phone use. (see below)
Encourage continued cell tower upgrades, retrofits and enhancements to ensure communication hubs are available in the event of an earthquake.	On-going activity.
Develop reseeding plans for losses due to all hazard events	Removed from the Earthquake Mitigation list. This is more relevant to wildland-urban interface fire and/or flooding.
GIS training for local jurisdictions with emphasis on hazards recognition and analysis for application to mitigation planning.	Removed
Investigate opportunities for developing or improving warning systems as a means to reduce loss of life, damage to property, and economic losses.	Warning systems have been developed and improved throughout the state at the local level, utilizing Homeland Security Grant Program funding and other funding. This is an on-going project, which is diminishing in need and priority.
Education programs encompassing multi-hazard insurance for business, resident and government application.	Multi-hazard insurance is promoted in the private insurance market, and is typically required by banks holding home or business mortgages. The Wyoming Office of Homeland Security has a staff person devoted to the National Flood Insurance Program.
Planning studies regarding transportation of essential and/or key personnel during all hazard events	Removed. This is a response planning activity, and best incorporated into the State Operations Plan.
Continue outreach to counties on identifying cost effective and feasible mitigation projects.	On-going activity.
Promote Continuity of Operations and Continuity of Government,	The Wyoming Office of Homeland

statewide.	Security has a staff person devoted to this activity. Wyoming Continuity of Operations and Continuity of Government planning is actively being pursued. This remains an on-going activity.
Maintain and continue to expand hazards databases that were generated for the State Hazard Mitigation Plan. Seek new sources of information.	New sources of earthquake information were implemented in the last update and are incorporated into this update also. This remains an on-going activity.
Identify, document, and advertise all volunteer agency's locations and contact information.	Wyoming VOAD is becoming more energized. The Wyoming Red Cross is spearheading this effort and is in the process of completing a VOAD tool which provides locations, contact information and capability details. This will remain an on-going activity because of turnover and entities entering, leaving, and changing disaster response activities.

State Mitigation Strategies: Expansive Soils

Enhance Wyoming soils mapping to determine extent of expansive soils.	Low priority to map expansive soils.
Research feasibility and costs of adding new frontage roads /detour routes to I-80, I-90, and I-25 to prevent significant delay in traffic flow and resultant economic loss and possible loss of life.	Removed
Provide hazards information to shelters, emergency facilities in public buildings, campgrounds, and phone books.	Medium priority. Information about individual hazards is being provided through different methods including PSAs, flyers, and state-wide exercises. On-going.
Provide emergency phones at strategic locations with direct lines to emergency dispatch services.	Removed
Develop reseeding plans for losses due to all hazard events.	Removed
GIS training for local jurisdictions with emphasis on hazards recognition and analysis for application to mitigation planning.	On-going.
Investigate opportunities for developing or improving warning systems as a means to reduce loss of life, damage to property, and economic losses.	Removed. Not applicable to expansive soils.

Education programs encompassing multi-hazard insurance for business, resident and government application.	Multi-hazard insurance is promoted in the private insurance market, and is typically required by banks holding home or business mortgages. The Wyoming Office of Homeland Security has a staff person devoted to the National Flood Insurance Program. Education is an on-going project.
Planning studies regarding transportation of essential and/or key personnel during all hazard events.	Removed. This is a response planning activity. Reference the State Operations Plan.
Continue outreach to counties on identifying cost effective and feasible mitigation projects.	Ongoing.
Promote Continuity of Operations and Continuity of Government, statewide.	The Wyoming Office of Homeland Security has a staff person devoted to this activity. Wyoming Continuity of Operations and Continuity of Government planning is actively being pursued. This remains an on-going activity.
Maintain and continue to expand hazards databases that were generated for the State Hazard Mitigation Plan. Seek new sources of information.	New sources of earthquake information were implemented in the last update and are incorporated into this update also. Maintenance of hazard database continues through the mitigation plan update process. This remains an on-going activity.
Identify, document, and advertise all volunteer agency's locations and contact information.	Wyoming VOAD is becoming more energized. The Wyoming Red Cross is spearheading this effort and is in the process of completing a VOAD tool which provides locations, contact information and capability details. The Wyoming Department of Health has developed and continues to maintain a volunteer database, which is available to the Wyoming Office of Homeland Security, as we continue to maintain a collaborative working relationship with one another. This will remain an on-going activity because of turnover and entities entering, leaving, and changing disaster response activities.

State Mitigation Strategies - Flood

Continue to encourage and promote participation in NFIP.	On-going activity

Locate septic systems in flood prone areas, and work with local jurisdictions to remedy potential problems.	
Study on flood-proofing government buildings and essential/critical facilities in floodplains.	
Active participation in RiskMAP	On-going activity
Flood hazard and flood insurance education.	On-going activity
Generate and publish summary of Wyoming Department of Transportation hydrologic and flood potential assessments.	
Drainage improvement projects.	On-going activity
Precisely locate structures in existing floodplain, and generate cost estimates for raising or removing structures.	
Early warning stream stage continuous recorders with warning function established throughout state.	
Storm-drain inspection and cleaning program.	Removed. This is a maintenance activity.
Provide all-hazards weather radios to all residences in Wyoming.	On-going activity
Identify and inspect shelters in hazard prone areas.	On-going activity
Research feasibility and costs of adding new frontage roads /detour routes to I-80, I-90, and I-25 to prevent significant delay in traffic flow and resultant economic loss and possible loss of life.	
Provide hazards info to shelters, emergency facilities in public buildings, campgrounds, and phone books.	
Provide emergency phones at strategic locations with direct lines to emergency dispatch services.	Removed. Outdated activity as most travelers utilize cell phones.
Develop reseeding plans for losses due to all hazard events.	Removed. Recovery activity.
GIS training for local jurisdictions with emphasis on hazards recognition and analysis for application to mitigation planning.	
Investigate opportunities for developing or improving warning systems as a means to reduce loss of life, damage to property, and economic losses.	On-going activity
Education programs encompassing multi-hazard insurance for business, resident and government application.	On-going activity
Education programs encompassing multi-hazard mitigation for business, resident and government application.	On-going activity
Planning studies regarding transportation of essential and/or key personnel during all hazard events.	Removed. This is a response activity.
Continue outreach to counties on identifying cost effective and feasible mitigation projects.	On-going activity
Promote Continuity of Operations and Continuity of Government, statewide.	On-going activity. A staff person within the Wyoming Office of Homeland Security has this responsibility.
Maintain and continue to expand hazards databases that were generated for the State Hazard Mitigation Plan. Seek	On-going activity

new sources of information.	
Identify, document, and advertise all volunteer agency's locations and contact information.	On-going activity

Mitigation Strategies - Hail

Education.	
Provide all-hazards weather radios to all residences in Wyoming.	
Identify and inspect shelters in hazard prone areas.	
Research feasibility and costs of adding new frontage roads /detour routes to I-80, I-90, and I-25 to prevent significant delay in traffic flow and resultant economic loss and possible loss of life.	
Provide hazards info to shelters, emergency facilities in public buildings, campgrounds, and phone books.	
Provide emergency phones at strategic locations with direct lines to emergency dispatch services.	
Develop reseeding plans for losses due to all hazard events.	
GIS training for local jurisdictions with emphasis on hazards recognition and analysis for application to mitigation planning.	
Investigate opportunities for developing or improving warning systems as a means to reduce loss of life, damage to property, and economic losses.	
Education programs encompassing multi-hazard insurance for business, resident and government application.	
Planning studies regarding transportation of essential and/or key personnel during all hazard events.	
Continue outreach to counties identifying cost effective and feasible mitigation projects.	
Promote Continuity of Operations and Continuity of Government, statewide.	
Maintain and continue to expand hazards databases that were generated for the State Hazard Mitigation Plan. Seek new sources of information.	
Identify, document, and advertise all volunteer agency's locations and contact information.	

Mitigation Strategies: Landslide

Apply soil stabilization measures to minimize or prevent impacts to roadways	Ongoing activity
Manage development in landslide hazard areas	
Limit activity that strips slopes of top soil in landslide hazard areas	
Stabilize vegetation on steep, publicly-owned slopes	Ongoing activity
Monitor landslide-prone areas (manually & through use of technology)	Ongoing activity
Install catch-fall nets for rocks at steep slopes near roadways	Ongoing activity
Improve set-backs at land-slide prone locations	Ongoing activity

State Mitigation Strategy – Lightning

Lightning Awareness / Education Program- Develop lightning brochure, post warning signage, PSAs, school teaching program	High priority.
Education program encompassing multi-hazard insurance for business, resident and government application	
Warning systems as a means to reduce loss of life, property damage and economic losses	Ongoing activity.
Protect Critical Facilities and Equipment- Surge protection, lightning rods, grounding equipment, etc. on electronic equipment, communications equipment and critical facilities	Ongoing activity.
Subscribe to lightning monitoring system such as Vaisala	Low priority.
Improve GIS mapping of landslide hazard areas	Medium priority.

State Mitigation Strategy- Liquefaction

Improve GIS mapping of areas subject to liquefaction hazard	Low Priority
Harden Critical Infrastructure	
Restrict development in liquefaction-prone areas	

State Mitigation Strategy – Technological & Human-Caused

Encourage hazardous material collection days	
Educate public on storage and disposal of hazardous household items	
State-wide Commodity Flow Study	Existing studies require updating
Establish buffer zones around stationary facilities storing hazardous materials	
Educate public on sheltering in place	
Identify areas most susceptible to release of toxic gas (H2S, CO2), review response plans and evacuation plans, and update as necessary.	
Provide all-hazards weather radios to all residences in Wyoming.	On-going activity

State Mitigation Strategy – Subsidance

Grout mined-out areas in developed communiites	On-going costing approximately $10 million annually
Map mined-out areas	Completed
Abate underground coal mine fires	On-going as needed
Business Contact through the environmental review process	On-going
Remediate new subsidence as it occurs	On-going as needed

State Mitigation Strategy – Avalanche

Develop & distribute education brochures on all hazards-including avalanche	Not started
Take advantage of educational meeting opportunities to discuss avalanche hazards, particularly in avalanche-prone areas	On-going as opportunities arise
Develop Public Service Announcements related to avalanche hazards	On-going as opportunities arise
Continue to support on-going mitigation activities listed above	On-going
Support local efforts to mitigate avalanche impact	

Mitigation Strategy – Space Weather

Monitor solar weather reports	
Develop shut-down procedures to prevent equipment damage	
Educate Public on Space Weather Hazard	

Mitigation Strategy – Tornado

Tornado education	On-going activitiy
Establish tornado shelters, especially in heavily-populated areas	
Determine governmental buildings qualified for tornado shelters	
Enhanced radar coverage	On-going activity
Improve warning systems	On-going activity
Provide all-hazards weather radios to all residents	On-going activity

State Mitigation Strategy – Wildand-Urban Interface Fire

Increase number of firewise communities	
Improve livestock evacuation plans in event of fire	
Fuel load reduction projects	
Encourage Development of Defensible space around Structures and Infrastructure	
Encourage Fire-Resistant Landscaping	
Encourage Fire-Resistand Construction Techniques and Materials	
Retrofit at-Risk Structures with Ignition-Resistant Materials	
Increase Wildfire Risk Awareness	
Educate Property Owners about Wildfire Mitigation Techniques	

State Mitigation Strategy – Wind

Encourage construction methods which include structural strengthing to minimize wind damage	
Protect power lines and other infrastructure	
Retrofit residential, public and critical facilities structures to minimize wind damage	
Increase awareness of high wind risk (education)	

State Mitigation Strategy – Windblown Deposits

Encourage management of development in windblown deposit hazard areas	
Promote site & building design standards to minimize windblown deposit risk	

Locate utilities and critical facilities outside windblown deposit hazard risk areas	
Develop and implement windblown hazard management plan	

State Mitigation Strategy – Winter Storm & Blizzard

Encourage residential & governmental structural retrofit to withstand low temperatures (add insulation) and snow loads	
Protect Power Lines from winter storm impacts through multiple mitigation actions including pole replacement and burying power lines	
Reduce winter storm impacts to roadways, including greater use of living and traditional snow fences	
Increase Public awareness of severe winter storms	
Improve outreach to vulnerable populations	
Encourage public preparations for winter weather, including development of a 3-day kit	
Encourage installation of fire and carbon monoxide monitors and alarms	
Add additional webcams to roadways for better road condition monitoring	
Improve livestock evacuation planning and livestock food stockpiling	

7. Plan Maintenance

7.1 Plan Monitoring, Evaluating and Updating

Requirement §201.4(c)(5)(i): *[The Standard State Plan Maintenance Process **must** include an] established method and schedule for monitoring, evaluating, and updating the plan.*

The plan will be updated and submitted to the Federal Emergency Management Agency (FEMA) as required by 44 CRF 201.4, which currently requires updates every three years from the date of approval. In addition, the plan will be reviewed and updated as appropriate subsequent to a Presidential Disaster Declaration issued for Wyoming. In the interim, major policy or program changes may necessitate revision. The plan is a living document, with revisions expected to be incorporated as circumstances change.

The Wyoming Office of Homeland Security (WOHS) is responsible for plan maintenance and updates based upon plan evaluations conducted by WOHS and the following entities:

- Pertinent Wyoming state government agencies
- Pertinent federal agencies and not-for-profit organizations
- County Homeland Security Coordinators
- Members and representatives of Wyoming cities, towns, and the general public

7.2 Monitoring Mitigation Activity

Requirement §201.4(c)(5)(ii): *[The Standard State Plan Maintenance Process **must** include a] system for monitoring implementation of mitigation measures and project closeouts.*

Requirement §201.4(c)(5)(iii): *[The Standard State Plan Maintenance Process **must** include a] system for reviewing progress on achieving goals as well as activities and projects in the Mitigation Strategy.*

WOHS will post this plan online at the Wyoming Office of Homeland Security's web page, located at http://hls.wyo.gov/index.aspx with a request for comments and reviews to be submitted to WOHS. As a result, monitoring the plan over the three-year planning cycle will commence immediately after FEMA approval of the plan and will run continuously through the next revision due date. Comments received during this period will be incorporated, as appropriate, into the next draft plan revision. Critical and timely comments will be incorporated into the existing plan as soon as possible, after state and FEMA

approval. The draft 2011 plan was also served online in January – February, 2011 in order to initiate the online serving and review process.

The formal plan evaluation will commence approximately one-year preceding the approval anniversary date. The planning process will include pertinent Wyoming state government agencies, federal agencies, not-for-profit organizations, county coordinators, local jurisdictions, and the general public. The draft update of the plan will be completed by WOHS and/or WOHS contractors, and will be based upon the online comments received, information contained in the county multi-hazard plans, and formal evaluations with state/federal/local entities and the general public. The draft update of the plan will also be posted online, with comments incorporated into the final plan.

As part of the evaluation process, the Wyoming Office of Homeland Security will conduct meetings with appropriate state and federal agencies, local jurisdictions, and members of the public as prevously. The following items will be addressed as part of the evaluation:

Consistency with the "Standard State Hazard Mitigation Plan Review Crosswalk" provided by FEMA. Ensure FEMA comments from the previous plan review are incorporated into the new plan.

Ensure risk assessment data is current. New information and maps will be incorporated into hazard profiles as needed. Hazard experts will validate the profiles.

Evaluate state mitigation strategies to include progress on achieving objectives and the status/effectiveness of each of the proposed state mitigation projects.

Ensure proposed mitigation measures address natural hazards having occurred in state since approval of previous plan.

Identify problems (technical, legal, financial, and other), which hinder or otherwise affect implementation of the plan and recommend action steps for resolving these issues.

Recommend necessary revisions to risk assessment, objectives, proposed projects, and rankings, based on collection of new information, and update the plan to reflect major changes in policies, priorities, programs, and funding, as appropriate. Recommendations will include post-disaster hazard mitigation report findings.

Incorporate, as necessary, information obtained from local multi-hazard mitigation plans, approved or unapproved by FEMA, which were submitted to WOHS since the most recent plan update to include documentation of local events, addition of recently collected geographic information systems (GIS) data, changes or additions of proposed mitigation projects, policies, codes, etc.

Coordinate Multi-Hazard Mitigation Plan with other state plans.

Comply with all applicable Federal statutes and regulations in effect with respect to the periods for which the State receives grant funding, in compliance with U.S. Code 13.11(c) and will amend the plan whenever it is necessary to reflect changes in State or Federal laws and statues as required in U.S. Code 13.11(d).

The WOHS will update/revise plan to reflect necessary additions and changes and submit the draft revision to all review and evaluation team members for their review and comments. Team members will re-rank hazards and proposed mitigation projects and measures as necessary.

If substantial or policy changes are made to the plan, the revised plan will be submitted to the key state agencies for review. A final draft of the revised plan will be submitted to FEMA at least 45 days prior to the three-year anniversary date.

After receiving FEMA review comments and any necessary changes are made to the plan, a copy of the revised plan will be placed on the WOHS website. State agencies, participating federal agencies, other planning partners, and the public will be invited to submit comments during a 14-day period. Based on a review of the comments, WOHS will incorporate any needed changes into the plan.

Changes in Plan Monitoring

Looking to the future, the next update is expected to incorporate mitigation strategies resulting from increased and improved communication between the Wyoming Office of Homeland Security, State and Federal governmental agencies, and the 23 counties. It is anticipated communication tools used will include face-to-face, pre-arranged meetings; informal meetings and gatherings; phone calls; and written communications to include informal e-mails and formal letters.

The 2014 update incorporated analysis of two additional hazards, wind and space weather. This exceeds our 2011 goal of incorporating one additional hazard. At the time of this update, no additional hazards are expected to be analyzed in the next update cycle.

Plan Update and Evaluation Methodology

The methodology used to monitor, edit, revise, and evaluate the Wyoming Multi-Hazard Mitigation Plan for the 2011 update was streamlined. During the 2014 update process, greater input from partners was pursued, making the end product more valuable. Input included meetings with partner agencies, local jurisdictions, and county coordinators, and public health officials. One-on-one, face-to-face meetings were held at multiple locations around the state with state and local partners and with the public. Colaboration was pursued and received via phone calls and e-mails. While not all meetings and collaborative efforts are documented because of their ‘spur of the moment’ nature, many of the communications are documented in **Appendix V**.

The process of re-establishing the Wyoming Multi-Hazard Task Force was started at the close of the 2011 update. However, the process was never completed. Currently there is discussion related to establishing a Committee/ Task Force whose responsibilities would include assisting with multiple activities of the

Wyoming Office of Homeland Security, including project selection for multiple grants, including HSGP, HMEP, and HMA grants. Mitigation planning is expected to also be incorporated into their role.

Additional, current collaborative efforts include input through serving the plan on the web site and actively requesting review and input. A contact list for each state, federal, local, and public entity has been established. The list is composed of the chain-of-command for each agency or organization, and typically contains the director, deputy director, and key division heads. Those entities are contacted for key decisions and input, including plan review. This ensures the management team in each agency or organization is current with planning or response activities of Wyoming Office of Homeland Security.