Part 2. RISK ASSESSMENT

7. DAM/CANAL FAILURE

7.1 GENERAL BACKGROUND

7.1.1 Causes of Dam Failure

Dam failures in the United States typically occur in one of four ways:

- Overtopping of the primary dam structure, which accounts for 34 percent of all dam failures, can occur due to inadequate spillway design, settlement of the dam crest, blockage of spillways, and other factors.
- Foundation defects due to differential settlement, slides, slope instability, uplift pressures, and foundation seepage can also cause dam failure. These account for 30 percent of all dam failures.
- Failure due to piping and seepage accounts for 20 percent of all failures. These are caused by internal erosion due to piping and seepage, erosion along hydraulic structures such as spillways, erosion due to animal burrows, and cracks in the dam structure.
- Failure due to problems with conduits and valves, typically caused by the piping of embankment material into conduits through joints or cracks, constitutes 10 percent of all failures.

The remaining 6 percent of dam failures are due to miscellaneous causes. Many are secondary results of other disasters, such as earthquakes, landslides, storms, snowmelt, equipment malfunction, structural damage, and sabotage. The most likely disaster-related causes of dam failure in Ada County are earthquakes, excessive rainfall and landslides. Poor construction, lack of maintenance and repair, and deficient operational procedures are preventable or correctable through regular inspections. Terrorism and vandalism are concerns that all operators of public facilities plan for; these threats are under continuous review by public safety agencies.

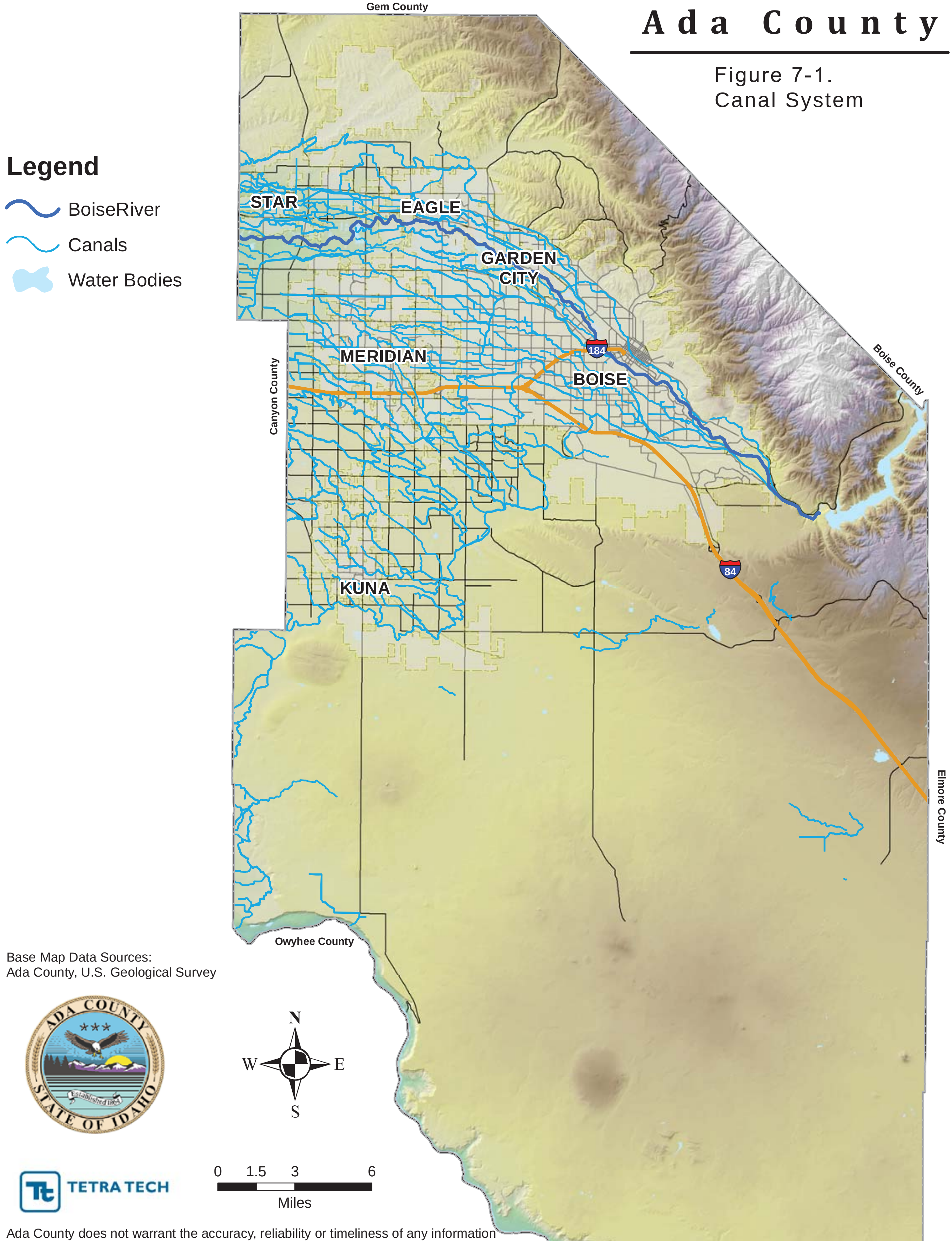
7.1.2 Irrigation Canals

Much of the arid land of Southwest Idaho was developed through reclamation projects of the early 1900s. These projects included dams to collect water and provide flood control and canals to deliver water to agricultural areas. Many canals crisscross the state, but they are not generally perceived as flood hazards. New development has encroached on the canals and the areas around them. Numerous housing developments in Ada County lie below large-capacity canals. This proximity creates risk to life, safety and property. Because of widespread ownership issues (private canals, irrigation districts, etc.) data for canal failure events is not readily obtainable. The Silver Jackets technical advisory group has expressed strong interest in monitoring this issue and the Idaho Office of Emergency Management anticipates further discussions regarding this hazard.

With a water delivery system that includes over 400 miles of canals (see Figure 7-1), Ada County and the Boise area have the highest urban canal density in the United States. These canals are generally well-maintained by their owners/operators because it is their livelihood. However, these facilities can convey flows as high as 2,800 cubic feet per second (cfs), and they have not been evaluated according to engineering standards. The assessment of risk associated with canals is limited in this plan. Canal owners/operators were invited to participate in this plan update process, but chose not to at this time. Future updates should continue to seek participation from these entities to better understand the risk posed by these facilities.

Ada County

Figure 7-1.
Canal System



Base Map Data Sources:
Ada County, U.S. Geological Survey

TETRA TECH

Ada County does not warrant the accuracy, reliability or timeliness of any information on this map, and shall not be held liable for losses caused by using this information.

7.1.3 Regulatory Oversight

The potential for catastrophic flooding due to dam failures led to passage of the National Dam Safety Act (Public Law 92-367), which requires a periodic engineering analysis of every major dam in the country. The goal of this FEMA-monitored effort is to identify and mitigate the risk of dam failure so as to protect the lives and property of the public.

Idaho Department of Water Resources Dam Safety Program

The Dam Safety Program of Idaho's Department of Water Resources monitors dams at the state level. The Department currently regulates nearly 600 water storage dams and more than 20 mine tailings impoundment structures throughout the state. The program regulates dams greater than or equal to 10 feet in height or reservoirs greater than or equal to 50 acre-feet in storage capacity. Each dam inspected by IDWR has a classification for size and risk:

- Large—40 feet high or more or with a storage capacity of more than 4,000 acre feet of water. *104 dams are currently listed as large*.
- Intermediate—More than 20 but less than 40 feet high or with a storage capacity of 100 to 4,000 acre feet of water. *198 dams are currently listed as intermediate*.
- Small—20 feet high or less and a storage capacity of less than 100 acre feet of water. *244 dams are currently listed as small*.

All statutory sized dams must be inspected by the IDWR no less than every five years. The frequency between individual dam inspections depends on such items as the project's physical condition, method of construction, maintenance record, age, hazard rating, and size and storage capacity. Inspection reports prepared by the IDWR for non-federal dams are available through the state office in Boise (Idaho Dam Safety Web Site, 2011).

U.S. Army Corps of Engineers Dam Safety Program

The U.S. Army Corps of Engineers is responsible for safety inspections of some federal and non-federal dams in the United States that meet size and storage limitations specified in the National Dam Safety Act. The Corps has inventoried dams; surveyed each state and federal agency's capabilities, practices and regulations regarding design, construction, operation and maintenance of the dams; and developed guidelines for inspection and evaluation of dam safety (U.S. Army Corps of Engineers, 1997).

Federal Energy Regulatory Commission Dam Safety Program

The Federal Energy Regulatory Commission (FERC) has the largest dam safety program in the United States. The FERC cooperates with a large number of federal and state agencies to ensure and promote dam safety and, more recently, homeland security. There are 3,036 dams that are part of regulated hydroelectric projects are in the FERC program. Two-thirds of these are more than 50 years old. As dams age, concern about their safety and integrity grows, so oversight and regular inspection are important. FERC staff inspects hydroelectric projects on an unscheduled basis to investigate the following:

- Potential dam safety problems
- Complaints about constructing and operating a project
- Safety concerns related to natural disasters
- Issues concerning compliance with the terms and conditions of a license.

Every five years, an independent consulting engineer, approved by the FERC, must inspect and evaluate projects with dams higher than 32.8 feet, or with a total storage capacity of more than 2,000 acre-feet.

FERC staff monitors and evaluates seismic research in geographic areas where there are concerns about seismic activity. This information is applied in investigating and performing structural analyses of hydroelectric projects in these areas. FERC staff also evaluates the effects of potential and actual large floods on the safety of dams. During and following floods, FERC staff visits dams and licensed projects, determines the extent of damage, if any, and directs any necessary studies or remedial measures the licensee must undertake. The FERC publication *Engineering Guidelines for the Evaluation of Hydropower Projects* guides the FERC engineering staff and licensees in evaluating dam safety. The publication is frequently revised to reflect current information and methodologies.

The FERC requires licensees to prepare emergency action plans (EAPs) and conducts training sessions on how to develop and test these plans. The plans outline an early warning system if there is an actual or potential sudden release of water from a dam due to failure. The plans include operational procedures that may be used, such as reducing reservoir levels and reducing downstream flows, as well as procedures for notifying affected residents and agencies responsible for emergency management. These plans are frequently updated and tested to ensure that everyone knows what to do in emergency situations.

U.S. Bureau of Reclamation

The U.S. Bureau of Reclamation's Dam Safety Program was officially implemented in 1978 with passage of the Reclamation Safety of Dams Act, Public Law 95-578. This act was amended in 1984 under Public Law 98-404, in 2000 under Public Law 106-377, in 2002 under Public Law 107-117, and in 2004 under Public Law 108-439 (Reclamation Safety of Dams Act, as amended). Program Development and administration of safety of dams activities is the responsibility of Reclamation's Dam Safety Office located in Denver, Colorado.

Dams must be operated and maintained in a safe manner, ensured through inspections for safety deficiencies, analyses utilizing current technologies and designs, and corrective actions if needed based on current engineering practices. In addition, future evaluations should include assessments of benefits foregone with the loss of a dam. For example, a failed dam can no longer provide needed fish and wildlife benefits.

The primary emphasis of the Safety Evaluation of Existing Dams (SEED) program is to perform site evaluations and to identify potential safety deficiencies on Reclamation and other Interior bureaus' dams. The basic objective is to quickly identify dams which pose an increased threat to the public, and to quickly complete the related analyses in order to expedite corrective action decisions and safeguard the public and associated resources.

The Safety of Dams (SOD) program focuses on evaluating and implementing actions to resolve safety concerns at Reclamation dams. Under this program, Reclamation will complete studies and identify and accomplish needed corrective action on Reclamation dams. The selected course of action relies on assessments of risks and liabilities with environmental and public involvement input to the decision making process.

7.2 HAZARD PROFILE

7.2.1 Past Events

According to the 2013 State of Idaho Hazard Mitigation Plan, the following dam failures have historically occurred within the State Idaho, some of which impacted the planning area:

- **Ridenbaugh Canal Failure, 1973—**On May 26, 1973, a 30-foot wide break in the Ridenbaugh Canal flooded southeast Boise. Waist deep water flooded 15 homes and the Triangle dairy as water flowed from the breach toward the Boise River.
- **Teton Dam Failure, 1976—**On June 5, 1976, Teton Dam in Fremont County failed (see Figure 7-2). An estimated 80 billion gallons of water were released into the Upper Snake River Valley from the reservoir.

Devastating flooding occurred in Wilford, Sugar City, Rexburg, and Roberts; additional significant flooding occurred in Idaho Falls and Blackfoot. At the time of its failure, Teton Dam was brand new, stood 305 feet high, with a crest length of 3,100 feet and a base width of 1,700 feet. The dam was a zoned earth-fill structure with a volume of 10 million cubic yards. The floodwaters threatened American Falls Dam downstream on the Snake River. Dam managers opened the outlet works on American Falls to empty the reservoir and to save American Falls Dam and the string of dams farther down the Snake River.

- **Oakley Dam, 1984—**Oakley Dam nearly overtopped; a canal was constructed to mitigate flooding.
- **Twin Falls County Dam, 1984—**Salmon Falls Creek release caused flooding.
- **Kirby Dam Failure, 1991—**In the summer of 1990, the old log crib structure of the Kirby Dam near Atlanta became unsound and was in jeopardy of failing. The possibility of failure was of special concern due to the large quantity of mine runoff and tailings that had collected behind the dam over the years. A strategy to stabilize the dam developed by the IDWR and the U.S. Forest Service was unsuccessful. On May 26, 1991, Kirby Dam collapsed, cutting off electrical power and blocking the primary access bridge to Atlanta. Sediments containing arsenic, mercury and cadmium were released into the Middle Fork of the Boise River.
- **Brown's Pond Dam, 2010—**Browns Pond Dam overtop and breach during rain on snow event; federal declaration DR-1927.

Figure 7-2. Teton Dam Failure, 1976

7.2.2 Location

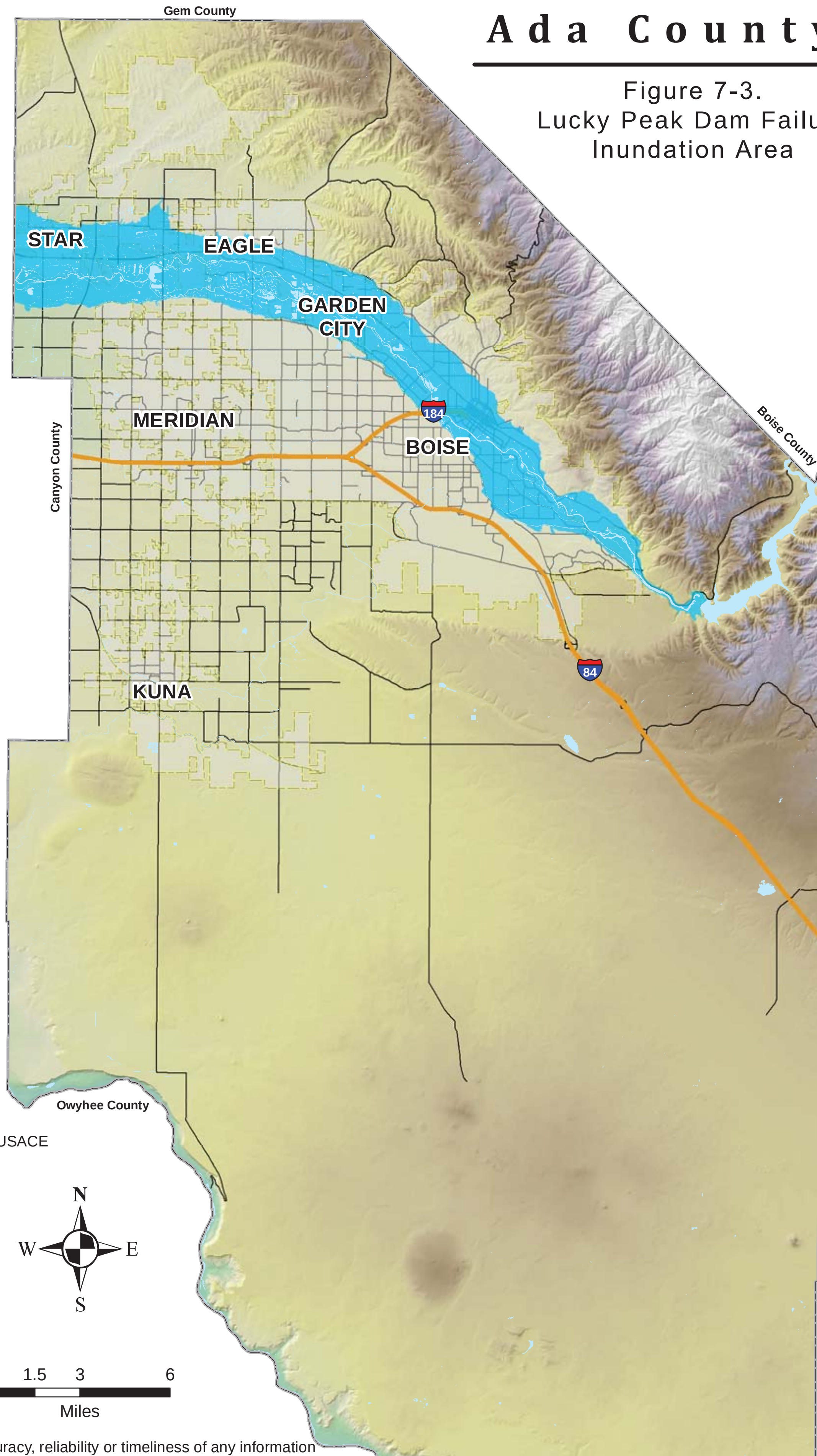
According to Idaho’s Dam Safety Program, there are 26 dams in Ada County that impound approximately 1.319 million acre-feet of water. These dams are listed in Table 7-1. Five are operated by federal agencies, and the rest are under the jurisdiction of the state. Dam failure inundation mapping is not available for every dam in the County. The planning team secured inundation mapping from the Corps of Engineers for the Lucky Peak Reservoir, which is the event most likely to have the largest impact on the planning area. This inundation area is the focus of the risk assessment for the dam failure hazard. It reflects the normal high pool and maximum inundation area associated with dam operations. Figure 7-3 illustrates the Lucky Peak Dam inundation area as used for the risk assessment.

Table 7-1. Dams That Impact Ada County

Name	National ID #	County	Year Built	Dam Type	Purpose	Crest Length (feet)	Height (feet)	Storage Capacity (acre-feet)	Downstream Hazard Potential
Swan Falls	ID00049	Ada	1901	Gravity	Hydro	1187	40	5800	Significant
CJ Strike	ID00054	Elmore	1952	Earth	Hydro	3220	115	250,000	High
Stuart Gulch-Main Fork	ID00480	Ada	1998	Earth	Flood Control	570	76.3	61	High
IDC Effluent Storage	ID00490	Ada	1998	Earth	Irrigation	3125	20	105	Significant
Blacks Creek	ID00208	Ada	1915	Earth	Multi-use	1700	51.5	3640	High
Barber	ID00207	Ada	1906	Timber	Multi-use	1225	3503	180	High
Micron #1	ID00415	Ada	1984	Earth	Multi-use	550	14	155	Low
Micron #2	ID00561	Ada	1991	Earth	Other	1720	12	0	Significant
Micron #3	ID00560	Ada	1997	Earth	Other	1540	13	30	Low
Hubbard	ID00376	Ada	1902	Earth	Irrigation	6000	23	4060	High
Boise Diversion	ID00281	Ada	1908	Gravity	Multi-use	500	56.9	600	High
Arrowrock	ID00280	Elmore	1915	Arch	Multi-use	1150	350	272,224	High
Anderson Ranch	ID00279	Elmore	1950	Earth	Multi-use	1350	456	474,942	High
Lucky Peak	ID00288	Ada	1954	Earth	Multi-use	2340	258	307,000	High
Orchard	ID00206	Ada	1902	Earth	Multi-use	2800	42.8	0	Significant
Terteling	ID00562	Ada	1973	Earth	Multi-use	1770	16.3	20	Low
Hidden Hollow Detention	ID00564	Ada	1997	Earth	Other	375	22.6	20	Low
Cottonwood Cr., Upper	ID00565	Ada	1961	Earth	Flood Control	840	18.1	17	High
Cottonwood Cr., Middle	ID00567	Ada	1961	Earth	Flood Control	1210	23.6	40	High
Cottonwood Cr., Middle	ID00477	Ada	1961	Earth	Flood Control	1710	15.4	88	High
Crane Creek-Main Fork	ID00478	Ada	1998	Earth	Flood Control	204	44	19	Significant
Crane Creek-East Fork	ID00479	Ada	1998	Earth	Flood Control	316	60.4	28	Significant
City of Kuna	ID00688	Ada	2001	Earth	Multi-use	940	18.3	15	Low
High Plains Estates	ID00691	Ada	2005	Erath	Multi-use	340	15.6	19	Significant
Hidden Springs-Cell 1A	ID00699	Ada	2007	Earth	Multi-use	--	26	9.4	Low
Hidden Springs-Cell 3A	ID00695	Ada	2007	Earth	Multi-use	--	42.5	81.3	High

Ada County

Figure 7-3.
Lucky Peak Dam Failure
Inundation Area



Legend

Maximum Pool Inundation Area

Area inundated by dam failure occurring when pool elevation is at the top of the impounding structure.

This map has been compiled using the best information available and is believed to be accurate, however, its preparation required many assumptions. Actual conditions during a failure may vary from those assumed, so the accuracy cannot be guaranteed. The limits of flooding shown and the temporal data should only be used as a guideline for emergency planning and response actions. Actual areas inundated and inundation timing will depend on specific flooding and failure conditions and may differ from the areas shown on the maps.

Base Map Data Sources:
Ada County, U.S. Geological Survey, USACE

ADA COUNTY STATE OF IDAHO

TETRA TECH

N W E S

0 1.5 3 6
Miles

7.2.3 Frequency

Dam failure events are infrequent and usually coincide with events that cause them, such as earthquakes, landslides and excessive rainfall and snowmelt. There is a "residual risk" associated with dams. Residual risk is the risk that remains after safeguards have been implemented. For dams, the residual risk is associated with events beyond those that the facility was designed to withstand. However, the probability of any type of dam failure is low in today's regulatory and dam safety oversight environment.

7.2.4 Severity

The Idaho Dam Safety Program classifies dams and reservoirs in a three-tier hazard rating system based on the potential consequences to downstream life and property that would result from a failure of the dam and sudden release of water (Idaho Dam Safety Web Site, 2011):

- **High Hazard**—A high-hazard means that if failure were to occur, the consequences likely would be a direct loss of human life and extensive property damage. All high-hazard dams must be properly designed and at all times responsibly maintained and operated. IDWR considers the inundation of residential structures with floodwater from a dam break to a depth greater than or equal to 2 feet to be a sufficient reason for assigning a high-hazard rating. An up-to-date EAP is a requirement for all owners of high-hazard dams.
- **Significant Hazard**—Significant hazard dams are those whose failure would result in significant damage to developed downstream property and infrastructure or that may result in an indirect loss of human life. An example would be a scenario where a roadway is washed out and people are killed or injured in an automobile crash caused by the damaged pavement.
- **Low Hazard**—Low hazard dams typically are in sparsely populated areas that would be largely unaffected by a dam breach. Although the dam and its works may be totally destroyed, damage to downstream property would be restricted to undeveloped land with minimal impact on infrastructure.

Table 7-2 shows the Corps of Engineers classification system for the hazard potential of dam failures The Idaho and Corps of Engineers hazard rating systems are both based only on the potential consequences of a dam failure; neither system takes into account the probability of such failures.

Table 7-2. Hazard Potential Classification

Hazard Category[a]	Direct Loss of Life[b]	Lifeline Losses[c]	Property Losses[d]	Environmental Losses[e]
Low	None (rural location, no permanent structures for human habitation)	No disruption of services (cosmetic or rapidly repairable damage)	Private agricultural lands, equipment, and isolated buildings	Minimal incremental damage
Significant	Rural location, only transient or day-use facilities	Disruption of essential facilities and access	Major public and private facilities	Major mitigation required
High	Certain (one or more) extensive residential, commercial, or industrial development	Disruption of essential facilities and access	Extensive public and private facilities	Extensive mitigation cost or impossible to mitigate

a. Categories are assigned to overall projects, not individual structures at a project.
b. Loss of life potential based on inundation mapping of area downstream of the project. Analyses of loss of life potential should take into account the population at risk, time of flood wave travel, and warning time.
c. Indirect threats to life caused by the interruption of lifeline services due to project failure or operational disruption; for example, loss of critical medical facilities or access to them.
d. Damage to project facilities and downstream property and indirect impact due to loss of project services, such as impact due to loss of a dam and navigation pool, or impact due to loss of water or power supply.
e. Environmental impact downstream caused by the incremental flood wave produced by the project failure, beyond what would normally be expected for the magnitude flood event under which the failure occurs.

Source: U.S. Army Corps of Engineers, 1995

7.2.5 Warning Time

Warning time for dam failure varies depending on the cause of the failure. In events of extreme precipitation or massive snowmelt, evacuations can be planned with sufficient time. In the event of a structural failure due to earthquake, there may be no warning time. A dam's structural type also affects warning time. Earthen dams do not tend to fail completely or instantaneously. Once a breach is initiated, discharging water erodes the breach until either the reservoir water is depleted or the breach resists further erosion. Concrete gravity dams also tend to have a partial breach as one or more monolith sections are forced apart by escaping water. The time of breach formation ranges from a few minutes to a few hours (U.S. Army Corps of Engineers, 1997).

ACEM protocols for flood warning and response to imminent dam failure are included in the flood warning portion of the Ada County Flood Response Plan. These protocols are tied to EAPs for each dam.

7.3 SECONDARY HAZARDS

Dam failure can cause severe downstream flooding, depending on the magnitude of the failure. Other potential secondary hazards of dam failure are landslides around the reservoir perimeter, bank erosion on the rivers, and destruction of downstream habitat.

7.4 EXPOSURE

The flood module of Hazus-MH was used for a Level 2 assessment of dam failure. Where possible, the Hazus-MH data was enhanced using GIS data from county, state and federal sources.

7.4.1 Population

All populations in a dam failure inundation zone would be exposed to the risk of a dam failure. The potential for loss of life is affected by the capacity of available evacuation routes. Table 7-3 summarizes the at-risk population in the Lucky Peak Dam inundation area by municipality.

Table 7-3. Population Exposed to Lucky Peak Dam Inundation Area

	Affected Population	% of City Population
Boise	72,927	33.72%
Eagle	10,711	47.60%
Garden City	11,420	100.00%
Kuna	0	0%
Meridian	0	0%
Star	7,146	97.95%
Unincorporated	1,490	2.33%
Total	103,694	24.33%

7.4.2 Property

Table 7-4 summarizes the total area and number of structures in the Lucky Peak Dam inundation area by municipality. About 1.2 percent of the 37,544 structures in the inundation area are in unincorporated areas. About 92 percent are residential. The value of exposed buildings is summarized in Table 7-5. The estimated value of building-and-contents exposed to the Lucky Peak Dam inundation area is $23.5 billion, 28.08 percent of the total assessed value of the planning area.

Table 7-4. Area and Structures Within the Lucky Peak Dam inundation area

	Area in Inundation area (Acres)	Number of Structures in Inundation area							
		Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Boise	12,280.93	24,159	1,699	2	3	60	9	18	25,950
Eagle	6,213.61	3,929	371	1	0	4	4	4	4,313
Garden City	2,717.06	3,383	707	0	0	9	4	1	4,104
Kuna	0	0	0	0	0	0	0	0	0
Meridian	3.58	0	0	0	0	0	0	0	0
Star	2,691.67	2,630	76	0	0	6	3	0	2,715
Unincorporated	9,301.63	438	19	0	1	2	2	0	462
Total	33,208.48	34,539	2,872	3	4	81	22	23	37,544

Table 7-5. Value of Property Exposed to Lucky Peak Dam inundation area

	Value Exposed			% of Total Assessed Value
	Building	Contents	Total	
Boise	$9,277,541,729	$6,363,867,150	$15,641,408,879	34.27%
Eagle	$1,990,884,748	$1,320,169,731	$3,311,054,479	56.52%
Garden City	$1,720,255,340	$1,222,910,251	$2,943,165,591	100.00%
Kuna	$0	$0	$0	0%
Meridian	$0	$0	$0	0%
Star	$745,928,462	$409,705,912	$1,155,634,374	97.70%
Unincorporated	$288,943,954	$197,747,629	$486,691,583	5.25%
Total	$14,023,554,233	$9,514,400,673	$23,537,954,906	28.08%

Table 7-6 shows the existing land use of all parcels in the Lucky Peak Dam inundation area within the unincorporated portion of the Ada County planning area. About 33 percent of the area is zoned for agricultural or open space uses. These are favorable, lower-risk uses for the inundation area. The amount of the inundation area that contains vacant, developable land is not known. This would be valuable information for gauging the future development potential of the inundation area.

Table 7-6. Land Use In Lucky Peak Dam Failure Inundation Area

Land Use	Lucky Peak Dam Failure Inundation Area	
	Acres	% of Total
Agriculture	5,496.00	16.55%
Agriculture Prime Farmland	2,420.90	7.29%
Commercial Retail and Office	2,497.28	7.52%
Industrial	89.66	0.27%
Open Space	3,204.62	9.65%
Other	4,552.88	13.71%
Public/Government	2,596.90	7.82%
Residential	11,094.95	33.41%
Residential TOD Density	767.12	2.31%
Schools	488.17	1.47%
Total	33,208.48	100%

7.4.3 Critical Facilities

GIS analysis determined that 223 of the planning area's critical facilities (53.6 percent) are in the mapped inundation area. Table 7-7 summarizes critical facilities in the inundation area and Table 7-8 summarizes exposed critical infrastructure.

Table 7-7. Critical Facilities in Lucky Peak Dam Failure Inundation Area

	Police & Fire Stations	Emergency Operations Centers	Medical Care	Schools & Educational Facilities	Hazardous Materials Facilities	Dams	Other Essential Facilities	Total
Boise	13	0	2	165	3	0	12	195
Eagle	2	0	1	25	1	0	1	30
Garden City	2	1	0	1	4	0	1	9
Kuna	0	0	0	0	0	0	0	0
Meridian	0	0	0	0	0	0	0	0
Star	3	1	0	1	0	0	2	7
Unincorporated	2	0	0	0	1	3	2	8
Total	22	2	3	192	9	3	18	249

Table 7-8. Critical Infrastructure in Lucky Peak Dam Failure Inundation Area

	Transportation Systems	Communications Facilities	Natural Gas Facilities	Electric Facilities	Potable Water Facilities	Wastewater Facilities	Total
Boise	94	3	0	7	57	3	164
Eagle	6	0	0	1	4	24	35
Garden City	10	1	0	0	19	0	30
Kuna	0	0	0	0	0	0	0
Meridian	0	0	0	0	0	0	0
Star	20	0	0	1	6	1	28
Unincorporated	24	0	0	3	14	0	41
Total	154	4	0	12	100	28	298

7.4.4 Environment

Reservoirs held behind dams affect many ecological aspects of a river. River topography and dynamics depend on a wide range of flows, but rivers below dams often experience long periods of very stable flow conditions or saw-tooth flow patterns caused by releases followed by no releases. Water releases from dams usually contain very little suspended sediment; this can lead to scouring of river beds and banks.

The environment would be exposed to a number of risks in the event of dam failure. The inundation could introduce many foreign elements into local waterways. This could result in destruction of downstream habitat and could have detrimental effects on many species of animals, especially endangered species such as salmon.

7.5 VULNERABILITY

7.5.1 Population

Vulnerable populations are all populations downstream from dam failures that are incapable of escaping the area within the allowable time frame. This population includes the elderly, the young and those who have access and functional needs, who may be unable to get themselves out of the inundation area. The vulnerable population also includes those who would not have adequate warning from a television, cell phone or radio emergency warning system.

7.5.2 Property

Vulnerable properties are those closest to the dam inundation area. These properties would experience the largest, most destructive surge of water. Low-lying areas are also vulnerable since they are where the dam waters would collect. Transportation routes are vulnerable to dam inundation and have the potential to be wiped out, creating isolation issues. This includes all roads, railroads and bridges in the path of the dam inundation. Those that are most vulnerable are those that are already in poor condition and would not be able to withstand a large water surge. Utilities such as overhead power lines, cable and phone lines could also be vulnerable. Loss of these utilities could create additional isolation issues for the inundation areas.

It is estimated that there could be up to $15.4 billion of loss from a dam failure affecting the planning area. This represents 65.1 percent of the total exposure within the inundation area, or 18.31 percent of the total assessed value of the planning area. Table 7-9 summarizes the loss estimates for dam failure.

Table 7-9. Loss Estimates for Dam Failure

	Building Loss	Contents Loss	Total Loss	% of Total Assessed Value
Boise	$5,615,647,357	$4,466,102,109	$10,081,749,465	22.09%
Eagle	$1,179,780,106	$930,510,715	$2,110,290,822	36.03%
Garden City	$1,189,052,559	$982,236,471	$2,171,289,030	73.77%
Kuna	$0	$0	$0	0%
Meridian	$0	$0	$0	0%
Star	$462,750,897	$282,767,826	$745,518,723	63.03%
Unincorporated	$139,655,627	$104,684,853	$244,340,480	2.64%
Total	$8,586,886,546	$6,766,301,974	$15,353,188,520	18.31%

7.5.3 Critical Facilities and Infrastructure

On average, critical facilities would receive 87.4 percent damage to structures and 98.1 percent damage to contents during a Lucky Peak dam failure event. The estimated time to restore these facilities to 100 percent of their functionality is 886 days. For critical infrastructure, the average damage to facilities would be 24.3%. Hazus-MH does not estimate loss of function for critical infrastructure for flood related hazards.

7.5.4 Environment

The environment would be vulnerable to a number of risks in the event of dam failure. The inundation could introduce foreign elements into local waterways, resulting in destruction of downstream habitat and detrimental effects on many species of animals, especially endangered species such as coho salmon. The extent of the vulnerability of the environment is the same as the exposure of the environment.

7.6 DEVELOPMENT TRENDS

The value of planning area properties exposed to the dam failure hazard has increased by 11.6 percent ($9.8 billion) since the last hazard mitigation plan update in 2011. This increase in risk exposure can be attributed to the wide extent of the dam failure hazard, a population growth of 10.7 percent in the same period, and property value increases associated with continued economic recovery from the 2008 economic downturn (see Section 4.5.3).

While dam and canal failures are not generally hazards addressed in comprehensive plans, the risk assessment in this plan creates an opportunity for Ada County and its planning partners to consider the inclusion of dam/canal hazards in their comprehensive plans. The municipal planning partners have established comprehensive policies regarding sound land use in identified flood hazard areas. Most of the areas vulnerable to the greatest impacts from dam failure intersect the mapped flood hazard areas. Flood-related policies in the comprehensive plans will help to reduce the risk associated with the dam failure hazard for all future development in the planning area. Future updates to comprehensive plans in the planning area may provide enhancements to floodplain management policies considering the potential impacts from dam or canal failures.

7.7 SCENARIO

An earthquake in the region could lead to liquefaction of soils around a dam. This could occur without warning during any time of the day. A human-caused failure such as a terrorist attack also could trigger a catastrophic failure of a dam.

While the probability of dam failure is very low, the probability of flooding associated with changes to dam operational parameters in response to climate change is higher. Dam designs and operations are developed based on hydrographs from historical records. If these hydrographs experience significant changes over time due to the impacts of climate change, dam design and operations may no longer be valid for the changed condition. This could have significant impacts on dams that provide flood control. Specified release rates and impound thresholds may have to be changed. This would result in increased discharges downstream of these facilities, increasing the probability and severity of flooding.

7.8 ISSUES

Flooding as a result of a dam or canal failure would significantly impact properties and populations in the inundation zones. There is often limited warning time for such failures. These events are frequently associated with other natural hazard events such as earthquakes, landslides or severe weather, which limits their predictability and compounds the hazard. Important issues associated with dam and canal failure hazards include the following:

- The true level of risk associated with canals in the planning area is not known. The lack of regulatory oversight of these facilities results in a void in the level of available information that can be used to assess risk and vulnerability.
- Owners of canals need to be educated on the benefits of participation in hazard mitigation planning. Their lack of participation in these planning efforts creates a gap in the coverage of these plans.
- Federally regulated dams have an adequate level of oversight and sophistication in the development of EAPs for public notification in the unlikely event of failure. However, the protocol for notification of downstream citizens of imminent failure needs to be tied to local emergency response planning.
- Mapping for federally regulated dams is already required and available; however, mapping for non-federally regulated dams that estimates inundation depths is needed to better assess the risk associated with dam failure from these facilities.
- Most dam failure mapping required at federal levels requires determination of the probable maximum flood. While the probable maximum flood represents a worst-case scenario, it is generally the event with the lowest probability of occurrence. For non-federally regulated dams, mapping of dam failure scenarios that are less extreme than the probable maximum flood but have a higher probability of occurrence can be valuable to emergency managers and community officials downstream of these facilities. This type of mapping can illustrate areas potentially impacted by more frequent events to support emergency response and preparedness.

- The concept of residual risk associated with structural flood control projects should be considered in the design of capital projects and the application of land use regulations.
- Addressing security concerns and the need to inform the public of the risk associated with dam failure is a challenge for public officials.
- A buildable-lands analysis that looks at vacant lands and their designated land use would be a valuable tool in helping decision-makers make wise decisions about future development.

8. DROUGHT

8.1 GENERAL BACKGROUND

Drought is a normal phase in the climactic cycle of most geographical regions. According to the National Drought Mitigation Center, drought “originates from a deficiency of precipitation over an extended period of time, usually a season or more. This deficiency results in a water shortage for some activity, group, or environmental sector.” Drought is the result of a significant decrease in water supply relative to what is “normal” in a given location.

Drought in Idaho is generally associated with a sustained period of low winter snowfall. Such periods result from a temporary change in the large-scale weather patterns in the western U.S. Limited snow packs result in reduced stream flows and groundwater recharge. Idaho’s system of reservoirs and natural storage can buffer the effects of minor events over a few years, but a series of dry winters (or an especially pronounced single low snowfall year) will result in a water shortage. Extended periods of above-average temperatures during spring and summer can increase the impacts of low snow packs.

8.1.1 Drought Definitions

There are four generally accepted operational definitions of drought (National Drought Mitigation Center, 2006):

- **Meteorological drought** is an expression of precipitation’s departure from normal over some period of time. Meteorological measurements are the first indicators of drought. Definitions are usually region-specific, and based on an understanding of regional climatology. A definition of drought developed in one part of the world may not apply to another, given the wide range of meteorological definitions.
- **Agricultural drought** occurs when there isn’t enough soil moisture to meet the needs of a particular crop at a particular time. Agricultural drought happens after meteorological drought but before hydrological drought. Agriculture is usually the first economic sector to be affected by drought.
- **Hydrological drought** refers to deficiencies in surface and subsurface water supplies. It is measured as stream flow and as lake, reservoir, and groundwater levels. There is a time lag between lack of rain and less water in streams, rivers, lakes and reservoirs, so hydrological measurements are not the earliest indicators of drought. After precipitation has been reduced or deficient over an extended period of time, this shortage is reflected in declining surface and subsurface water levels.
- **Socioeconomic drought** occurs when a physical water shortage starts to affect people, individually and collectively. Most socioeconomic definitions of drought associate it with the supply and demand of an economic good.

Water supply is controlled not only by precipitation, but also by other factors, including evaporation (which is increased by higher than normal heat and winds), transpiration (the use of water by plants), and human use.

8.1.2 Monitoring Drought

The National Oceanic and Atmospheric Administration (NOAA) has developed several indices to measure drought impacts and severity and to map their extent and locations:

- The ***Palmer Crop Moisture Index*** measures short-term drought on a weekly scale and is used to quantify drought's impacts on agriculture during the growing season. Figure 8-1 shows this index for the week ending July 2, 2016.
- The ***Palmer Z Index*** measures short-term drought on a monthly scale. Figure 8-2 shows this index for December 2015.
- The ***Palmer Drought Severity Index*** measures the duration and intensity of long-term drought-inducing circulation patterns. Long-term drought is cumulative, so the intensity of drought during a given month is dependent on the current weather patterns plus the cumulative patterns of previous months. Weather patterns can change quickly from a long-term drought pattern to a long-term wet pattern, and the Palmer Drought Index can respond fairly rapidly. Figure 8-3 shows this index for December 2015.
- The hydrological impacts of drought (e.g., reservoir levels, groundwater levels, etc.) take longer to develop and it takes longer to recover from them. The ***Palmer Hydrological Drought Index***, another long-term index, was developed to quantify hydrological effects. The Palmer Hydrological Drought Index responds more slowly to changing conditions than the Palmer Drought Index. Figure 8-4 shows this index for December 2015.
- While the Palmer indices consider precipitation, evapotranspiration and runoff, the ***Standardized Precipitation Index*** considers only precipitation. In the Standardized Precipitation Index, an index of zero indicates the median precipitation amount; the index is negative for drought and positive for wet conditions. The Standardized Precipitation Index is computed for time scales ranging from one month to 24 months. Figure 8-5 shows the 24-month Standardized Precipitation Index map for January 2013 through December 2015.

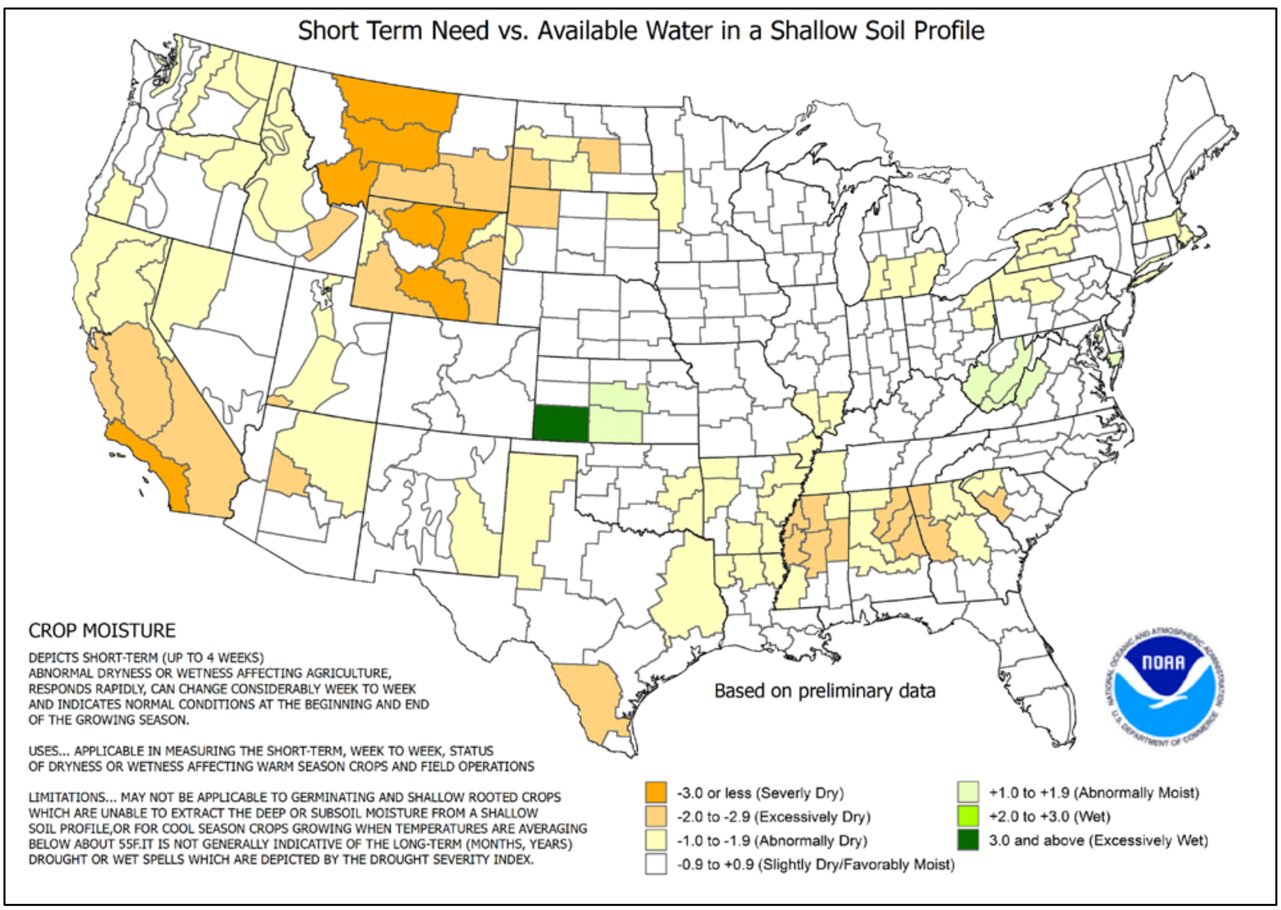


Figure 8-1. Crop Moisture Index for Week Ending July 2, 2016

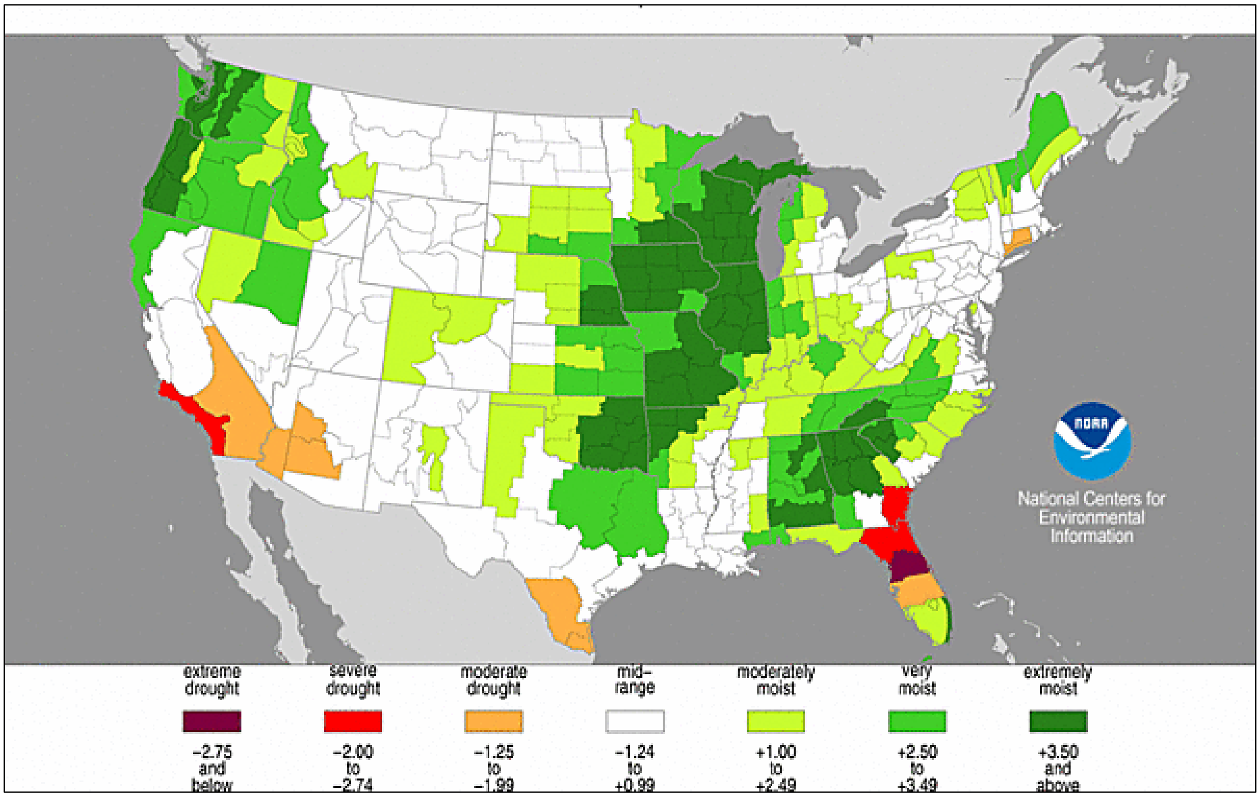


Figure 8-2. Palmer Z Index Short-Term Drought Conditions (December 2015)

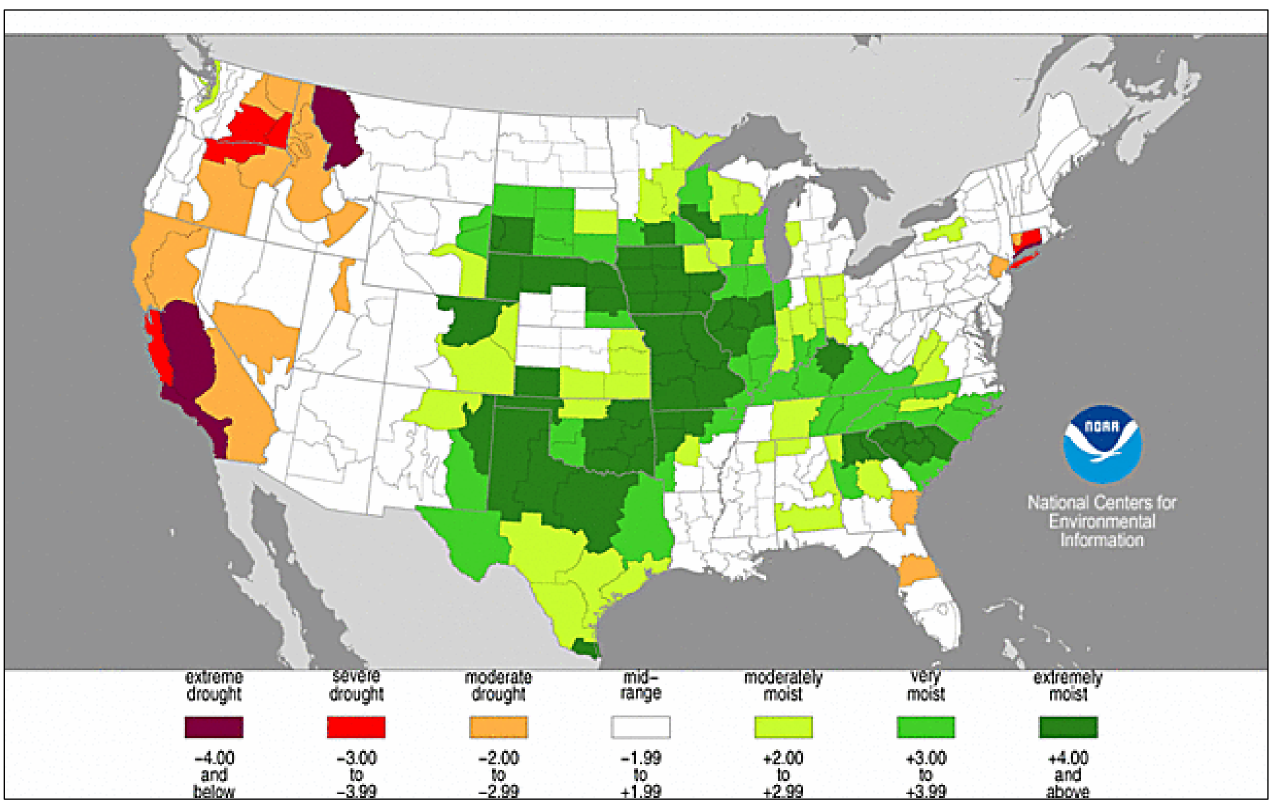


Figure 8-3. Palmer Drought Severity Index (December 2015)

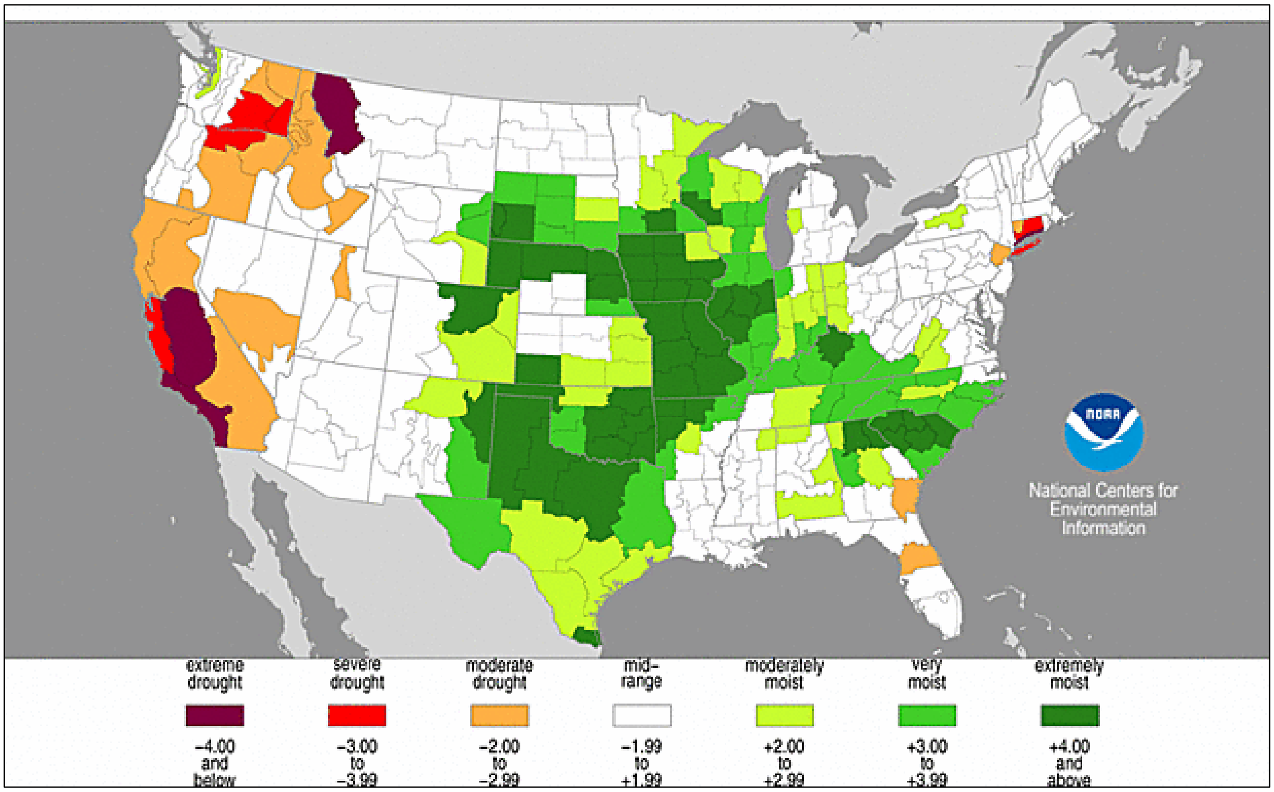


Figure 8-4. Palmer Hydrological Drought Index Long-Term Hydrologic Conditions (December 2015)

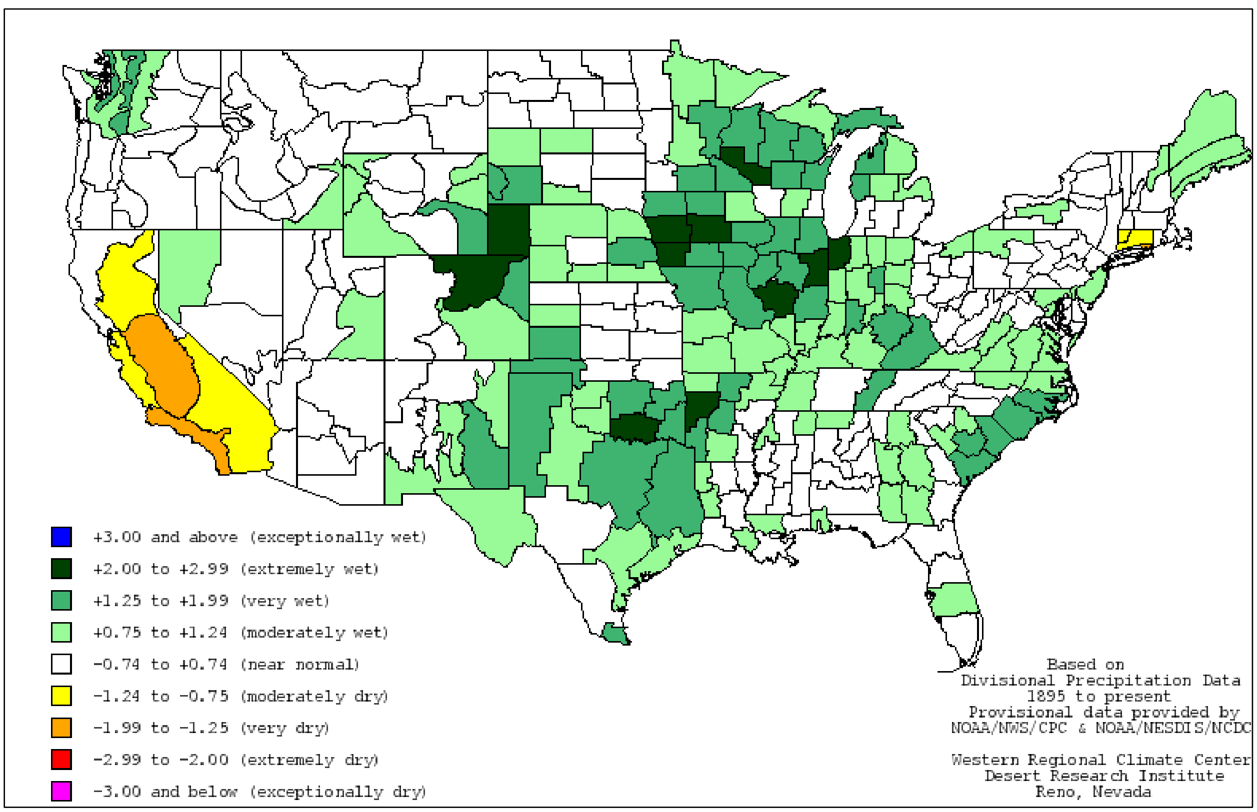


Figure 8-5. 24-Month Standardized Precipitation Index (January 2013 – December 2015)

8.2 HAZARD PROFILE

Droughts originate from a deficiency of precipitation resulting from an unusual weather pattern. If the weather pattern lasts a short time (a few weeks or a couple months), the drought is considered short-term. If the weather pattern becomes entrenched and the precipitation deficits last for several months or years, the drought is considered to be long-term. It is possible for a region to experience a long-term circulation pattern that produces drought, and to have short-term changes in this long-term pattern that result in short-term wet spells. Likewise, it is possible for a long-term wet circulation pattern to be interrupted by short-term weather spells that result in short-term drought.

8.2.1 Past Events

Drought is never the result of a single cause. It is the result of many causes, often synergistic in nature; these include global weather patterns that produce persistent, upper-level high-pressure systems along the West Coast with warm, dry air resulting in less precipitation. Scientists do not know how to predict drought more than a month in advance for most locations. Predicting drought depends on the ability to forecast precipitation and temperature. Anomalies of precipitation and temperature may last from several months to several decades. How long they last depends on interactions between the atmosphere and the oceans, soil moisture and land surface processes, topography, internal dynamics, and the accumulated influence of weather systems on the global scale.

According to the Idaho State Hazard Mitigation Plan, Ada County has been impacted by drought conditions five times since 1977 (see Table 8-1). The most prolonged drought in Idaho was during the 1930s. For most of the state, this drought lasted for 11 years (1929-41) despite greater than average stream flows in 1932 and 1938.

Table 8-1. Historic Droughts in Ada County

Year	State Drought Emergency Declaration	Part of Federal Disaster Declaration?
1988	Unknown	No
1991	Unknown	No
1992	Unknown	No
2001	Yes	No
2005	Yes	No

Of all the statewide drought emergency declarations, only one was also a federal disaster: 1977, the worst single year on record. This event was part of a more widespread water shortage faced by the United States. In Idaho, a lack of winter snowfall resulted in the lowest runoff on record at most gages in the state. Ski resorts were closed for much of the ski season. Irrigation ditches were closed well before the end of the growing season, and crop yields were below normal. Domestic wells in the Big and Little Wood River basins became dry early in April 1977, and many shallow wells in six western Idaho counties became dry in June.

8.2.2 Location

Drought can have the broadest effect of all of Idaho's hazards, sometimes affecting all regions of the state simultaneously. Although deaths and injuries are rarely direct results, drought can have significant impacts on the economic, environmental, and social well-being of the state. Idaho's arid climate predisposes it to periodic drought. Some areas of the state, however, have a greater potential for drought than others. The Idaho Department of Water Resources reports that, based on analyses of historical stream flow records, southeastern Idaho and the upper portions of the Snake River Plain appear to have the highest probability for persistent, severe stream flow deficits.

8.2.3 Severity

The severity of a drought depends on the degree of moisture deficiency, the duration, and the size and location of the affected area. The longer the duration of the drought and the larger the area impacted, the more severe the potential impacts. Droughts are not usually associated with direct impacts on people or property, but they can have significant impacts on agriculture, which can impact people indirectly. When measuring the severity of droughts, analysts typically look at economic impacts on a planning area.

A drought directly or indirectly affects all people and all areas of the state. A drought can result in farmers not being able to plant crops or the failure of the planted crops. This results in loss of work for farm workers and those in related food processing jobs. Other water-dependent industries are commonly forced to shut down all or a portion of their facilities, resulting in further layoffs. A drought can spell disaster for recreational companies that use water (e.g., swimming pools, water parks, and river rafting companies) and for landscape and nursery businesses because people will not invest in new plants if water is not available to sustain them. Also, people could pay more for water if utilities increase their rates.

Strains on global water resources are expected to become greater in the future due to the following stresses:

- Growing populations
- Increased competition for available water
- Poor water quality
- Environmental claims
- Uncertain reserved water rights
- Groundwater overdraft
- Aging urban water infrastructure.

8.2.4 Warning Time

Droughts are climatic patterns that occur over long periods of time. Only generalized warning can take place due to the numerous variables that scientists have not pieced together well enough to make accurate and precise predictions.

8.3 SECONDARY HAZARDS

The secondary hazard most commonly associated with drought is wildfire. A prolonged lack of precipitation dries out vegetation, which becomes increasingly susceptible to ignition as the drought continues.

8.4 EXPOSURE

All people, property and environments in the Ada County planning area would be exposed to some degree to the impacts of moderate to extreme drought conditions.

8.5 VULNERABILITY

Drought produces a complex web of impacts that spans many sectors of the economy and reaches well beyond the area experiencing physical drought. This complexity exists because water is integral to the ability to produce goods and provide services. Drought can affect a wide range of economic, environmental and social activities. The vulnerability of an activity to the effects of drought usually depends on its water demand, how the demand is met, and what water supplies are available to meet the demand.

8.5.1 Population

The planning partnership has the ability to minimize any impacts on residents and water consumers in the county should several consecutive dry years occur. This would be accomplished through proactive water conservation and identification and utilization of alternative water supplies. No significant life or health impacts are anticipated as a result of drought within the planning area.

8.5.2 Property

No structures will be directly affected by drought conditions, though some structures may become vulnerable to wildfires, which are more likely following years of drought. Droughts can also have significant impacts on landscapes, which could cause a financial burden to property owners. However, these impacts are not considered critical in planning for impacts from the drought hazard.

8.5.3 Critical Facilities

Critical facilities as defined for this plan will continue to be operational during a drought. The risk to the critical facilities inventory will be largely aesthetic. For example, when water conservation measures are in place, landscaped areas will not be watered and may die. These aesthetic impacts are not considered significant.

8.5.4 Environment

Environmental losses from drought are associated with damage to plants, animals, wildlife habitat, and air and water quality; forest and range fires; degradation of landscape quality; loss of biodiversity; and soil erosion. Some of the effects are short-term and conditions quickly return to normal following the end of the drought. Other environmental effects linger for some time or may even become permanent. Wildlife habitat, for example, may be degraded through the loss of wetlands, lakes and vegetation. However, many species will eventually recover from this temporary condition. The degradation of landscape quality, including increased soil erosion, may lead to a more permanent loss of biological productivity. Although environmental losses are difficult to quantify, growing public awareness and concern for environmental quality has forced public officials to focus greater attention and resources on these effects.

8.5.5 Economic Impact

Economic impact will be largely associated with industries that use water or depend on water for their business. For example, landscaping businesses were affected in the droughts of the past as the demand for service significantly declined because landscaping was not watered. Agricultural industries will be impacted if water usage is restricted for irrigation.

8.6 DEVELOPMENT TRENDS

Because all of the planning area is exposed to the drought hazard, the increase in exposed population and property since the last hazard mitigation plan update is equal to the countywide trends since then: a 10.7-percent increase in population, a 29.2-percent increase in number of general building stock structures, and an 83.5-percent increase in assessed property value (see Section 4.56.3). However, since droughts typically do not kill or injure people or damage structures, there would be no increase in vulnerability to drought from this increased exposure.

The principal resource impacted by drought conditions is water. The 2007 Ada County comprehensive plan has established goals and policies to preserve and protect groundwater and surface waters. These goals and policies equip the county to deal with the impacts of future droughts on future development.

8.7 SCENARIO

An extreme multiyear drought more intense than the 1977 drought could impact the region. Combinations of low precipitation and unusually high temperatures could occur over several consecutive years. Intensified by such conditions, extreme wildfires could break out throughout Ada County, increasing the need for water. Surrounding communities, also in drought conditions, could increase their demand for water supplies relied upon by the planning partnership, causing social and political conflicts. If such conditions persisted for several years, the economy of Ada County could experience setbacks, especially in water dependent industries.

8.8 ISSUES

The planning team has identified the following drought-related issues:

- Identification and development of alternative water supplies
- Utilization of groundwater recharge techniques to stabilize the groundwater supply
- The probability of increased drought frequencies and durations due to climate change
- The promotion of active water conservation even during non-drought periods.
- Public education on water conservation.

9. EARTHQUAKE

9.1 GENERAL BACKGROUND

9.1.1 How Earthquakes Happen

An earthquake is the vibration of the earth's surface that follows a release of energy in the earth's crust. This energy can be generated by a sudden dislocation of segments of the crust or by a volcanic eruption. Most destructive quakes are caused by dislocations of the crust. The crust may first bend and then, when the stress exceeds the strength of the rocks, break and snap to a new position. In the process of breaking, vibrations called "seismic waves" are generated. These waves travel outward from the source of the earthquake along the surface and through the earth at varying speeds, depending on the material through which they move. Earthquakes tend to occur along faults, which are zones of weakness in the earth's crust. Even if a fault zone has recently experienced an earthquake, there is no guarantee that all the stress has been relieved. Another earthquake could still occur. In fact, relieving stress along one part of a fault may increase stress in another part.

Horizontal Extension

Most earthquakes occur at the boundaries of Earth's tectonic plates. Idaho is not on a plate boundary, but many faults in the state have produced large earthquakes. Tectonic forces in the western part of the North American plate combine with high heat from the underlying mantel to stretch the crust in a northeast-southwest direction. In response to this stretching, the rigid crust breaks and shifts along faults, and the fault movement produces earthquakes. Stretching, or horizontal extension, of the crust produces a type of dipping fault called a "normal" fault (Figure 9-1). The movement of normal faults is characterized by the crust above the fault plane moving down relative to the crust below the fault plane. This up/down movement differs from movement on strike-slip faults like the San Andreas Fault in California, where the crust on one side of the fault slides horizontally past the crust on the other side. Earthquakes in Idaho can be generated by movement on a variety of types of faults, but the faults that are considered capable of generating large surface-faulting earthquakes are mainly normal faults.

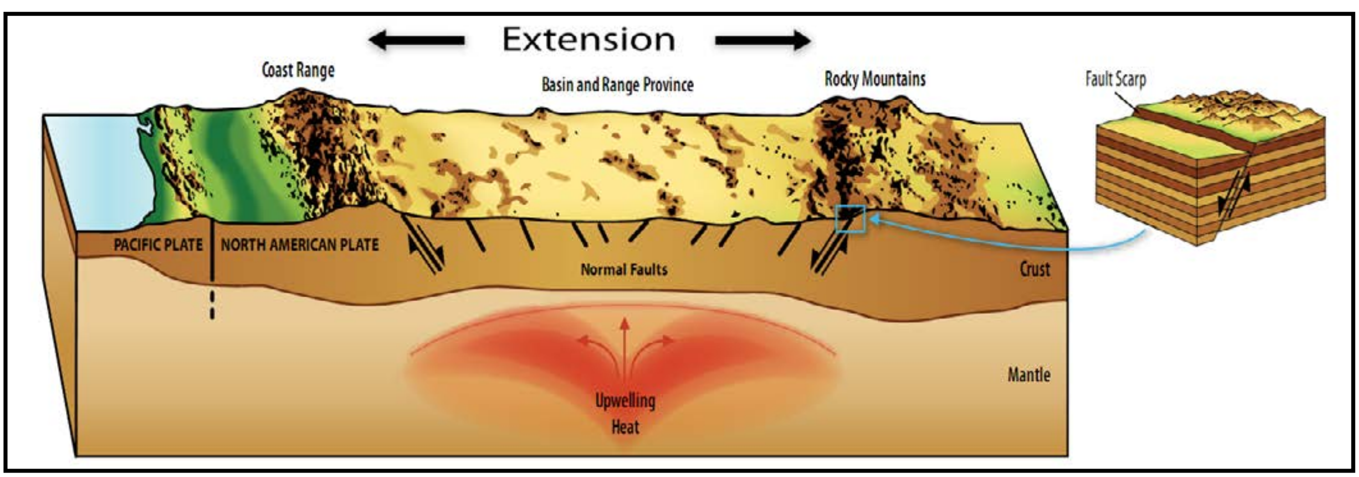


Figure 9-1. Horizontal Extension Creates Normal Faults

Seismic Conditions in Idaho

Most earthquakes in Idaho occur along a belt of seismicity called the Intermountain Seismic Belt that extends from the northwest corner of Montana, along the Idaho-Wyoming border, through Utah, and into southern Nevada. Along most of its length, the Intermountain Seismic Belt straddles the boundary between the Basin and Range Province to the west and more stable parts of North America to the east.

The eastern Snake River Plain formed as the North American continent passed over a “hotspot” of hot rock rising from the earth’s mantle. This plume is called the “Yellowstone hotspot” because it is presently located in the Yellowstone National Park area. Beginning along the Oregon-Nevada-Idaho border about 14.5 million years ago and continuing as recently as 600,000 years ago in Yellowstone, the hotspot melted crustal rocks passing over it, creating huge volumes of magma that erupted to form explosive calderas. These calderas are progressively younger to the northeast because of the continuous movement of the North American continent over the hotspot.

In an area around the eastern Snake River Plain, the Yellowstone hotspot has interacted with the Basin and Range Province to create a pattern of earthquakes and mountain building called the Yellowstone Tectonic Parabola Figure 9-2). A major branch of the Intermountain Seismic Belt extends from the Yellowstone area westward across central Idaho. This zone includes at least eight major active faults and has been the site of numerous earthquake swarms and seismic events, including the two largest historic earthquakes in the Intermountain West.

The pattern of earthquake activity in eastern and central Idaho seems to be related to interactions between the Yellowstone hotspot and the Basin and Range Province to the west. Geologists divide the region into five tectonic belts based on historical earthquake activity and the age and amount of movement on prehistoric faults. Within the Snake River Plain, earthquake activity is very low. Earthquake activity increases and faults become younger away from the Plain, culminating in a band of active faults that forms the tectonic parabola on the east.

9.1.2 Earthquake Classifications

Earthquakes are classified according to the amount of energy released as measured by magnitude or intensity scales. Currently the most commonly used scales are the moment magnitude (Mw) scale, and the modified Mercalli intensity scale. Estimates of moment magnitude roughly match the local magnitude scale commonly called the Richter scale.

One advantage of the moment magnitude scale is that, unlike other magnitude scales, it does not saturate at the upper end. That is, there is no value beyond which all large earthquakes have about the same magnitude. For this reason, moment magnitude is now the most often used estimate of large earthquake magnitudes. Table 9-1 presents a classification of earthquakes according to their magnitude. Table 9-2 compares the moment magnitude scale to the modified Mercalli intensity scale.

9.1.3 Ground Motion

Earthquake hazard assessment is also based on expected ground motion. This involves determining the annual probability that certain ground motion accelerations will be exceeded, then summing the annual probabilities over the time period of interest. The most commonly mapped ground motion parameters are the horizontal and vertical peak ground accelerations (PGA) for a given soil or rock type. Instruments called accelerographs record levels of ground motion due to earthquakes at stations throughout a region. These readings are recorded by state and federal agencies that monitor and predict seismic activity.

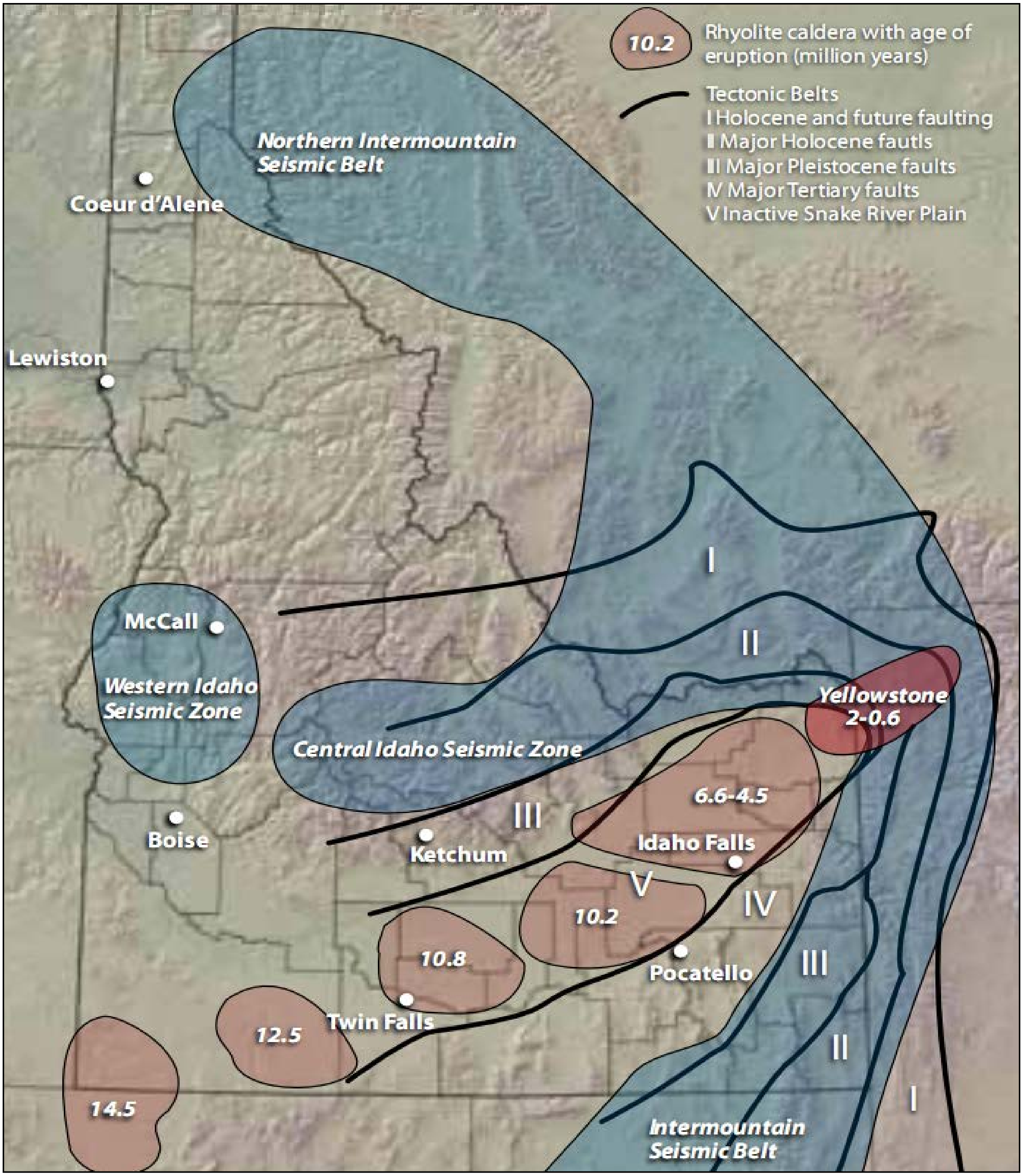


Figure 9-2. Volcanic and Tectonic Features of the Yellowstone-Snake River Plain System

Table 9-1. Earthquake Magnitude Classes

Magnitude Class	Magnitude Range (M = magnitude)
Great	M > 8
Major	7 <= M < 7.9
Strong	6 <= M < 6.9
Moderate	5 <= M < 5.9
Light	4 <= M < 4.9
Minor	3 <= M < 3.9
Micro	M < 3

Table 9-2. Earthquake Magnitude and Intensity

Magnitude (Mw)	Intensity (Modified Mercalli)	Description
1.0—3.0	I	I. Not felt except by a very few under especially favorable conditions
3.0—3.9	II—III	II. Felt only by a few persons at rest, especially on upper floors of buildings. III. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it is an earthquake. Standing cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
4.0—4.9	IV—V	IV. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like a heavy truck striking building. Standing cars rocked noticeably.
5.0—5.9	VI—VII	VI. Felt by all; many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight. VII. Damage negligible in buildings of good design and construction; slight in well-built ordinary structures; considerable in poorly built or badly designed structures. Some chimneys broken.
6.0—6.9	VII—IX	VIII. Damage slight in specially designed structures; considerable damage in ordinary buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
7.0 and higher	VIII and higher	X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent. XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly. XII. Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Maps of PGA values form the basis of seismic zone maps that are included in building codes such as the International Building Code. Building codes that include seismic provisions specify the horizontal force due to lateral acceleration that a building should be able to withstand during an earthquake. PGA values are directly related to these lateral forces that could damage "short period structures" (e.g. single-family dwellings). Longer period response components determine the lateral forces that damage larger structures with longer natural periods (apartment buildings, factories, high-rises, bridges). Table 9-3 lists damage potential by PGA factors compared to the Mercalli scale.

Table 9-3. Mercalli Scale and Peak Ground Acceleration Comparison

Mercalli Scale	Potential Damage	Estimated PGA
I	None	0.017
II-III	None	0.017
IV	None	0.014-0.039
V	Very Light	0.039-0.092
VI	None to Slight; USGS-Light	0.02-0.05
	Unreinforced Masonry-Stair Step Cracks; Damage to Chimneys; Threshold of Damage	0.04-0.18
VII	Slight-Moderate; USGS-Moderate	0.05-0.10
	Unreinforced Masonry-Significant; Cracking of parapets	0.08-0.16
	Masonry may fail; Threshold of Structural Damage	0.10-0.34
VIII	Moderate-Extensive; USGS: Moderate-Heavy	0.10-0.20
	Unreinforced Masonry-Extensive Cracking; fall of parapets and gable ends	0.16-0.65
IX	Extensive-Complete; USGS-Heavy	0.20-0.50
	Structural collapse of some un-reinforced masonry buildings; walls out of plane. Damage to seismically designed structures	0.32-1.24
X	Complete ground failures; USGS- Very Heavy (X+); Structural collapse of most un-reinforced masonry buildings; notable damage to seismically designed structures; ground failure	0.50-1.00

9.1.4 Effect of Soil Types

The impact of an earthquake on structures and infrastructure is largely a function of ground shaking, distance from the source of the quake, and liquefaction, a secondary effect of an earthquake in which soils lose their shear strength and flow or behave as liquid, thereby damaging structures that derive their support from the soil. Liquefaction generally occurs in soft, unconsolidated sedimentary soils. A program called the National Earthquake Hazard Reduction Program (NEHRP) creates maps based on soil characteristics to help identify locations subject to liquefaction. Table 9-4 summarizes NEHRP soil classifications.

Table 9-4. NEHRP Soil Classification System

NEHRP Soil Type	Description	Mean Shear Velocity to 30 meters (m/s)
A	Hard Rock	1,500
B	Firm to Hard Rock	760-1,500
C	Dense Soil/Soft Rock	360-760
D	Stiff Soil	180-360
E	Soft Clays	< 180
F	Special Study Soils (liquefiable soils, sensitive clays, organic soils, soft clays >36 meters thick)	

NEHRP Soils B and C typically can sustain ground shaking without much effect, dependent on the earthquake magnitude. The areas that are commonly most affected by ground shaking have NEHRP Soils D, E and F. In general, these areas are also most susceptible to liquefaction.

9.2 HAZARD PROFILE

The actual movement of the ground in an earthquake is seldom the direct cause of injury or death. Casualties generally result from falling objects and debris as the shocks shake buildings and other structures. Disruption of communications, electrical power supplies and gas, sewer and water lines should be expected. Earthquakes may trigger fires, dam failures, landslides or releases of hazardous material, compounding their disastrous effects.

Small, local faults produce lower magnitude quakes, but ground shaking can be strong and damage can be significant in areas close to the fault. In contrast, large regional faults can generate earthquakes of great magnitudes but, because of their distance and depth, they may result in only moderate shaking in an area.

9.2.1 Past Events

The historical record demonstrates that earthquakes can occur throughout Idaho. Most earthquakes felt by Idaho residents have occurred within the Yellowstone Tectonic Parabola. Notable exceptions include large earthquakes in northern Nevada, eastern Washington and western Montana. The 2008 magnitude-6.0 Wells, Nevada earthquake was felt by thousands in Boise, Twin Falls and Pocatello. Because large earthquakes are felt over hundreds of miles, the locations of some early events not recorded by seismographs are uncertain. Table 9-5 lists past seismic events felt in Idaho.

9.2.2 Location

Ada County is situated near two fault zones: the western Idaho fault system and Owyhee Mountains fault system. The Squaw Creek, Big Flat and Jake Creek faults are active structures near Emmett, about 25 miles north of Boise. The most important of these, the Squaw Creek fault, has geologic evidence for movement as recently as 7,600 years ago. About 57 miles southeast of Boise and 13 miles from Grand View is the Water Tank fault. Recently discovered in 1997, this fault was active as recently as 3,000 years ago. Other faults present in and around Ada County do not appear to be active.

The impact of an earthquake is largely a function of the following components:

- Ground shaking (ground motion accelerations)
- Liquefaction (soil instability)
- Distance from the source (both horizontally and vertically).

Mapping that shows the impacts of these components was used to assess the risk of earthquakes in the planning area. The mapping used in this assessment is described below.

Shake Maps

A shake map is a representation of ground shaking produced by an earthquake. The information it presents is different from the earthquake magnitude and epicenter that are released after an earthquake because shake maps focus on the ground shaking resulting from the earthquake, rather than the parameters describing the earthquake source. An earthquake has only one magnitude and one epicenter, but it produces a range of ground shaking at sites throughout the region, depending on the distance from the earthquake, the rock and soil conditions at sites, and variations in the propagation of seismic waves from the earthquake. A shake map shows the extent and variation of ground shaking in a region immediately following significant earthquakes. Maps are derived from peak ground motion amplitudes recorded on accelerometers, with interpolation where data are lacking. Color-coded instrumental intensity maps are derived from empirical relations between peak ground motions and Modified Mercalli intensity.

Table 9-5. Historical Earthquakes Strongly Felt in Idaho

Year	Magnitude	Location	Description
1872	7.4	Lake Chelan, WA	Largest quake in Washington State; felt strongly in north Idaho.
1884	6.0	Bear Lake Valley	The earthquake damaged houses considerably in Paris, Idaho.
1905	6.0	SW Idaho or NE NV	Considerable damage at Shoshone, Idaho.
1913	5.0	Adams County	Broke windows and dishes.
1914	6.0	UT-ID State Line	Intensity VII; between Ogden, Utah and Montpelier, Idaho.
1915	7.75	Pleasant valley, NV	Considerable damage in southwest Idaho a hundred miles from epicenter.
1916	6.0	North of Boise	Boise residents rushed into the street; chimneys fell.
1918	5.0	North Idaho	Widely felt near Sandpoint.
1925	6.6	SW Montana	Felt throughout Idaho.
1926	4.0	North Idaho	Felt at Avery and Wallace.
1927	5.0	Connor Creek	On Idaho-Oregon border west of Cascade.
1934	6.6	Hansel valley, UT	Largest Utah event on record; 20 miles south of Idaho border. 2 fatalities.
1935	6.25	Helena, MT	Extensive damage. Multiple large events throughout Idaho. 4 fatalities.
1936	6.4	Walla Walla, WA	Damaging earthquake; widely felt in Idaho.
1942	5.0	Sandpoint area	Cracked plaster; rock fall onto railroad tracks.
1944	6.0	Central Idaho	Knocked people to ground in Custer County.
1944	4.0	Lewiston area	Widely felt in northern Idaho.
1945	6.0	Central Idaho	Epicenter near Clayton. Slight damage in Idaho City and Weiser.
1947	6.25	Southwest Montana	Epicenter in Gravelly range, 10 miles north of Idaho border.
1947	5.0	Central Idaho	Several large cracks formed in a well-constructed brick building.
1959	7.3	Hebgen Lake, MT	Major event, extensive fault scarps. 20 miles from Idaho. 29 fatalities.
1960	5.0	Soda Springs	Foundations and plaster cracked.
1962	5.7	Cache Valley	Heavily damaged older buildings.
1963	5.0	Clayton	Plaster cracked and windows broken.
1969	5.0	Ketchum	Cement floors cracked.
1975	6.1	NW Yellowstone	Widely felt in Yellowstone region.
1975	6.1	Pocatello Valley	Some 520 homes damaged in Ridgedale and Malad City.
1977	4.5	Cascade	Drywall, foundations cracked. Ceiling beams separated.
1978	4.0	Flathead lake, MT	Felt in northwest Idaho.
1983	6.9	Borah Peak	Major event, 21 mile surface scarp, 11 buildings destroyed, 2 fatalities.
1984	5.0	Challis	Largest of many Borah Peak aftershocks.
1988	4.1	Cooper Pass	Montana border northeast of Mullan.
1994	5.9	Draney Peak	Remote area on Wyoming border. One injury from falling flower pot.
1994	3.5	Avery area	Rare north Idaho event centered near Hoyt Mountain.
1999	5.3	Lima, MT	In Red Rock valley just north of Idaho border.
2001	4.0	Spokane, WA	At least 75 felt events at shallow depth beneath the city.
2005	5.6	Dillon, MT	Felt across Idaho.
2005	4.0	Alpha Swarm	Four Magnitude-4 events, thousands of smaller tremors south of Cascade.
2008	6.0	Wells, NV	Felt strongly throughout southern Idaho.

Two types of shake map are typically generated:

- A **probabilistic seismic hazard map** shows the hazard from earthquakes that geologists and seismologists agree could occur. The maps are expressed in terms of probability of exceeding a certain ground motion, such as the 10-percent probability of exceedance in 50 years. This level of ground shaking has been used for designing buildings in high seismic areas. Figure 9-3 and Figure 9-4 show the estimated ground motion for the 100-year and 500-year probabilistic earthquakes in Ada County.
- Earthquake scenario maps describe the expected ground motions and effects of hypothetical large earthquakes for a region. Maps of these scenarios can be used to support all phases of emergency management. The scenario chosen for this plan is a Magnitude 7.0 event on the Squaw Creek fault (see Figure 9-5).

NEHRP Soil Maps

NEHRP soil types define locations that will be significantly impacted by an earthquake. This is a key component to assessing seismic risk. NEHRP soils data is available for the Ada County planning area, but it is not a countywide data set. Figure 9-6 shows the available NEHRP soil classification for the planning area.

Liquefaction Maps

Soil liquefaction maps are useful tools to assess potential damage from earthquakes. When the ground liquefies, sandy or silty materials saturated with water behave like a liquid, causing pipes to leak, roads and airport runways to buckle, and building foundations to be damaged. In general, areas with NEHRP Soils D, E and F are also susceptible to liquefaction. If there is a dry soil crust, excess water will sometimes come to the surface through cracks in the confining layer, bringing liquefied sand with it, creating sand boils. This is a vital need for assessing seismic risk within the planning area. Liquefaction maps are available for the planning area, but they are not countywide. This data tracks with where NEHRP soils data is available. Available liquefaction mapping is shown in Figure 9-7.

9.2.3 Frequency

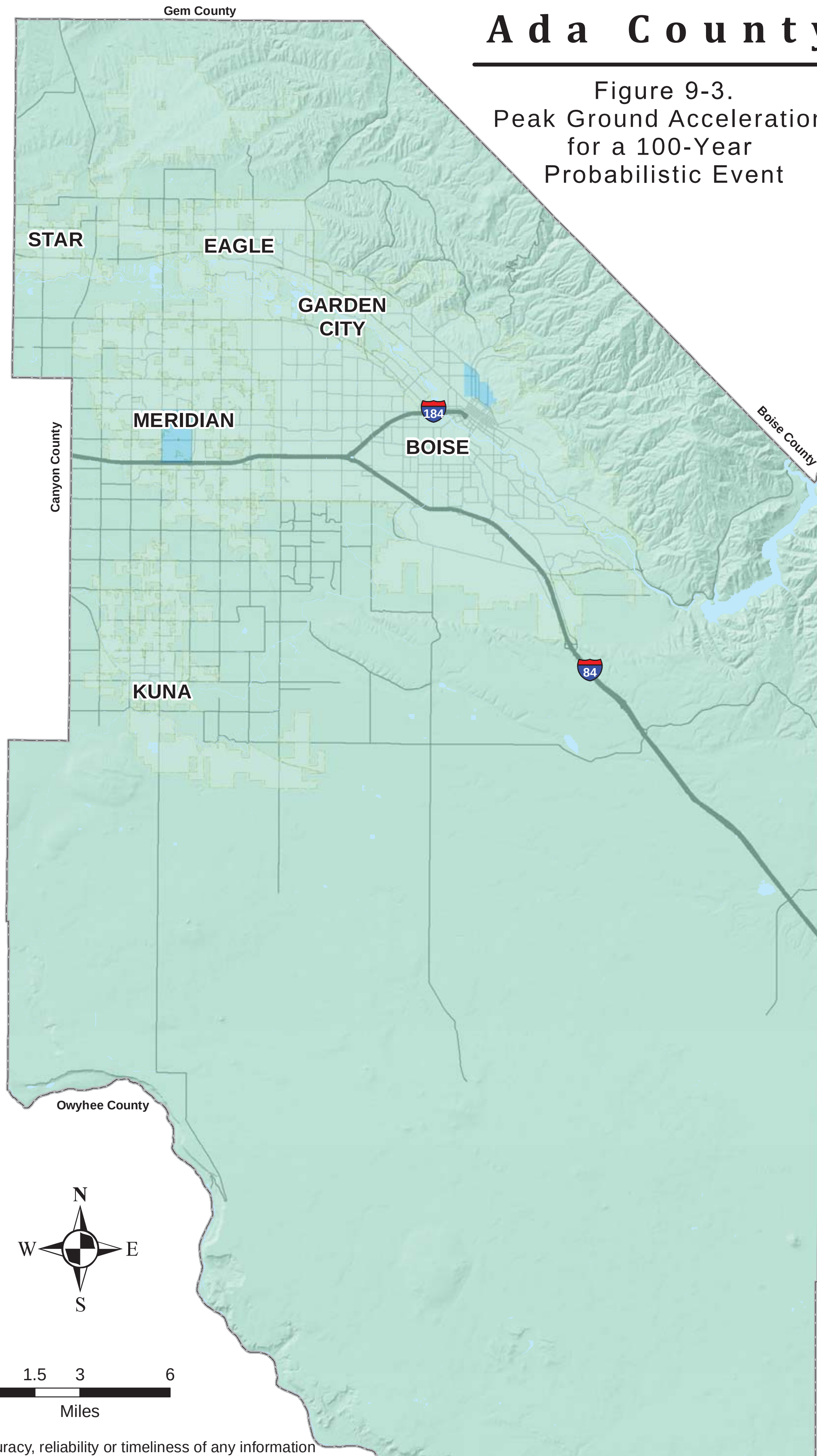
Hundreds of earthquakes have been recorded in Idaho. Table 9-6 summarizes statistics from 1973 to 2009. The 1,225 events in that period represent an average of 33 per year. This average includes the many aftershocks that occur after large earthquakes. For example, there were 22 earthquakes in 1981-82, the year before the 1983 Borah Peak event. Aftershocks raised the yearly total to 87 in 1983-84 and 161 in 1984-85. The number of small earthquakes (magnitude less than 3) is greatly under-reported in Idaho because of limited seismic monitoring.

Table 9-6. Idaho Earthquake Statistics 1973-2009

	Number of events
Magnitude 1-2	2
Magnitude 2-3	380
Magnitude 3-4	739
Magnitude 4-5	83
Magnitude 5-6	5
Magnitude 6-7	2
Total	1,225

Ada County

Figure 9-3. Peak Ground Acceleration for a 100-Year Probabilistic Event



Legend

Modified Mercalli Scale, Potential Shaking

- I (Not Felt)
- II-III (Weak)
- IV (Light)
- V (Moderate)
- VI (Strong)
- VII (Very Strong)
- VIII (Severe)
- IX (Violent)
- X+ (Extreme)

Probabilistic Peak Ground Acceleration data generated by Hazus-MH 2.2. In Hazus' probabilistic analysis procedure, the ground shaking demand is characterized by spectral contour maps developed by the United States Geological Survey (USGS) as part of a 2008 update of the National Seismic Hazard Maps.

USGS probabilistic seismic hazard maps are revised about every six years to reflect newly published or thoroughly reviewed earthquake science and to keep pace with regular updates of the building code.

Hazus includes maps for eight probabilistic hazard levels: ranging from ground shaking with a 39% probability of being exceeded in 50 years (100 year return period) to the ground shaking with a 2% probability of being exceeded in 50 years (2500 year return period).

Base Map Data Sources:
Ada County, U.S. Geological Survey

ADA COUNTY STATE OF IDAHO Established 1864

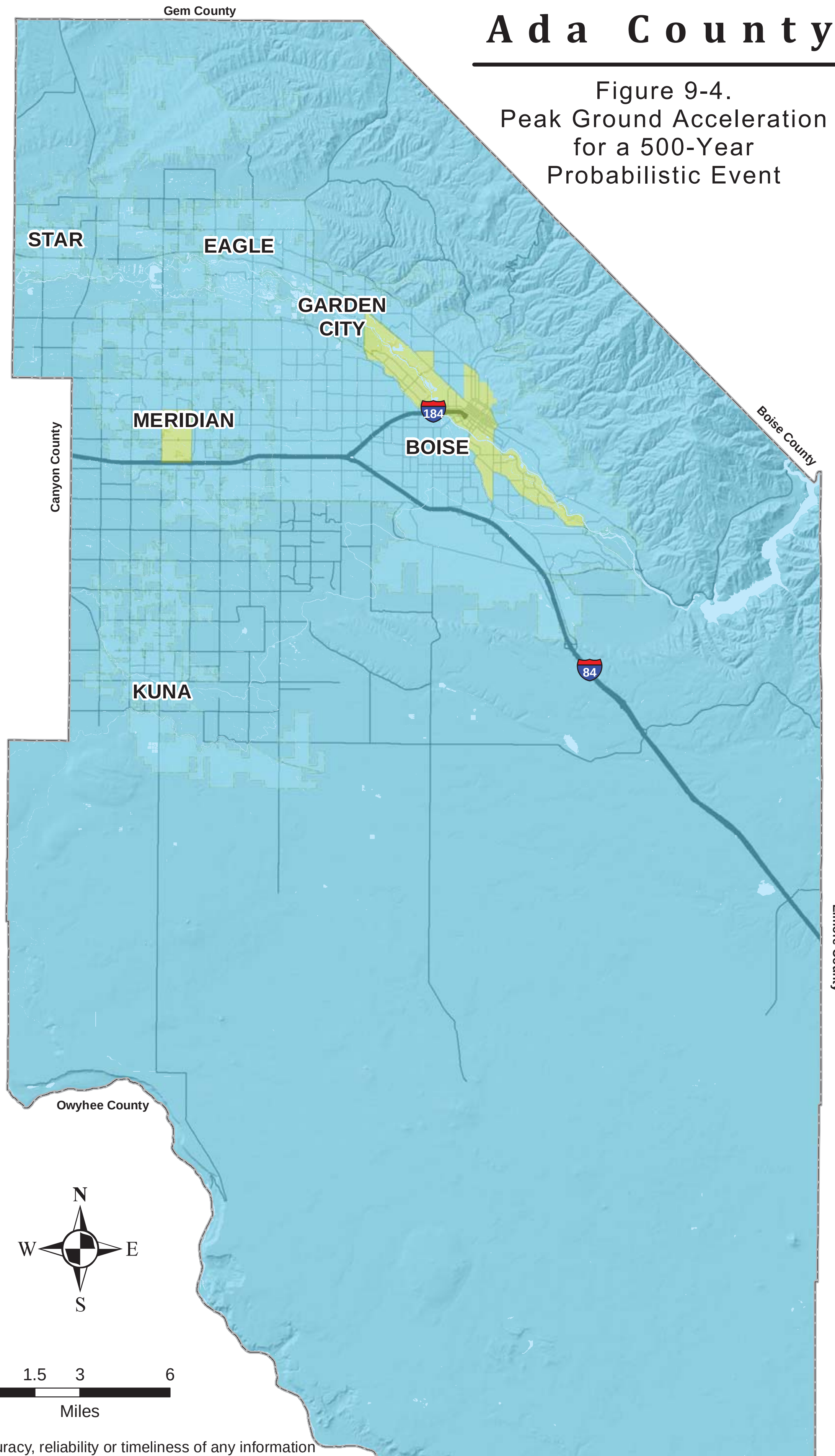
TETRA TECH

N W E S

0 1.5 3 6
Miles

Ada County

Figure 9-4.
Peak Ground Acceleration for a 500-Year Probabilistic Event



Legend

Modified Mercalli Scale, Potential Shaking

- I (Not Felt)
- II-III (Weak)
- IV (Light)
- V (Moderate)
- VI (Strong)
- VII (Very Strong)
- VIII (Severe)
- IX (Violent)
- X+ (Extreme)

Probabilistic Peak Ground Acceleration data generated by Hazus-MH 2.2. In Hazus' probabilistic analysis procedure, the ground shaking demand is characterized by spectral contour maps developed by the United States Geological Survey (USGS) as part of a 2008 update of the National Seismic Hazard Maps.

USGS probabilistic seismic hazard maps are revised about every six years to reflect newly published or thoroughly reviewed earthquake science and to keep pace with regular updates of the building code.

Hazus includes maps for eight probabilistic hazard levels: ranging from ground shaking with a 39% probability of being exceeded in 50 years (100 year return period) to the ground shaking with a 2% probability of being exceeded in 50 years (2500 year return period).

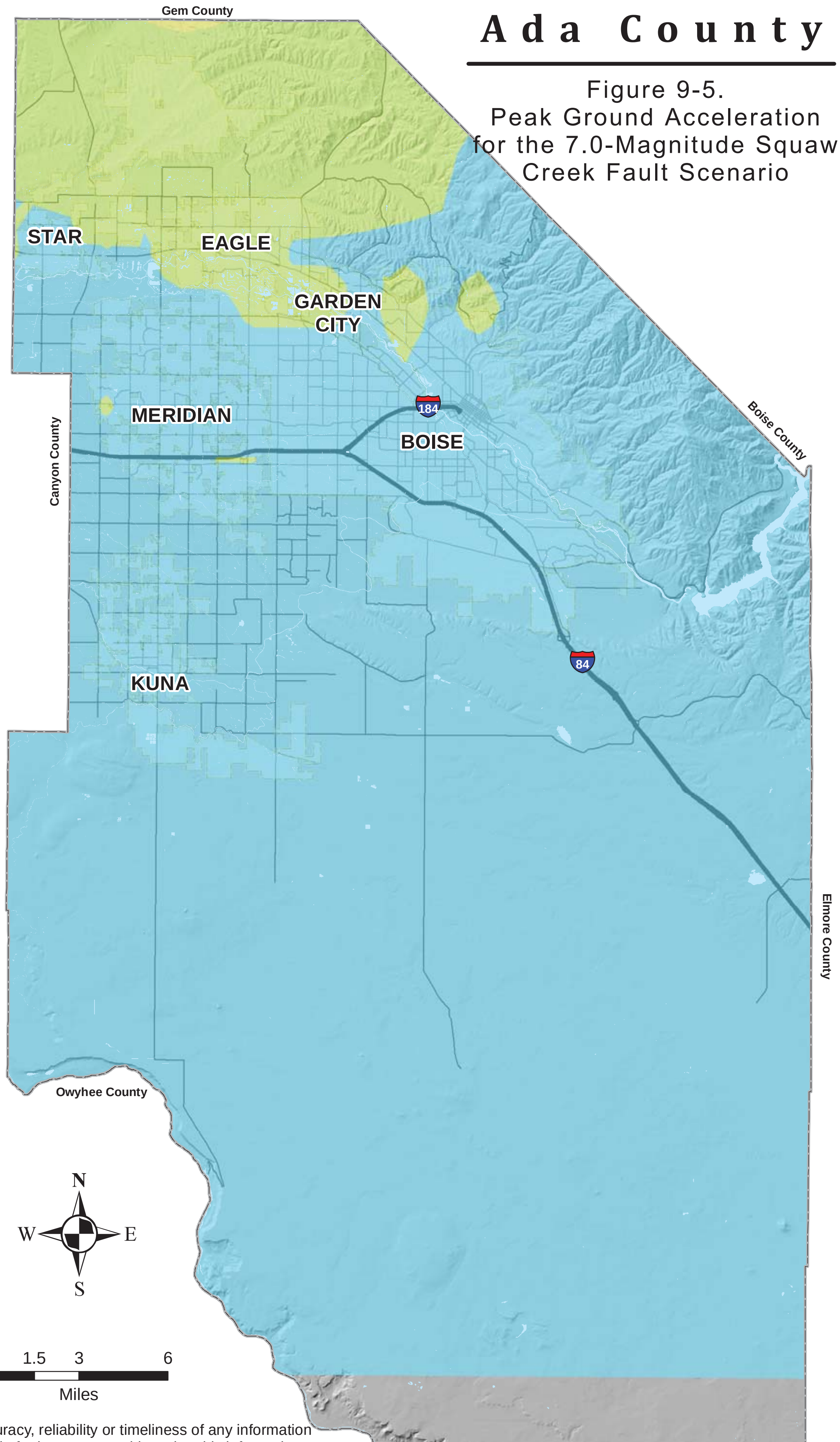
Base Map Data Sources:
Ada County, U.S. Geological Survey

ADA COUNTY STATE OF IDAHO Established 1864

TETRA TECH

Ada County

Figure 9-5.
Peak Ground Acceleration
for the 7.0-Magnitude Squaw
Creek Fault Scenario



Legend

No Data Available

Modified Mercalli Scale, Potential Shaking

- I (Not Felt)
- II-III (Weak)
- IV (Light)
- V (Moderate)
- VI (Strong)
- VII (Very Strong)
- VIII (Severe)
- IX (Violent)
- X+ (Extreme)

Magnitude: 7.0
Epicenter: N44.22 W116.22
Depth: 15.0km

A ShakeMap is designed as a rapid response tool to portray the extent and variation of ground shaking throughout the affected region immediately following significant earthquakes. Ground motion and intensity maps are derived from peak ground motion amplitudes recorded on seismic sensors (accelerometers), with interpolation based on both estimated amplitudes where data are lacking, and site amplification corrections. Color-coded instrumental intensity maps are derived from empirical relations between peak ground motions and Modified Mercalli intensity.

Base Map Data Sources:
Ada County, U.S. Geological Survey

ADA COUNTY STATE OF IDAHO Established 1864

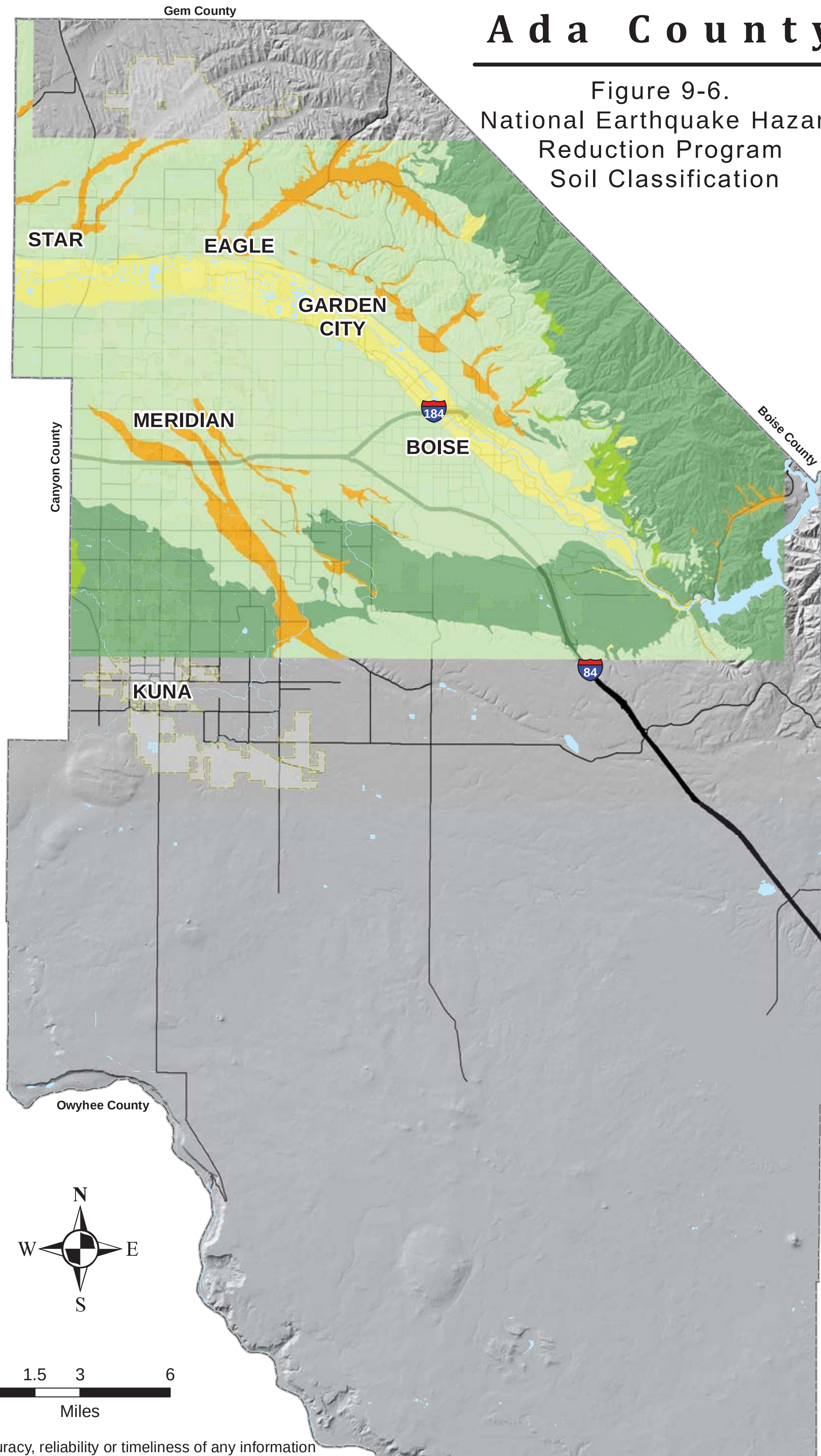
N W E S

0 1.5 3 6
Miles

TETRA TECH

Ada County

Figure 9-6.
National Earthquake Hazard Reduction Program Soil Classification



Legend

No Data Available

Class / Soil Profile

- B / Rock
- BC / Soft Rock
- C / Very Dense Soil
- D / Stiff Soil
- E / Soft Soil

Soil classification data provided by the Idaho Geological Survey. The most recent procedures for determining NEHRP site classes are described in Chapter 20 of ASCE/SEI standard 7-10 (ASCE/SEI, 2010, p. 203-205). Site classes (A-F) are determined in engineering studies with geotechnical properties of earth materials within 100 feet (30 m) of the ground surface. This approach has been used to produce regional NEHRP site class maps in a number of areas in the western United States (e.g. Palmer and others, 2004; Wills and others, 2000).

This NEHRP site class map was produced in the area geologically mapped by Othberg and Stanford (1992). This map was chosen because it contains all major cities and towns of the Boise 2 region, and because it is the most complete geologic mapping available at a scale (1:100,000) sufficient for estimating site classes with good precision. County soil surveys for the project area are by Collett (1980), Priest and others (1972), Harkness (1998), Rasmussen (1976), and Troeh and others (1965).

Base Map Data Sources:
Ada County, U.S. Geological Survey

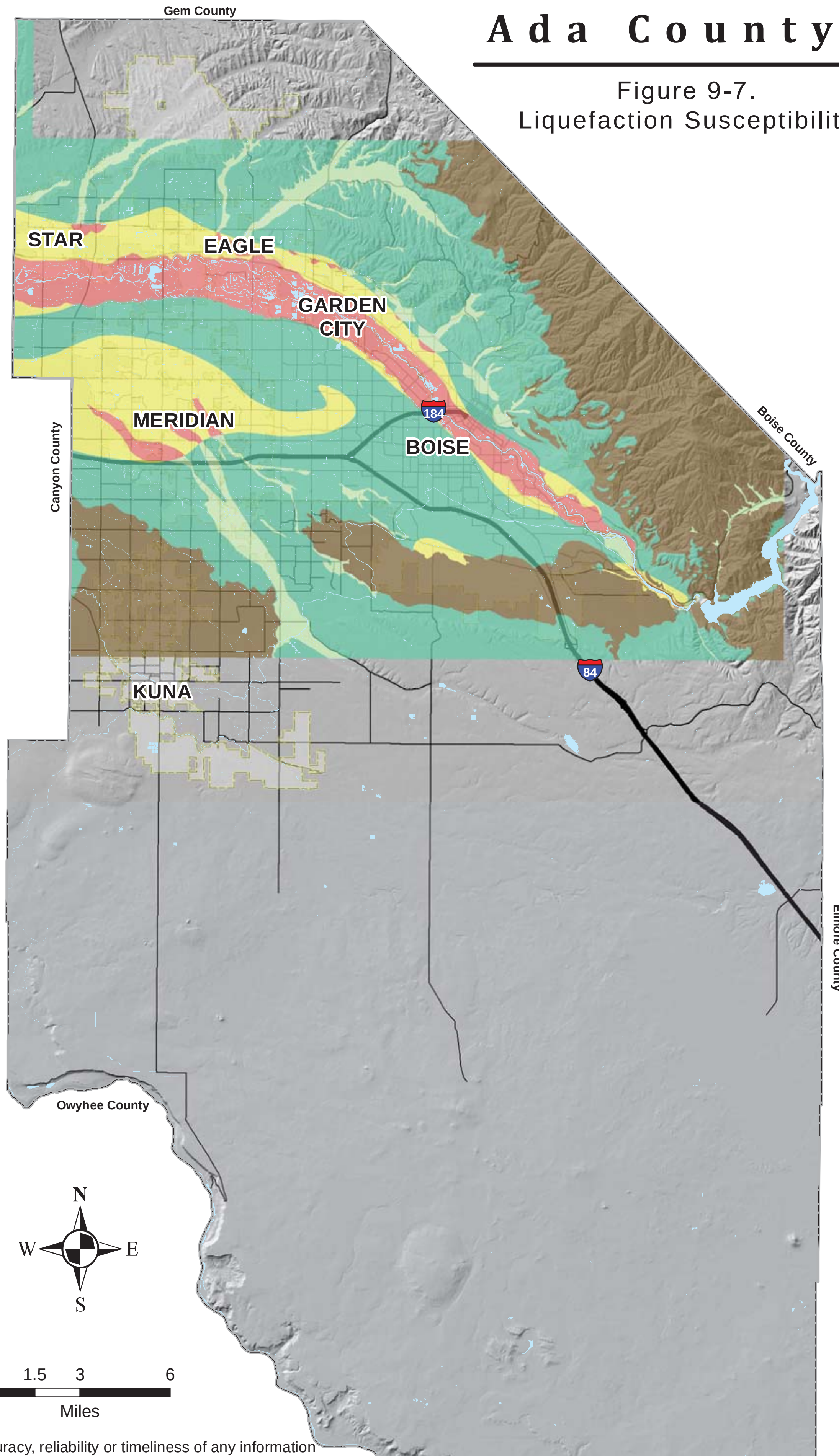
N W E S

0 1.5 3 6
Miles

TETRA TECH

Ada County

Figure 9-7. Liquefaction Susceptibility



Legend

No Data Available

Liquefaction Class

- Not Susceptible / Bedrock
- Very Low
- Low
- Moderate
- Moderate to High
- High

Liquefaction data provided by the Idaho Geological Survey. Liquefaction susceptibility is related to deposit age, texture, and environment of deposition (Federal Emergency Management Administration, 2009, Table 4-10, p. 4-22; Youd and Perkins, 1978). A classification process similar to that employed in Washington State (Palmer and others, 2004) was used to relate these factors to deposits. Earth materials within about 100 ft (30 m) of the surface were classified using a 1:100,000-scale geologic map (Othberg and Stanford, 1992) of the Boise metro area. For each geologic map unit, a score between 0-5 was assigned for each classifying factor based upon unit descriptions. Equal weighting was given to age, texture, and environment. Liquefaction cannot occur in bedrock, so these units were given a score of zero although they were classified as to age, texture, and environment.

This map is a general guide to outlining areas with the potential for liquefaction. Because this map is based on regional geological and hydrological data, detailed geotechnical investigations are required to determine actual ground conditions for specific building sites.

This map is intended to be used at a scale of 1:100,000. As with all maps, users should not apply this map, either digitally or on paper, at more detailed scales.

Base Map Data Sources:
Ada County, U.S. Geological Survey

Seismologists use a historical distribution of extreme values to estimate the probability of shaking at or above a given intensity over a 50-year year exposure time. Using this methodology, Idaho Geological Survey has estimated the following for Ada County (Boise metropolitan area):

- A >50-percent chance of a midrange intensity event (VI or greater) in any 50-year period.
- A 33-percent chance of intensity VII in any 50-year period.
- An 18-percent chance of intensity VIII in any 50-year period
- A 10-percent chance of intensity IX in any 50-year period

These probabilities are for the maximum shaking on unstable sites within a 300-mile radius of the Boise area. The exact location of unstable sites is not known for the entire planning area due to the lack of countywide NEHRP soils maps.

9.2.4 Severity

The severity of an earthquake can be expressed in terms of intensity or magnitude. Intensity represents the observed effects of ground shaking on people, buildings and natural features. Magnitude is related to the amount of seismic energy released at the hypocenter of an earthquake. It is determined by the amplitude of the earthquake waves recorded on instruments. Whereas intensity varies depending on location with respect to the earthquake epicenter, magnitude is represented by a single, instrumentally determined value for each earthquake event. The severity of an earthquake event can be measured in the following terms:

- How hard did the ground shake?
- How did the ground move? (Horizontally or vertically)
- How stable was the soil?
- What is the fragility of the built environment in the area of impact?

The severity of a seismic event is directly correlated to the stability of the ground close to the event's epicenter. The difference in severity between intensity ranges can be immense. A poorly built structure on a stable site in Boise is far more likely to survive a large earthquake than a well-built structure on an unstable site. Thorough geotechnical site evaluations should be the rule of thumb for new construction in the planning area until creditable soils mapping becomes available.

The USGS creates ground motion maps based on current information about fault zones, showing the PGA that has a certain probability (2 percent or 10 percent) of being exceeded in a 50-year period. The PGA is measured in numbers of g's (the acceleration associated with gravity). Figure 9-8 shows the PGAs with a 2-percent exceedance chance in 50 years in the northwestern United States. Southwestern Idaho is a medium-risk area.

9.2.5 Warning Time

Earthquakes can last from a few seconds to over five minutes. They may be one-time events or occur as a series of tremors over several days. There is currently no reliable way to predict the day or month that an earthquake will occur at any given location. Research is being done with warning systems that use the low energy waves that precede major earthquakes. These potential warning systems give approximately 40 seconds notice that a major earthquake is about to occur. The warning time is very short but it could allow for someone to get under a desk, step away from a hazardous material they are working with, or shut down a computer system.

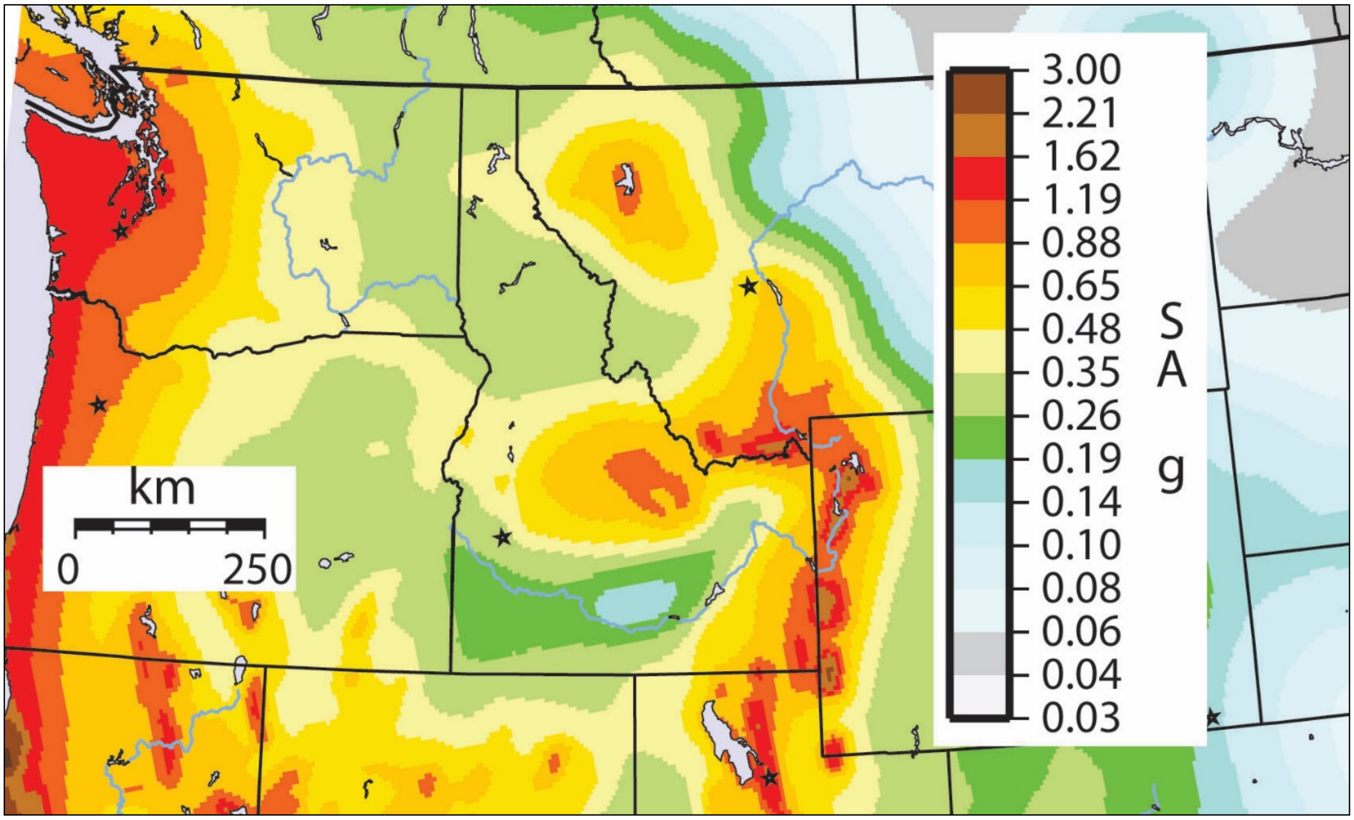


Figure 9-8. PGA with 2-Percent Probability of Exceedance in 50 Years, Northwest Region

9.3 SECONDARY HAZARDS

Earthquakes can cause large and sometimes disastrous landslides and mudslides. River valleys are vulnerable to slope failure, often as a result of loss of cohesion in clay-rich soils. Soil liquefaction occurs when water-saturated sands, silts or gravelly soils are shaken so violently that the individual grains lose contact with one another and float freely in the water, turning the ground into a pudding-like liquid. Building and road foundations lose load-bearing strength and may sink into what was previously solid ground. Unless properly secured, hazardous materials can be released, causing significant damage to the environment and people. Earthen dams and levees are highly susceptible to seismic events and the impacts of their eventual failures can be considered secondary risks for earthquakes.

9.4 EXPOSURE

9.4.1 Population

The entire population of Ada County is potentially exposed to direct and indirect impacts from earthquakes. The degree of exposure is dependent on many factors, including the age and construction type of the structures people live in, the soil type their homes are constructed on, their proximity to fault location, etc. Whether directly impacted or indirectly impact, the entire population will have to deal with the consequences of earthquakes to some degree. Business interruption could keep people from working, road closures could isolate populations, and loss of functions of utilities could impact populations that suffered no direct damage from an event itself.

9.4.2 Property

Building Value

The Ada County Assessor estimates that there are 146,488 buildings in Ada County, with a total assessed value of $83.8 billion. Since all structures in the planning area are susceptible to earthquake impacts, this total represents the countywide property exposure to earthquakes. Most of the buildings (91.8 percent) are residential.

Building Age

Building codes were not state-mandated in Idaho until 2008. However, the Ada County planning area has had a strong influence of building code enforcement as modern building codes have evolved nationally. Seismic code requirements have principally come from California, due to that state's immense seismic risk. The California State Building Code Council has identified significant milestones in building and seismic code requirements that can be used as a gauge of structural integrity of existing building stock. Using these time periods, the planning team used Hazus to identify the number of structures in the County by date of construction. Table 9-7 shows the results of this analysis.

Table 9-7. Age of Structures in Ada County

Time Period	Number of Current County Structures Built in Period	Significance of Time Frame
Pre-1933	3,173	Before 1933, there were no explicit earthquake requirements in building codes. State law did not require local governments to have building officials or issue building permits.
1933-1940	2,651	In 1940, the first strong motion recording was made.
1941-1960	18,051	In 1960, the Structural Engineers Association of California published guidelines on recommended earthquake provisions.
1961-1975	24,284	In 1975, significant improvements were made to lateral force requirements.
1976-1994	35,659	In 1994, the Uniform Building Code was amended to include provisions for seismic safety.
1994—present	62,630	Seismic code is currently enforced.
Total	146,448	

The number of structures does not reflect the number of total housing units, as many multi-family units and attached housing units are reported as one structure. Structures constructed after the Uniform Building Code was amended in 1994 to include seismic safety provisions account for 42.7 percent of the planning area's structures. Approximately 2.1 percent were built before 1933 when there were no building permits, inspections or seismic standards.

9.4.3 Critical Facilities and Infrastructure

All critical facilities in Ada County are exposed to the earthquake hazard. Table 4-2 and Table 4-3 list the number of each type of facility by jurisdiction. Facilities holding hazardous materials are of particular concern because of possible isolation of neighborhoods surrounding them. During an earthquake, structures storing these materials could rupture and leak into the surrounding area or an adjacent waterway, having a disastrous effect on the environment. Transportation corridors can be disrupted during an earthquake, leading to the release of hazardous materials to the surrounding environment.

9.4.4 Environment

Secondary hazards associated with earthquakes will likely have some of the most damaging effects on the environment. Earthquake-induced landslides can significantly impact surrounding habitat. It is also possible for streams to be rerouted after an earthquake. This can change the water quality, possibly damaging habitat and feeding areas. There is a possibility of streams fed by groundwater drying up because of changes in underlying geology.

9.5 VULNERABILITY

Earthquake vulnerability data was generated for the 100-year and 500-year earthquakes and the Squaw Creek scenario event using a Level 2 Hazus-MH analysis. Once the location and size of a hypothetical earthquake are identified, Hazus-MH estimates the intensity of the ground shaking, the number of buildings damaged, the number of casualties, the damage to transportation systems and utilities, the number of people displaced from their homes, and the estimated cost of repair and clean up.

9.5.1 Population

Table 9-8 summarizes the estimated impacts of modeled earthquake events on persons and households in the planning area.

Table 9-8. Estimated Earthquake Impact on Person and Households

	Number of Displaced Households	Number of Persons Requiring Short-Term Shelter
100-Year Earthquake	None	None
500-Year Earthquake	10	6
Squaw Creek Scenario	1	None

9.5.2 Property

Table 9-9 and Table 9-10 summarize the estimated impacts of modeled earthquake events for two types of property loss:

- Structural loss, representing damage to building structures
- Non-structural loss, representing the value of lost contents and inventory, relocation, income loss, rental loss, and wage loss.

The analysis also estimated the amount of earthquake-caused debris, as summarized in Table 9-11.

Table 9-9. Earthquake Building Loss Potential—Probabilistic

	Estimated Earthquake Loss Value					
	100- Year Probabilistic Earthquake			500- Year Probabilistic Earthquake		
	Structural	Non-Structural	Total	Structural	Non-Structural	Total
Boise	$2,751,839	$398,188	$3,150,027	$55,028,152	$15,771,234	$70,799,386
Eagle	$206,735	$25,336	$232,071	$5,126,008	$1,294,691	$6,420,699
Garden City	$275,136	$32,177	$307,313	$4,822,115	$1,292,435	$6,114,550
Kuna	$724	$97	$821	$390,961	$83,599	$474,560
Meridian	$750,787	$101,960	$852,747	$16,272,229	$4,345,985	$20,618,214
Star	$80,561	$12,667	$93,228	$1,815,632	$461,011	$2,276,642
Unincorporated	$223,464	$29,060	$252,524	$6,236,407	$1,559,963	$7,796,370
Total	$4,289,246	$599,485	$4,888,731	$89,691,504	$24,808,918	$114,500,421

Table 9-10. Earthquake Building Loss Potential—7.0-Magnitude Squaw Creek Fault

	Estimated Earthquake Loss Value		
	Structural	Non-Structural	Total
Boise	$15,054,572	$8,644,858	$23,699,431
Eagle	$5,030,581	$2,796,903	$7,827,484
Garden City	$2,112,768	$1,101,635	$3,214,403
Kuna	$120,815	$54,498	$175,313
Meridian	$4,713,081	$2,694,746	$7,407,826
Star	$2,855,639	$1,363,997	$4,219,637
Unincorporated	$3,827,847	$1,954,768	$5,782,615
Total	$33,715,303	$18,611,405	$52,326,709

Table 9-11. Estimated Earthquake-Caused Debris

	Debris to Be Removed (x 1,000 tons)
100-Year Earthquake	1.76
500-Year Earthquake	23.35
Squaw Creek Earthquake Scenario	2.58

9.5.3 Critical Facilities and Infrastructure

Level of Damage

Hazus-MH classifies the vulnerability of critical facilities to earthquake damage in five categories: no damage, slight damage, moderate damage, extensive damage, or complete damage. The model was used to assign a vulnerability category to each critical facility in the planning area except hazmat facilities and "other infrastructure" facilities, for which there are no established damage functions. Table 9-12 and Table 9-13 summarize the results for the 100-year event and the Squaw Creek scenario.

Table 9-12. Critical Facility Vulnerability to 100-Year Earthquake Event

Category[a]	No Damage	Slight Damage	Moderate Damage	Extensive Damage	Complete Damage
Medical and Health	7	0	0	0	0
Government Functions	9	0	0	0	0
Protective Functions	58	0	0	0	0
Schools	272	0	0	0	0
Other Critical Functions	56	0	0	0	0
Hazardous Materials Facilities	41	0	0	0	0
Transportation Systems	636	0	0	0	0
Water supply	386	0	0	0	0
Wastewater	9	0	0	0	0
Power	51	0	0	0	0
Natural Gas	7	0	0	0	0
Communications	45	0	0	0	0
Total	1577	0	0	0	0

a. Vulnerability not estimated for hazmat facilities or for "other " facilities due to lack of established damage functions for these type facilities.

Table 9-13. Critical Facility Vulnerability to Squaw Creek Fault Scenario

Category[a]	No Damage	Slight Damage	Moderate Damage	Extensive Damage	Complete Damage
Medical and Health	5	2	0	0	0
Government Functions	7	2	0	0	0
Protective Functions	52	6	0	0	0
Schools	268	4	0	0	0
Other Critical Functions	56	0	0	0	0
Hazardous Materials Facilities	38	2	1	0	0
Transportation Facilities	600	36	0	0	0
Water supply	384	2	0	0	0
Wastewater	2	7	0	0	0
Power	12	39	0	0	0
Natural gas	0	7	0	0	0
Communications	13	32	0	0	0
Total	1437	139	1	0	0

a. Vulnerability not estimated for hazmat facilities or for "other infrastructure" facilities due to lack of established damage functions for these type facilities.

Time to Return to Functionality

Hazus-MH estimates the time to restore critical facilities to fully functional use. Results are presented as probability of being functional at specified time increments: 1, 3, 7, 14, 30 and 90 days after the event. For example, Hazus-MH may estimate that a facility has 5 percent chance of being fully functional at Day 3, and a 95-percent chance of being fully functional at Day 90. The analysis of critical facilities in the planning area was performed for the 100-year and the Squaw Creek Fault earthquake events. Table 9-14 and Table 9-15 summarize the results.

Table 9-14. Functionality of Critical Facilities for 100-Year Event

	# of Critical Facilities	Probability of Being Fully Functional (%)					
		at Day 1	at Day 3	at Day 7	at Day 14	at Day 30	at Day 90
Medical and Health	7	99.63	99.63	99.84	99.84	99.90	99.90
Government Functions	9	99.9	99.9	99.9	99.9	99.9	99.9
Protective Functions	58	99.89	99.89	99.90	99.91	99.91	99.91
Schools	272	99.89	99.89	99.90	99.90	99.90	99.90
Other Critical functions	56	99.03	99.04	99.79	99.80	99.90	99.90
Hazardous materials facilities	41	98.93	98.96	99.56	99.56	99.89	99.90
Transportation Facilities	636	100.00	100.00	100.00	100.00	100.00	100.00
Water supply	386	99.83	99.90	99.90	99.90	99.90	99.90
Wastewater	9	99.71	99.90	99.90	99.90	99.90	99.90
Power	51	99.68	99.90	99.90	99.90	99.90	99.90
Natural Gas	7	99.9	99.9	99.9	99.9	99.9	99.9
Communications	45	99.9	99.9	99.9	99.9	99.9	99.9
Total/Average	1577	99.7	99.7	99.9	99.9	99.9	99.9

Table 9-15. Functionality of Critical Facilities for Squaw Creek Fault Event

	# of Critical Facilities	Probability of Being Fully Functional (%)					
		at Day 1	at Day 3	at Day 7	at Day 14	at Day 30	at Day 90
Medical and Health	7	98.93	98.93	99.04	99.04	99.07	99.10
Government Functions	9	99.22	99.22	99.24	99.24	99.26	99.28
Protective Functions	58	99.59	99.59	99.62	99.62	99.63	99.64
Schools	272	99.80	99.80	99.81	99.81	99.82	99.82
Other Critical functions	56	99.07	99.08	99.86	99.86	99.90	99.90
Hazardous Materials Facilities	41	97.89	97.94	99.31	99.32	99.62	99.64
Transportation Facilities	636	99.90	99.91	99.91	99.92	99.92	99.92
Water supply	386	95.37	99.64	99.86	99.88	99.90	99.90
Wastewater	9	80.93	88.28	89.76	89.87	89.88	89.9
Power	51	92.32	98.92	99.84	99.89	99.90	99.90
Natural Gas	7	93.9	99.2	99.8	99.9	99.9	99.9
Communications	45	99.12	99.86	99.88	99.89	99.90	99.90
Total/Average	1577	96.3	98.4	98.8	98.9	98.9	98.9

9.5.4 Environment

The environment vulnerable to earthquake hazard is the same as the environment exposed to the hazard.

9.6 DEVELOPMENT TRENDS

Because all of the planning area is exposed to the earthquake hazard, the increase in exposed population and property since the last hazard mitigation plan update is equal to the countywide trend over that time period: a 10.7-percent increase in population, a 29.2-percent increase in number of general building stock structures, and an 83.5-percent increase in total assessed property value (see Section 4.56.3). However, Hazus modeling shows a 45-percent decrease in vulnerability since 2011, measured as potential structure damage. The change is attributable to improved analysis techniques, rather than any change in conditions in the planning area. The current update used NEHRP soils data and liquefaction data for the planning area that was not available in 2011. These data allow for more accurate modeling of damage based on differences in earthquake intensity across the planning area. The new results should be considered the baseline for all future analyses seeking to gage changes in earthquake risk for the planning area.

The entire planning area is under the influence of the International Building Code as mandated by the State of Idaho since 2008. This is a significant capability for the planning area in the management of seismic risk in future development. Strict adherence and enforcement of the seismic provisions of the IBC will play a significant role in the management of seismic risk for new development in the future.

9.7 SCENARIO

Any seismic activity of 6.0 or greater on faults within the planning area would have significant impacts throughout Ada County. The seismic event likely to have the largest impact is a 7.1 magnitude or greater event on the Squaw Creek fault. Potential warning systems could give 40 seconds' notice that a major earthquake is about to occur; this would not provide adequate time for preparation. Earthquakes of this magnitude or higher would lead to massive structural failure of property on unstable soils. With the abundance of imported fill used to elevate building pads for homes in the Boise River floodplain, liquefaction impacts in these areas could be widespread. Un-engineered canal embankments would likely fail, representing a loss of critical infrastructure. The structural integrity of Lucky Peak Dam could be jeopardized as well. These events could cause secondary hazards, including landslides and mudslides. River valley hydraulic-fill sediment areas are also vulnerable to slope failure, often as a result of loss of cohesion in clay-rich soils. Soil liquefaction would occur in water-saturated sands, silts or gravelly soils.

9.8 ISSUES

Important issues associated with an earthquake include but are not limited to the following:

- NEHRP soils mapping is not available for the entire planning area. Acquiring this data in areas it does not currently exist would enhance the accuracy of future risk assessments for the planning area.
- Shake maps should be developed for the Squaw Creek and Water Tank fault scenarios.
- Approximately 33 percent of the planning area's building stock was built prior to 1975, when seismic provisions became uniformly applied through building codes.
- Critical facility owners should be encouraged to create or enhance Continuity of Operations Plans using the information on risk and vulnerability contained in this plan.
- Geotechnical standards should be established that take into account the probable impacts from earthquakes in the design and construction of new or enhanced facilities.
- The County has over 400 miles of canals that were not constructed to engineering standards. The structural integrity of these facilities as it pertains to seismic impacts is not known.
- Earthquakes could trigger other natural hazard events such as dam failures and landslides, which could severely impact the county.
- Dam failure warning and evacuation plans and procedures should be updated to reflect the earthquake risk associated with a large number of earthen dams in the planning area.
- Hazard mitigation plan survey results indicate that the public does not perceive a significant seismic risk in the planning area.
- Unreinforced masonry structures in the planning area are particularly vulnerable to the earthquake hazard.
- It is difficult to develop seismic retrofit projects that are cost-effective for FEMA hazard mitigation grant programs, due to the lack of state and federal risk data to support FEMA benefit-cost methodologies.

10. FLOOD

10.1 GENERAL BACKGROUND

A floodplain is the area adjacent to a river, creek or lake that becomes inundated during a flood. Floodplains may be broad, as when a river crosses an extensive flat landscape, or narrow, as when a river is confined in a canyon.

When floodwaters recede after a flood event, they leave behind layers of rock and mud. These gradually build up to create a new floor of the floodplain. Floodplains generally contain unconsolidated sediments (accumulations of sand, gravel, loam, silt, and/or clay), often extending below the bed of the stream. These sediments provide a natural filtering system, with water percolating back into the ground and replenishing groundwater. These are often important aquifers, the water drawn from them being filtered compared to the water in the stream. Fertile, flat reclaimed floodplain lands are commonly used for agriculture, commerce and residential development.

Connections between a river and its floodplain are most apparent during and after major flood events. These areas form a complex physical and biological system that not only supports a variety of natural resources but also provides natural flood and erosion control. When a river is separated from its floodplain with levees and other flood control facilities, natural, built-in benefits can be lost, altered, or significantly reduced.

10.1.1 Measuring Floods and Floodplains

The frequency and severity of flooding are measured using a discharge probability, which is the probability that a certain river discharge (flow) will be equaled or exceeded in a given year. Flood studies use historical records to determine the probability of occurrence for different discharge levels. The flood frequency equals 100 divided by the discharge probability. For example, the 100-year discharge has a 1-percent chance of being equaled or exceeded in any given year. The “annual flood” is the greatest flood event expected to occur in a typical year. These measurements reflect statistical averages only; it is possible for two or more floods with a 100-year or higher recurrence interval to occur in a short time period. The same flood can have different recurrence intervals at different points on a river.

The extent of flooding associated with a 1-percent annual probability of occurrence (the base flood or 100-year flood) is used as the regulatory boundary by many agencies. Also referred to as the special flood hazard area (SFHA), this boundary is a convenient tool for assessing vulnerability and risk in flood-prone communities. Many communities have maps that show the extent and likely depth of flooding for the base flood. Corresponding water-surface elevations describe the elevation of water that will result from a given discharge level, which is one of the most important factors used in estimating flood damage.

10.1.2 Floodplain Ecosystems

Floodplains can support ecosystems that are rich in plant and animal species. A floodplain can contain 100 or even 1,000 times as many species as a river. Wetting of the floodplain soil releases an immediate surge of nutrients: those left over from the last flood, and those that result from the rapid decomposition of organic matter that has accumulated since then. Microscopic organisms thrive and larger species enter a rapid breeding cycle.

Opportunistic feeders (particularly birds) move in to take advantage. The production of nutrients peaks and falls away quickly, but the surge of new growth endures for some time. This makes floodplains valuable for agriculture. Species growing in floodplains are markedly different from those that grow outside floodplains. For instance, riparian trees (trees that grow in floodplains) tend to be very tolerant of root disturbance and very quick-growing compared to non-riparian trees.

10.1.3 Effects of Human Activities

Because they border water bodies, floodplains have historically been popular sites to establish settlements. Human activities tend to concentrate in floodplains for a number of reasons: water is readily available; land is fertile and suitable for farming; transportation by water is easily accessible; and land is flatter and easier to develop. But human activity in floodplains frequently interferes with the natural function of floodplains. It can affect the distribution and timing of drainage, thereby increasing flood problems. Human development can create local flooding problems by altering or confining drainage channels. This increases flood potential in two ways: it reduces the stream's capacity to contain flows, and it increases flow rates or velocities downstream during all stages of a flood event. Human activities can interface effectively with a floodplain as long as steps are taken to mitigate the activities' adverse impacts on floodplain functions.

The extent of damage caused by a flood depends on several variables: how much area is flooded, the height of flooding, the velocity of flow, the rate of rise, sediment and debris carried, the duration of flooding, and the effectiveness of flood fighting.

10.1.4 Federal Flood Programs

National Flood Insurance Program

The NFIP makes federally backed flood insurance available to homeowners, renters and business owners in participating communities. For most participating communities, FEMA has prepared a detailed Flood Insurance Study. The study presents water surface elevations for floods of various magnitudes, including the 1-percent annual chance flood and the 0.2-percent annual chance flood (the 500-year flood). Base flood elevations and the boundaries of the 100- and 500-year floodplains are shown on Flood Insurance Rate Maps (FIRMs), which are the principal tool for identifying the extent and location of the flood hazard. FIRMs are the most detailed and consistent data source available, and for many communities they represent the minimum area of oversight under their floodplain management program.

Participants in the NFIP must follow NFIP criteria for regulating development in floodplains. Before issuing a permit to build in a floodplain, participating jurisdictions must ensure that three criteria are met:

- New buildings and those undergoing substantial improvements must, at a minimum, be elevated to protect against damage by the 100-year flood.
- New floodplain development must not aggravate existing flood problems or increase damage to other properties.
- New floodplain development must exercise a reasonable and prudent effort to reduce its adverse impacts on threatened salmonid species.

Ada County entered the NFIP on December 18, 1984. Structures permitted or built in the County after then are called "post-FIRM" structures and are eligible for reduced flood insurance rates, since they were constructed after regulations and codes were adopted to decrease vulnerability. Structures built before then are called "pre-FIRM" and are subject to higher rates because they may not meet code or may be located in hazardous areas. The effective date for the current countywide FIRM is October 2, 2003. This map is a DFIRM (digital flood insurance rate map).

All incorporated cities in Ada County also participate in the NFIP. The county and cities are currently in good standing with the provisions of the NFIP. Compliance is monitored by FEMA regional staff and by the Idaho Department of Water Resources under a contract with FEMA. Maintaining compliance under the NFIP is an important component of flood risk reduction. All planning partners that participate in the NFIP have identified actions to maintain their good standing.

The Community Rating System

The CRS is a voluntary program within the NFIP that encourages floodplain management activities that exceed the minimum NFIP requirements. Flood insurance premiums are discounted to reflect the reduced flood risk resulting from community actions meeting the three goals of the CRS: reduce flood losses; facilitate accurate insurance rating; and promote awareness of flood insurance. CRS activities can help to save lives and reduce property damage.

For participating communities, flood insurance premiums are discounted in increments of 5 percent based on CRS classification: Class 1 communities receive a 45-percent discount, and Class 9 communities receive a 5-percent discount. The classifications are based on 18 activities in the following categories: public information; mapping and regulations; flood damage reduction; and flood preparedness.

Figure 10-1 shows the nationwide number of CRS communities by class as of May 1, 2010, when there were 1,138 communities receiving flood insurance premium discounts under the CRS program. Communities participating in the CRS represent a significant portion of the nation's flood risk; over 66 percent of the NFIP's policy base is located in these communities. Communities receiving premium discounts through the CRS range from small to large and represent a broad mixture of flood risks.

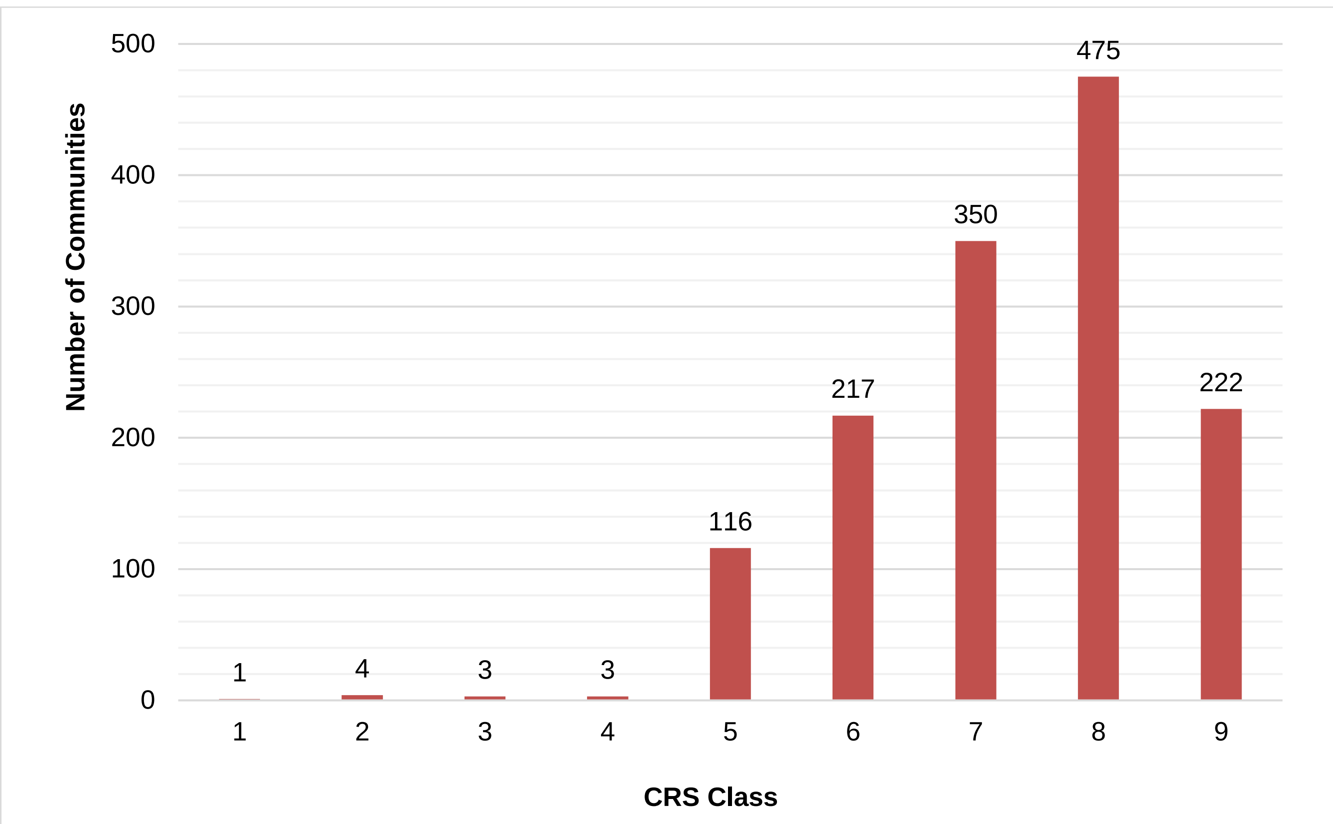


Figure 10-1. CRS Communities by Class Nationwide as of May 1, 2016

Ada County and the cities of Boise, Eagle, Garden City and Meridian are currently participating in the CRS, as summarized in Table 10-1. Total annual savings on flood insurance premiums in the planning area is $166,150, an average of $85 per policy. Many of the mitigation actions identified this plan are creditable activities under the CRS program. Therefore successful implementation of this plan offers the potential for these communities to enhance their CRS classifications and for currently non-participating communities to join the program.

Table 10-1. CRS Community Status in Ada County

Community	NFIP Community #	CRS Entry Date	Current CRS Classification	% Premium Discount, SFHA/non-SFHA	Total Premium Savings
Ada County	160001	10/1/1994	6	20/10	$29,599
Boise	160002	10/1/1991	6	20/10	$81,310
Eagle	160003	4/1/2000	6	20/10	$22,749
Garden City	160004	10/1/1998	8	10/5	$25,813
Meridian	160180	5/1/2016	8	10/5	$6,679
Total					$166,150

10.2 HAZARD PROFILE

Flooding in Ada County is typically caused by high-intensity, short-duration (1 to 3 hours) storms concentrated on a stream reach with already saturated soil. Two types of flooding are typical:

- Flash floods that occur suddenly after a brief but intense downpour. They move rapidly, end suddenly, and can occur in areas not generally associated with flooding (such as subdivisions not adjacent to a water body and areas serviced by underground drainage systems). Although the duration of these events is usually brief, the damage they cause can be severe. Flash floods cannot be predicted accurately and happen whenever there are heavy storms.
- Riverine floods described in terms of their extent (including the horizontal area affected and the vertical depth of floodwater) and the related probability of occurrence (expressed as the percentage chance that a flood of a specific extent will occur in any given year).

Flooding is predominantly confined within traditional riverine valleys. Locally, some natural or manmade levees separate channels from floodplains and cause independent overland flow paths. Occasionally, railroad, highway or canal embankments form barriers, resulting in ponding or diversion of flows. Some localized flooding not associated with stream overflow can occur where there are no drainage facilities to control flows or when runoff volumes exceed the design capacity of drainage facilities.

10.2.1 Principal Flooding Sources

The Boise River

The Boise River is about 200 miles long and flows generally east to west. The headwaters are in the Sawtooth Mountains and the mouth is near Parma, Idaho, where it empties into the Snake River. Principal tributaries of the Boise River are the North, Middle, and South Forks, and Mores Creek. Total drainage area of the Boise River is 4,134 square miles. Deep V-shaped valleys, steep slopes and narrow ridges characterize the watershed above Lucky Peak Dam. In the upper basin, elevation ranges from 3,000 to 10,600 feet,. The watershed below Lucky Peak Dam is roughly 1,485 square miles and is composed of river bottoms, terraces, and low rolling to steep hills. The bottomland adjoining the main stream constitutes the floodplain and varies from 1 to 3 miles in width.

Water gradients on the Boise River vary from 150 feet per mile in the upper reaches of the watershed to 6 feet per mile in the lower Reaches from Barber Dam to the Ada-Canyon County border, the river has an average slope of

11.5 feet per mile. The natural runoff of the Boise River usually consists of low flows from late July through February, increasing flows during March, and high flows in April, May and June. Occasionally this pattern is interrupted by high flows of short duration in winter caused by rainstorms. The vast majority of the runoff is generated above Lucky Peak Dam. Average discharge near Boise is about 2,750 cubic feet per second (cfs) or 2 million acre-feet per year. The maximum recorded mean daily discharge was 35,500 cfs, on June 14, 1896.

The principal dams on the Boise River are Anderson Ranch, Arrowrock and Lucky Peak. These dams provide flood-control storage for 64 percent of the drainage area of the river. The dams have greatly reduced the magnitude and frequency of Boise River floods. In spite of the flood protection provided by the existing system, major floods still cannot be fully controlled. Boise River water levels reach bank-full stage (6,500 cfs at the Glenwood Bridge gage) virtually every year. However, the reservoirs provide enough regulation to generally allow for 24 to 72 hours' warning before cities along the Boise River in Ada County experience major flooding.

The river's ability to carry a flood has been significantly reduced over time by siltation. Before the upstream dams regulated flows, spring runoff flushed and scoured the river channel. Since 1954, when Lucky Peak, the last of the three big dams, went into operation, the capacity of the river channel has gradually been reduced. A 1972 USGS study noted a considerable decrease in stream capacity at the gauging stations at Notus and Boise. At the same river stage, flows at Notus were 11,800 cfs in 1938 and 8,000 cfs in 1972. Flows at the same stage at Boise were 9,600 cfs in 1943 and 7,700 cfs in 1972. This is a reduction in carrying capacity of 32 percent at Notus and 20 percent in Boise. In the decades since that study, silt has continued to be deposited in the floodway. With present downstream channel capacity, there is not enough reservoir space in the system to fully regulate the standard flood. There is a 1-percent chance in any year of flows at Boise exceeding 16,600 cfs, and a 2-percent chance in any year of flows exceeding 11,000 cfs.

Other factors that affect flooding on the Boise River are the construction and condition of levees, the proliferation of plant growth along the river, and the construction of structures in the floodway. With these changes, water levels that in the past were merely an inconvenience now can cause significant damage. Flood elevations may be only slightly less for the 10- or 50-year flood than for the 100-year flood; so unforeseen debris blockages may cause 100-year elevations during a 10-year flood.

The Snake River

The Snake River forms part of the southern boundary of Ada County, running from Castle Butte in the east to Gaffey Butte in the west. The river flows through a deep canyon bordered by high, steep walls. The main threat of flooding on the Snake River is from ice jams. The potential for other types of flooding is limited since large dams control the river. There is very little development along this part of the Snake River. The main residential area is near Swan Falls Dam. Depending on the time of year, varying numbers of recreationists may be on the river.

Tributaries

The most hazardous streams in Ada County are the Boise River tributaries that have their headwaters in the Boise Foothills: Seaman Gulch, Pierce Gulch, Polecat Gulch, Stuart Gulch, Crane Creek, Hull's Gulch, and Cottonwood Creek. These streams flow southwest and are dry most of the year. Only after periods of heavy rainfall or snowmelt do they have significant flows. The soil of these streams is almost entirely deep sandy loam, loam with areas of clay, or clay loam, and all are highly erodible. Vegetation in these gulches is sparse and consists mainly of sagebrush, bitterbrush and perennial grasses. Elevations range from about 2,800 feet at the Boise city limits to about 5,800 feet at the summit of Boise Ridge.

The danger on these streams is flash flooding. Cottonwood Creek is the largest of these drainages and carries the greatest threat for extensive flash flooding. The largest flood in recent history from these Foothills streams occurred August 20, 1959, when Cottonwood Creek flooded, inundating about 50 blocks in Boise and several hundred acres of farmland with water, rocks and mud.

Precipitation normally varies from 12 inches in Boise to about 22 inches at higher elevations. Both frontal storms and thunderstorms can be sufficiently heavy to cause flooding. The maximum recorded 24-hour rainfall in Boise is 2.7 inches. The maximum observed short-duration rainfall at the Boise weather station is 4.1 inches/hour. However, intensities as high as 7.5 inches/hour have been logged in southwestern Idaho and eastern Oregon. Peaks for both of these types of floods occur in a rather short time: from 15 minutes to several hours.

Two conditions may cause floods in the drainages on the Boise Front: (a) the combination of a rainstorm with snowmelt on frozen ground in the winter and early spring; (b) high-intensity thunderstorms, usually during the summer. Winter storm floods generally occur during January through March. Thunderstorms may occur at any time of the year, although they usually happen from March through September.

Sandy soil and sparse vegetation combine to foster flash floods when intense thunderstorms hit the area. Floods from thunderstorms do not occur as frequently as those from general rain and snowmelt conditions, but are far more severe. The possibility for injury and death from flash floods is heightened because they are so uncommon that people do not recognize or accept the potential danger.

The onset of flooding in these gulches can range from extremely slow to very fast. This variability depends on the cause of flooding and other factors such as rainfall intensity, the areas receiving the rain, temperature, and the condition of the soil. Floods that occur quickly are usually caused by thunderstorms, while floods that occur more slowly are often the result of moderate but prolonged rainfall, snowmelt or a combination of both. In the case of intense rainfall immediately above developed areas, the onset of flooding may occur in a matter of minutes.

The lower portions of most of the gulches contain residential developments, including single-family homes, mobile home parks and apartment complexes. A large portion of the older residential district in the City of Boise is located within the floodplains of these gulches. Residential streets form the flood channel in several locations. A number of gulches and areas immediately below the gulches contain commercial and public facilities.

Between August 26 and September 2, 1996, 15,300 acres of the Boise City foothills were burned by the Eight Street wildfire. About 50 percent of the area in the Stuart Gulch and Cottonwood Creek watersheds was burned. Crane Gulch and Hulls Gulch watersheds were burned almost totally. The fire removed the vegetation and caused the soil to become water repellent. As a result, for several years the threat of flash flooding was significantly increased. Treatments applied in an effort to reduce the flood risk included contour felling of trees, tillage and aerial seeding, placing straw wattles, hand trenching, contour trenching, and straw bale check dams. Flood control structures were as follows:

- Enlarging the Cottonwood Creek Mountain Cove ponds to 150 acre-feet combined and re-channeling the flow through the Mountain Cove Road turn at the head of the flume, and constructing a wall along Reserve Street to direct the flow of water
- Constructing a 35-acre-foot upper catch basin and a 15-acre-foot lower catch basin on Hulls Gulch
- Constructing a 19-acre-foot dam on the Main Fork of Crane Gulch, and a 28-acre-foot dam on the East Fork of Crane Gulch
- Elevating sections of the Bogus Basin Road to act as a 61-acre-foot dam across Stuart Gulch.

Recent studies addressing flash floods have focused on these Boise gulches. However, long-term consideration of all drainages is necessary to avoid similar problems. Other streams in Ada County that may be subject to flooding are Big Gulch Creek, Black’s Creek, Bryans Run Creek, Corder Creek, Council Spring Creek, Current Creek, Dry Creek, Eightmile Creek, Fivemile Creek, Highland Valley Gulch, Indian Creek, Little Gulch Creek, Maynard Gulch, Ninemile Creek, Rabbit Creek, Sand Creek, Sheep Creek, Spring Valley Creek, Tenmile Creek, Threemile Creek, Warm Spring Creek, and Willow Creek. The majority of these streams are dry most of the year.

Canals

There are more than two dozen canals in Ada County, extending over 400 miles. The canals draw water from the Boise River, generally from about the first day of April to the last day of October. This is the time of year when canals present the greatest flood danger. There are several types of flood threats posed by canals. The first type is from a break or breach in the canal. This has the potential for significant flooding, especially if the canal is elevated or located on a hillside. Another possibility is be from an obstruction in a canal that causes water to overtop the canal bank. Other potential risks are vandalism, piping of water, gopher holes, etc. A break would pose the most serious problem.

Urban Flooding

Like many areas in the western U.S., Ada County has experienced rapid change due to urban development in once rural areas. Drainage facilities in these recently urbanized areas are a series of pipes, roadside ditches and channels. Urban flooding occurs when these conveyance systems lack the capacity to convey rainfall runoff to nearby creeks, streams and rivers. As drainage facilities are overwhelmed, roads and transportation corridors become conveyance facilities. The two key factors that contribute to urban flooding are rainfall intensity and duration. Topography, soil conditions, urbanization and groundcover also play an important role.

Urban floods can be a great disturbance of daily life in urban areas. Roads can be blocked and people may be unable to go to work or school. Economic damage can be high but the number of casualties is usually limited, because of the nature of the flood. On flat terrain, the flow speed is low and people can still drive through it. The water rises relatively slowly and usually does not reach life endangering depths.

10.2.2 Past Events

Ada County has a long and extensive history of flooding. The most common problem areas for flooding are the Boise River and the Boise Foothills streams. The greatest flood of known magnitude on the Boise River occurred on June 14, 1896. Peak flow was estimated at 35,500 cfs. The largest recent flood occurred in April 1943. Peak flow for this event was estimated at 21,000 cfs. Both of these events occurred prior to the river being regulated by Lucky Peak Dam. Table 10-2 shows flood events that have impacted the planning area since 1955.

Table 10-2. Ada County Flood Events

Date	Declaration #	Type of event
7/08/2015	N/A	Flash Flood
Strong thunderstorms and heavy rain crossed parts of southwest Idaho. Heavy rain from slow moving thunderstorms caused flash flooding in downtown Boise and in the north and northwest parts of the city. Over an inch of rain fell in less than an hour in parts of Boise.		
5/01/2012	N/A	Planned Dam Release
Unusually high rainfall triggered a rapid snow melt. Peak inflow into the three-dam reservoir system was over 26,000 cfs. Flows peaked at 8100 cfs through town. The high flows also caused an overtopping of a canal head-gate and two riverbank breeches along the Little Pioneer Ditch. Uncontrolled flows into the irrigation canal caused flooding on agricultural lands and threatened numerous public rights of way in Star. Ada County Highway District took the lead and completed the bank repairs that resolved this issue.		
5/30/2011	N/A	Planned Dam Release
Due to capacity issues at Lucky Peak Dam, officials were forced to increase flow on the Boise River, causing the channel to go above flood stage during the day. The river crested at 10.03 feet around 3:00 pm MDT.		
5/20/2008	N/A	Flooding-Boise River
High flows on the Boise River forced Boise Parks & Recreation to close three sections of the Greenbelt. The walking-only pedestrian area was underwater from the Cottonwoods Apartments past River Run in southeast Boise. Two other areas were also closed: Broadway Avenue tunnel on the north side of the river and Loggers Creek footbridge from Leadville Avenue east to the Park Center Bridge.		

Date	Declaration #	Type of event
5/6/2006	N/A	Flooding-Kuna-Mora canal
A breach in the Kuna-Mora Canal flooded parts of a south Kuna subdivision and came close to compromising a sewage pump about 2.5 miles away. Thirty to forty homeowners reported flooding. The canal broke about one quarter south of King Road. It started as a six foot breach and quickly became a 40 foot breach.		
5/25/2006	N/A	Flooding-Boise River
High water levels along the Boise River created a breach in the riverbank near Eagle Island. About 8- 10 homes along Artesian and Trout Roads were affected. The State of Idaho repaired the breach. For the affected residents Ada County provided sandbags, portable toilets, sump pumps and diesel for tractors.		
5/11/2006	N/A	Flooding –Boise River
High flows on the Boise River eroded a bridge near Garden City and nearly caused it to collapse into the river.		
4/5/2006	N/A	Flooding-Tributaries
Flooding along Five mile Creek and Lake Patricia flooded two homes and threatened several others as well as a small, private dam, southeast of Boise. Ada County inmate crews assisted in sandbagging.		
7/7/2004	N/A	Urban Flooding
The Idaho State Capital building was inundated by a flash flood. The flood occurred in the basement, displacing about 20 workers. Repairs are estimated to be between $70,000 and $100,000.		
3/7/1999	N/A	Flooding-Boise River
High water levels released from Lucky Peak Reservoir caused flooding in low lying areas. Segments of the Greenbelt were closed and areas in southeast Boise near Logger's Creek and Cottonwood Apartments were flooded. Also a 200' section of riverbank near Eagle's Starwood subdivision collapsed.		
May/June 1998	N/A	Flooding-Boise/Snake
Two weeks of rain fell on a melting snowpack caused flooding along the Snake, Weiser, Payette and Boise Rivers for the second year in a row. A levee break near Eagle Island caused flooding of nearby homes.		
9/11/1997	N/A	Flash Flooding
Flash flooding from thunderstorms caused damage in the Boise Foothills. Cloudburst dropped 0.40" of rain in 9 minutes on the Foothills area burned by the 1996 Eighth Street Fire, flooding homes, Highlands Elementary School, and streets in the Crane Creek and Hulls Gulch areas. Floodwaters were contained in several holding ponds. 15 people were evacuated and sheltered at Les Bois Junior High.		
March/July 1997	DR 1177	Riverine Flooding
Rapid melt of a record snowmelt led to flooded rivers throughout southern Idaho. The Snake River Basin received significant snowfall during the winter of 1996-97, and in higher elevations the snow pack exceeded 250 percent of normal, causing above normal runoff during the spring melt.		
1/1/1997	DR1154	Riverine Flooding
Warm temperatures combined with a rainfall 4-6 times normal caused snowmelt triggering floods, mudslides and avalanches in the Weiser, Payette and Salmon River drainages, damaging communities and infrastructure throughout Idaho. Increased flows in the Boise River to make room in reservoirs flooded homes and businesses along Eagle Island. A dike near South Eagle Road broke, flooding a road and surrounding fields. Parts of the Greenbelt along the Boise River were closed.		
May 1993	N/A	Flooding-Boise River
Boise River floodwaters soaked 10 Eagle homes, 1 woman drowned.		
February 1986	N/A	Flooding-Tributaries
Melting snow flooded North Boise from creeks in the Foothills. Streets in downtown Boise were closed to form a temporary diversion cancel to channel water from Cottonwood Creek to the Boise River. The canal carried an est. 800,000 gallons of water an hour		
June 1983	N/A	Flooding-Boise River
Snowmelt caused by high temperatures led to the raising of the Boise River to a peak runoff of 24,294 cfs. Flooding damaged the Greenbelt and river banks along Barber Park, Parkcenter, Garden City and Eagle Island. Homes along the river were flooded, and residents of Eagle Island used boats to travel. Cottonwood trees fell into the river, causing damming and further flooding. Municipal Park lost a chunk of land 300' long and 55' deep.		
February 1982	N/A	Flooding-Tributaries
Mudslides closed Hwy 55 three times in one month; erosion from floodwaters caused damage to numerous streets in the Foothills.		

Date	Declaration #	Type of event
1/5/1979	N/A	Flooding-Tributaries
In Boise, rain and melting snow caused flooding in North and West Boise from Foothills creeks. Over a dozen homes in the Highlands near Crane Creek were hardest hit, flooding basements, yards and streets despite sandbagging efforts. Flooding was also seen along Polecat Gulch, Stewart Gulch and Cottonwood Creek north of Boise, and Three mile, Five mile, Eight mile and Ten mile Creeks south of the airport, flooding homes, businesses and farmlands. Eckert Road bridge was closed.		
5/26/1973	N/A	Flooding-Canal
A 30' wide break in the Ridenbaugh Canal flooded the Triangle Dairy and 15 houses in SE Boise with muddy, waist-deep water. The affected area was between Broadway/Linden/Leadville		
1/17/1971	N/A	Urban Flooding
Heavy rain and snow over four days caused flooding in southwest Idaho. Basements, yards and low-lying roads were flooded. In Orchard, 3 of 30 homes were evacuated by rowboat. Floodwaters covered approximately 160 acres in the town.		
1/22/1969	N/A	Flooding-tributaries
Crane Creek, Cottonwood Creek, and other drainages in the Foothills flooded, with the Cottonwood Creek flow being measured at 30 percent above normal. The Boise River reached 3,643 cfs, three times normal. Flooding was mostly confined to roads and yards in North Boise.		
5/22/1965	N/A	Flooding-Boise River
300 acres of farmland and several houses near Eagle Island were flooded by the Boise River when a levee broke.		
1/29/1965	N/A	Flooding-Tributaries
Flooding from Cottonwood and Dry Creeks, Crane, Stuart and Hulls Gulch. Damage mostly was for repair to bridges and cleanup.		
12/21/1964	N/A	Riverine Flooding
Warm weather combined with heavy rains and melting snow caused flooding along the Payette, Big Wood, Little Wood, Portneuf, Clearwater and Boise River drainages. Hwy 21 and 15, US 95N and 30E were closed. Over 100 homes were damaged, numerous bridges were washed out, and thousands of acres of farmlands were flooded. Two deaths were attributed to the flood. A state of emergency was declared. Boise was isolated as surrounding roads and highways were closed, train and bus service cut off.		
2/1/1963	N/A	Flooding
In Ada County, Meridian streets and homes were flooded, farmland along Hwy 20-26 flooded. Canals in the area were running 3' above normal. Several highways were closed, bridges were washed away, and homes had basements and yards.		
9/22/1959	N/A	Flash Flooding
Heavy storms caused flooding along Cottonwood Creek and other Foothill drainages. The force of the water broke dikes across from the Armory on Reserve Street. Hwy 21 was closed because of debris flows. The area affected was mainly in the North End, from Fourth to Eighth Streets and Thatcher to Resseguie; also from Reserve Street to MK Plaza to Eighth Street. After these floods, several local and federal agencies cooperated in the "Boise Front Watershed Restoration Project" involving contour trenching, furrowing, seeding with trees and grasses and building protective fences, at a cost of approx. $165,000.		
8/20/1959	N/A	Cloudburst Floods
Severe thunderstorms in the NE Boise Foothills were estimated to be a 50- to 100-year rainfall event; 0.30" of rain fell in 5 minutes at Deer Point. Earlier Lucky Peak fires had denuded the foothills of vegetation. Debris flows filled basements and yards in north and east Boise. Floodwaters were diverted along Broadway Avenue to the Boise River. Some 500 houses were damaged by mud; over 160 acres were covered by silt and debris. The agriculture area between Lucky Peak Dam and East Boise suffered extensive property, crop and livestock losses. The Boise police clubhouse on Mountain Cove Road was destroyed. The Idaho National Guard headquarters on Reserve Street was inundated.		
1/12/1958	N/A	Flash Flooding
A rainstorm that dumped over 2" of rain in Boise in a 12 hour period caused extensive flooding and heavy crop damage. Homes, roads and storm basins were flooded, several families were evacuated. The Boise Bench was hit hardest, with one family on Atlantic Street evacuated when their house was flooded with over a foot of water.		
2/25/1957	N/A	Flooding-tributaries
Parts of Eagle flooded by Dry Creek.		
8/1/1955	n/a	Flooding-Canals
200' section of the New York Canal broke 7 miles SE of Boise and flooded 200-300 acres of farmland with water, mud and rock. A dozen homes near the break were flooded with 3' of water and families were evacuated.		

10.2.3 Flooding Extent and Location

Major floods in Ada County have resulted from intense rainstorms between November and March. Flooding in portions of the county has been extensively documented by gage records, high water marks, damage surveys and personal accounts. This documentation was the basis for the October 2, 2003 DFIRM for Ada County generated by FEMA. Three sources of data were used to map the extent of the flood risk for this risk assessment:

- FEMA's 2003 DFIRM
- The Corps of Engineers' Boise River flood study from the Diversion Dam to the Glenwood Bridge
- The Idaho Department of Water Resources Boise River Flood Study from Glenwood Bridge to Canyon County Line.

There are questions as to which of these studies best reflects the true flood risk in the planning area, based on release rates from Lucky Peak Dam and split flow hydraulics at the head of Eagle Island. Until these issues can be resolved by the best available data, science and technology, the three sources of information are viewed cumulatively for this risk assessment. The areas of all three studies are merged into one flood risk area. Where these areas overlap, the deepest flood depth is used to measure flood vulnerability. This represents a conservative approach to assessing flood risk until a regionally accepted flood model can be developed. The resulting area of flood risk is shown on Figure 10-2.

10.2.4 Frequency

Ada County experiences episodes of river flooding almost every winter. Large floods that can cause property damage typically occur every three to seven years. Urban portions of the county annually experience nuisance flooding related to drainage issues.

10.2.5 Severity

The principal factors affecting flood damage are flood depth and velocity. The deeper and faster flood flows become, the more damage they can cause. Shallow flooding with high velocities can cause as much damage as deep flooding with slow velocity. This is especially true when a channel migrates over a broad floodplain, redirecting high velocity flows and transporting debris and sediment. Flood severity is often evaluated by examining peak discharges; Table 10-3 lists peak flows used by FEMA to map the floodplains of Ada County.

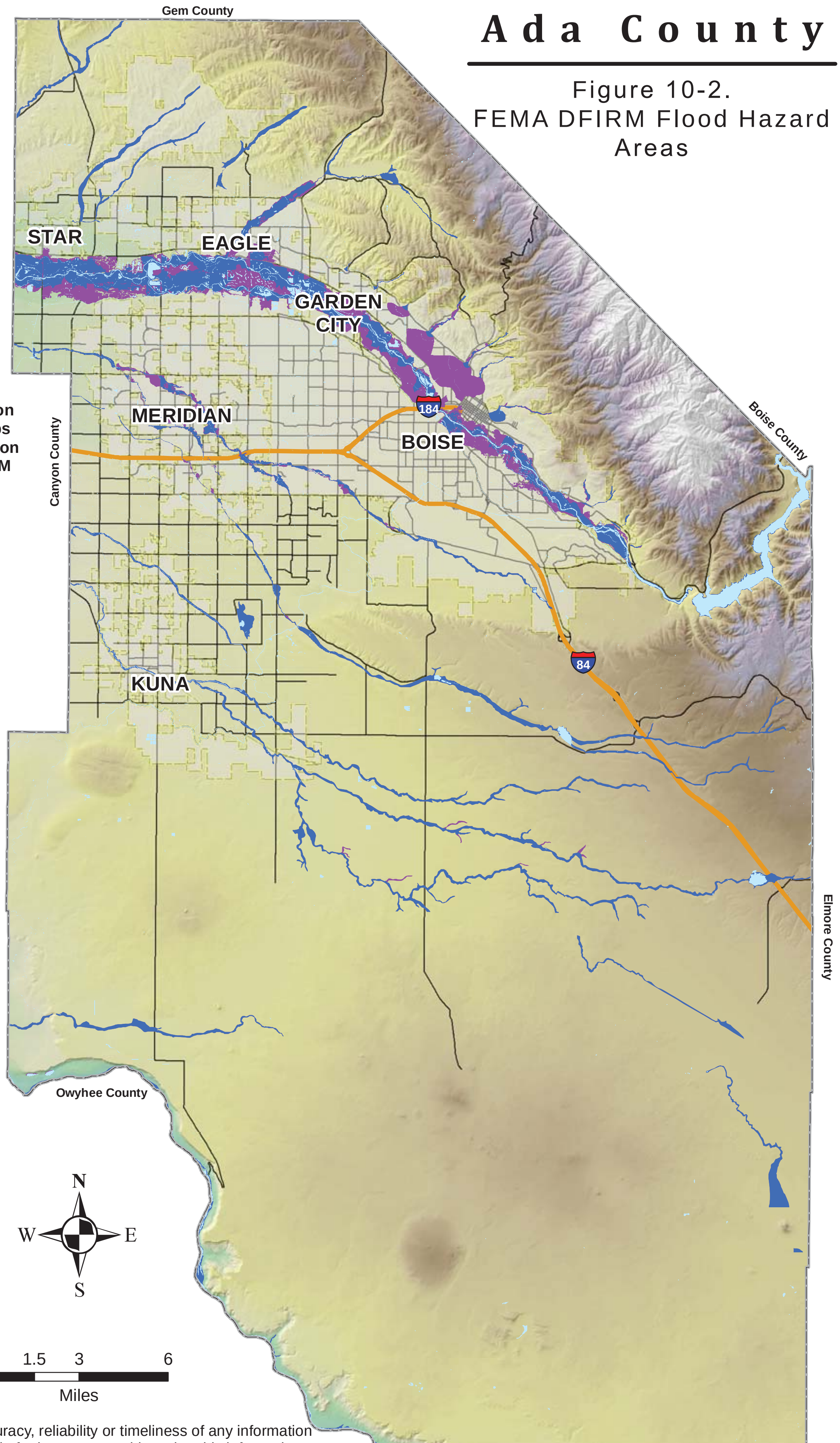
10.2.6 Warning Time

Due to the extended pattern of weather conditions needed to cause serious flooding, warning times for floods can be between 24 and 48 hours. Flash flooding can be less predictable, but potential hazard areas can be warned in advanced of potential flash flooding danger.

ACEM has developed a Flood Response Plan outlining the response to flooding in the planning area. Since flows on the Boise River system are regulated by the Corps of Engineers, warning on this system is tied to water release rates set by the Corps. Each significant increase in release rates from Lucky Peak Dam requires notification to emergency managers by the Corps. These announcements usually occur well in advance (24 to 48 hours) of increased release rates.

Ada County

Figure 10-2.
FEMA DFIRM Flood Hazard Areas



Legend

- 100-Year Flood Boundary
- 500-Year Flood Boundary

Flood Hazard Areas as depicted on FEMA Digital Insurance Rate Maps (DFIRM). This map is a combination of effective and preliminary DFIRM boundaries.

Base Map Data Sources:
Ada County, U.S. Geological Survey

N W E S

0 1.5 3 6
Miles

TETRA TECH

Ada County does not warrant the accuracy, reliability or timeliness of any information on this map, and shall not be held liable for losses caused by using this information.

Table 10-3. Summary of Peak Discharges Within Ada County

Source/Location	Drainage Area (Square Miles)	Discharge (cubic feet/second)			
		10-Year	50-Year	100-Year	500-Year
Boise River at Lucky Peak Dam (regulated flows)	2,250	7,200	11,000	16,600	34,800
Boise River Side Channel at Park Center	N/A	N/A	N/A	675	N/A
Cottonwood Gulch-at mouth	16.5	242	1,450	3,650	25,500
Cottonwood Gulch-above Freestone Creek	11.7	192	1,016	2,688	19,282
Crane Gulch-at mouth	7.8	154	376	1,030	8,428
Dry Creek-at Eagle	67	610	2,700	4,000	13,200
Dry Creek-below confluence w/ Spring Valley Creek	35.1	--	--	3650	--
Dry Creek-5700 feet downstream of Cartwright Rd	--	--	--	2,230	--
Eightmile Creek-at confluence with Fivemile Creek	16.7	330	525	590	850
Eightmile Creek-at Victory Rd.	13.4	275	390	425	580
Eightmile Creek-above New York Canal	9.9	300	700	950	1,800
Fivemile Creek-below Ninemile Creek	5.6	70	135	175	290
Fivemile Creek-below Eightmile Creek	52.5	530	780	900	1,375
Fivemile Creek-below Threemile Creek	33	300	390	440	650
Fivemile Creek-below New York Canal	30.2	250	280	300	500
Fivemile Creek-above New York Canal	30.2	725	1450	1850	3,000
Highland Valley Gulch	2.5	150	940	1,250	2,100
Hulls Gulch-at mouth	4.3	108	263	360	2,200
Maynard Gulch	2.3	150	830	1,100	1,850
Ninemile Creek-at Tenmile Rd.	5.6	70	135	175	290
Ninemile Creek- at Locust Grove Rd.	2.9	40	80	95	150
Pierce Gulch	2.0	140	760	1,100	1,700
Polecat Gulch	1.2	110	580	780	1,300
Seaman Gulch	1.8	140	760	1,100	1,700
Stuart Gulch-at mouth	9.1	169	538	1,494	11,794
Tenmile Creek-at Roosevelt Rd.	10.0	215	415	510	820
Tenmile Creek-at Tenmile Community Church	1.8	83	160	200	320
Tenmile Creek-at Interstate 84	6.5	185	350	440	680
Warms Springs Creek	5.0	230	1,860	2,500	4,300

The National Weather Service (NWS) uses a two-tiered warning system for flash flooding:

- A Flash Flood Watch covers a large area (a thousand square miles or greater, usually several counties) for up to 12 hours. A Flash Flood Watch is issued when conditions are favorable to produce flash flooding on the Boise Foothills within the next 12 hours.
- A Flash Flood Warning generally covers a very small area (a few square miles to several hundred square miles) for up to 6 hours. A flash flood warning for the Boise Foothills is issued under the following conditions:
    - Rainfall in the Boise Foothills is occurring or is imminent and is falling at a rate that could cause flash flooding.
    - Heavy rainfall is falling on snowpack and flash flooding is occurring or imminent.

- Flash flooding is occurring and has been confirmed by stream flow gauges, NWS spotters, emergency responders or citizens.

There is no warning system for flooding from canal breaches or failures. Warning for failures of these systems will occur likely well after the event has begun.

10.2.7 Natural and Beneficial Floodplain Functions

What Are Beneficial Floodplain Functions?

Flooding is a natural event, and floodplains provide many natural and beneficial functions. Riparian areas—the zones along the edge of a river or stream that are influenced by or are an influence upon the water body—generally have a greater diversity and structure of vegetation than upland areas. Shelter, space, food and water available in these areas determine the health of wildlife populations. Riparian communities are of special importance for many animals since water supply is a major limiting factor to the animals' population. Animals depend upon a supply of water for their existence.

CRS Credit for Protecting Natural Floodplain Functions

Wildlife and fisheries are impacted when plant communities are eliminated or fundamentally altered to reduce habitat. Human disturbance to riparian areas can limit wildlife's access to water, remove breeding or nesting sites, and eliminate suitable areas for rearing young. Changes in hydrologic conditions also can alter the plant community. FEMA's Community Rating System provides credits for adopting plans that protect one or more natural functions within a community's floodplain (Activity 510), such as the following (FEMA, 2013):

- A habitat conservation plan that explains and recommends actions to protect rare, threatened, or endangered aquatic or riparian species
- A habitat protection or restoration plan that identifies critical habitat within the floodplain, actions to protect remaining habitat, or actions to restore fully functioning habitat.
- A green infrastructure plan that identifies open space corridors or connected networks of wetlands, woodlands, wildlife habitats, wilderness, and other areas that support native species, maintain natural ecological processes, or sustain air and water resources (the corridors or networks must include some floodplains)
- All or part of a comprehensive or other community plan that includes an inventory of the ecological attributes of a watershed or floodplain and recommends actions for protecting them through a mechanism such as a development regulation, development order, grant program, or capital improvement plan.

The credit requires that the following criteria be met:

- The plan may cover more than one community, but it must have an impact on natural floodplain functions within the community seeking credit.
- The plan must be adopted. If the plan is not a community plan adopted by the community's governing body, it must be adopted by an appropriate regional agency.
- The plan must be updated at least once every 10 years. The update must include a review of any changes to conditions as well as progress made since the original plan was prepared. Any changes to the adopted plan must be approved by the original adopting agency.
- The plan must include action items for protecting one or more identified species of interest and natural floodplain functions. The action items must describe who is responsible for implementing the action, how it will be funded, and when it will be done. General policy statements with no means of implementation are not considered action items.

- There is no credit (under CRS Activity 510) for a plan that addresses water quality issues as a requirement for a permit under the National Pollution Discharge Elimination System (credit for such plans may be available under other CRS activities).
- The plan must include a comprehensive inventory of the natural floodplain habitat within the community. It must identify areas that warrant protection or preservation in order to maintain fully functioning habitat for the species of interest. Where threatened or endangered species are present, each species must be addressed and a restoration plan must be included.
- A community can get credit for other plans that meet these credit criteria. These could be single-issue or single-species plans or plans that cover only one area of the community's floodplain.

The Boise River Enhancement Plan

In early 2011, local stakeholders planned a workshop on environmental enhancement opportunities on the Boise River. All interested individuals and organizations were invited to participate. An organizing committee of nonprofit and for-profit staff, volunteers and agency representatives agreed on the following workshop goal:

> To increase opportunities for public and private ecosystem enhancement of the Lower Boise River by establishing networks, building knowledge, envisioning possibilities and tackling challenges.

The workshop, titled "From Vision to Reality," brought together 106 area experts, academics, decision makers, and citizens to discuss the challenges and opportunities for environmental enhancement of the Boise River. The workshop identified key enhancement goals and interests, challenges to enhancement, approaches to enhancements and key next steps. Participants identified that the most important next step was to continue the group and develop a plan.

Interested organizations the formed the Boise River Enhancement Network (BREN). This group received a grant from the Bureau of Reclamation's WaterSMART program to establish a watershed group and write a watershed enhancement plan. BREN used the results of the workshop to identify key subject areas. The *Boise River Enhancement Plan* is a result of these efforts.

This plan was developed through an extensive literature review and stakeholder feedback process. From the existing literature and research, summary reports were created for four subject areas: geomorphology, fisheries and aquatic habitat, wetland and riparian habitat, and water quality. The summary reports were presented at four workshops, posted online and reviewed by expert panels. The subject papers were then revised and the most pertinent issues and solutions were identified for application in the Enhancement Plan.

The subject papers are included as appendices to the Enhancement Plan. Additional appendices include a high-level geomorphic assessment performed as part of the BREN effort, case studies of ongoing activities in the watershed, BREN governance and outreach documentation, and project concepts from other watersheds. The appendices provide citations, justification and detail for the Enhancement Plan. The draft plan was released to the public and presented to public and private groups, and underwent a comment and review period that involved significant outreach.

The goal of the Enhancement Plan is to provide an overview of the ecological condition of the river and to identify key issues and effective enhancement opportunities. The plan identifies projects that bring the greatest benefit to multiple ecological subject areas and recommends a collaborative approach to achieve the vision. Important next steps include continuing outreach, research, funding and identification of site-specific actions.

The Boise River Enhancement Plan will meet CRS beneficial function requirements for the Ada County planning area. Integrating elements of the Boise River Enhancement Plan with the Hazard Mitigation Plan will provide an opportunity to review both documents through the plan maintenance protocol identified in the Mitigation Plan.

This will ensure viability and integration of both plans as the community seeks to make the Ada County planning area more flood-resilient. The complete Boise River Enhancement Plan, providing detailed information on the natural and beneficial floodplain functions of the Boise River, is provided in Appendix D of this volume. Jurisdictions that choose to support or enhance actions identified in the Enhancement Plan have done so by identifying and prioritizing actions in their jurisdictional annexes in Volume 2 of the Hazard Mitigation Plan.

10.3 SECONDARY HAZARDS

The most problematic secondary hazard for flooding is bank erosion, which in some cases can be more harmful than actual flooding. This is especially true in the upper courses of rivers with steep gradients, where floodwaters may pass quickly and without much damage, but scour the banks, edging properties closer to the floodplain or causing them to fall in. Flooding is also responsible for hazards such as landslides when high flows over-saturate soils on steep slopes, causing them to fail. Hazardous materials spills are a secondary hazard of flooding if storage tanks rupture and spill into streams or storm sewers.

10.4 EXPOSURE

A Level 2 Hazus-MH analysis was used to assess exposure to flooding in the planning area. The model used census data at the block level and FEMA floodplain data, which has a level of accuracy acceptable for planning purposes. Where possible, the Hazus-MH default data was enhanced using local GIS data from county, state and federal sources.

10.4.1 Population

Counts of those living in the floodplain in the planning area were generated by analyzing census blocks that intersect with the 100-year and 500-year floodplains identified on FIRMs. Census blocks do not follow the boundaries of the floodplain, so these estimates counted census block groups whose centers are in the floodplain or where the majority of the population most likely lives in or near the floodplain. The population living in the floodplain was estimated by calculating the percentage of total planning area residential structures in the floodplain and applying that percentage to the total planning area population based on U.S. Census data.

The estimated exposed planning area population is 10,662 in the 100-year floodplain (2.5 percent of the total county population) and 46,737 in the 500-year floodplain (10.97 percent of the total). For the unincorporated portions of the county, the estimated exposed population is 690 in the 100-year floodplain (1.08 percent of the total unincorporated county population) and 1,030 in the 500-year floodplain (1.61 percent of the total).

10.4.2 Property

Structures in the Floodplain

Table 10-4 and Table 10-5 summarize the total area and number of structures in the floodplain by municipality. The Hazus-MH model determined that there are 3,766 structures in the 100-year floodplain and 16,785 structures in the 500-year floodplain. In the 100-year floodplain, about 5 percent of these structures are in unincorporated areas, 92.6 percent are residential, and 7.1 percent are commercial or industrial.

Table 10-4. Area and Structures Within the 100-Year Floodplain

	Area in Floodplain (Acres)	Number of Structures in Floodplain							
		Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Boise	2,377.46	888	69	2	0	0	2	0	961
Eagle	2,696.96	587	73	1	0	0	0	0	661
Garden City	840.91	1,012	49	0	0	4	1	0	1066
Kuna	349.73	6	0	0	0	0	0	0	6
Meridian	528.08	279	56	1	0	0	1	0	337
Star	879.86	513	7	0	0	1	0	0	521
Unincorporated	15,255.56	203	10	0	0	1	0	0	214
Total	22,928.56	3,488	264	4	0	6	4	0	3,766

Table 10-5. Area and Structures Within the 500-Year Floodplain

	Area in Floodplain (Acres)	Number of Structures in Floodplain							
		Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Boise	5,918.97	8,571	585	2	0	19	4	9	9190
Eagle	3,906.50	1,927	250	1	0	3	3	0	2184
Garden City	2,085.89	2,779	421	0	0	8	3	0	3211
Kuna	349.73	6	0	0	0	0	0	0	6
Meridian	907.12	1,068	79	1	0	2	2	1	1153
Star	1,084.38	692	24	0	0	2	2	0	720
Unincorporated	17,240.83	303	15	0	0	2	1	0	321
Total	31,493.42	15,346	1374	4	0	36	15	10	16,785

Exposed Value

Table 10-6 and Table 10-7 summarize the estimated value of exposed buildings in the planning area. This methodology estimated $3.22 billion worth of building-and-contents exposure to the 100-year flood, representing 3.84 percent of the total assessed value of the planning area, and $11.3 billion worth of building-and-contents exposure to the 500-year flood, representing 13.49 percent of the total.

Table 10-6. Value of Exposed Buildings Within 100-Year Floodplain

	Estimated Flood Exposure			% of Total Assessed Value
	Structure	Contents	Total	
Boise	$678,732,818	$501,207,766	$1,179,940,584	2.59%
Eagle	$423,226,947	$295,946,750	$719,173,697	12.28%
Garden City	$398,357,803	$238,069,049	$636,426,852	21.62%
Kuna	$2,179,289	$1,089,644	$3,268,933	0.17%
Meridian	$162,910,326	$119,412,360	$282,322,687	1.66%
Star	$164,433,864	$85,929,485	$250,363,349	21.17%
Unincorporated	$93,653,202	$53,448,925	$147,102,127	1.59%
Total	$1,923,494,249	$1,295,103,979	$3,218,598,229	3.84

Table 10-7. Value of Exposed Buildings Within 500-Year Floodplain

	Estimated Flood Exposure			% of Total Assessed Value
	Structure	Contents	Total	
Boise	$3,572,021,616	$2,401,515,260	$5,973,536,876	13.09%
Eagle	$1,157,980,909	$788,599,987	$1,946,580,896	33.23%
Garden City	$1,271,355,350	$841,213,959	$2,112,569,309	71.78%
Kuna	$2,179,289	$1,089,644	$3,268,933	0.17%
Meridian	$395,100,205	$250,299,550	$645,399,755	3.78%
Star	$219,108,818	$118,540,564	$337,649,382	28.55%
Unincorporated	$179,605,838	$113,987,142	$293,592,980	3.17%
Total	$6,797,352,025	$4,515,246,106	$11,312,598,131	13.49

Land Use in the 100-Year Floodplain

Some land uses are more vulnerable to flooding, such as single-family homes, while others are less vulnerable, such as agricultural land or parks. Table 10-8 shows the existing land use of all unincorporated parcels in the 100-year and 500-year floodplain within the Ada County planning area.

Table 10-8. Land Use Within the Floodplain

	100-Year Floodplain		500-Year Floodplain	
Land Use	Area (acres)	% of total	Area (acres)	% of total
Agriculture	3,407.05	14.84%	4,459.40	14.16%
Agriculture Prime Farmland	3,404.75	14.83%	3,905.18	12.40%
Commercial Retail and Office	759.93	3.31%	1,810.87	5.75%
Industrial	107.91	0.47%	119.67	0.38%
Open Space	2,410.65	10.50%	2,943.60	9.35%
Other	2,874.41	12.52%	3,668.98	11.65%
Public/Government	6,219.47	27.09%	7,186.80	22.82%
Residential	3,480.51	15.16%	6,590.57	20.93%
Residential TOD Density	259.44	1.13%	518.61	1.65%
Schools	34.44	0.15%	289.74	0.92%
Total	22,958.56	100.00%	31,493.42	100%

About 40 percent of the area in the 100-year floodplain is zoned for agricultural or open space uses. These are favorable, lower-risk uses for the floodplain. The amount of the floodplain that contains vacant, developable land is not known. This would be valuable information for gauging the future development potential of the floodplain.

10.4.3 Critical Facilities and Infrastructure

The critical facilities and infrastructure in the 100-year and 500-year floodplains of Ada County are summarized in Table 10-9 through Table 10-12. Details are provided in the following sections.

Table 10-9. Critical Facilities in the 100-Year Floodplain

	Medical and Health Services	Government Function	Protective	Hazardous Materials	Schools	Other	Total
Boise	1	2	1	0	10	3	17
Eagle	1	0	0	0	0	0	1
Garden City	0	1	0	3	0	0	4
Kuna	0	0	0	0	0	0	0
Meridian	0	1	1	0	0	0	2
Star	0	0	0	0	0	0	0
Unincorporated	0	1	1	0	1	6	9
Total	2	5	3	3	11	9	33

Table 10-10. Critical Facilities in the 500-Year Floodplain

	Medical and Health Services	Government Function	Protective	Hazardous Materials	Schools	Other	Total
Boise	1	9	6	0	142	3	161
Eagle	1	2	3	0	4	0	10
Garden City	0	1	3	4	1	0	9
Kuna	0	0	0	0	0	0	0
Meridian	0	1	2	0	1	0	4
Star	0	2	2	0	0	0	4
Unincorporated	0	2	2	0	1	6	10
Total	2	17	18	4	149	9	198

Table 10-11. Critical Infrastructure in the 100-Year Floodplain

	Transportation Systems	Water Supply	Wastewater	Power	Communications	Other	Total
Boise	41	17	0	0	0	0	58
Eagle	6	7	0	1	0	0	14
Garden City	2	2	0	0	0	0	4
Kuna	4	0	0	0	0	0	4
Meridian	19	2	0	1	0	0	22
Star	2	0	1	0	0	0	3
Unincorporated	59	4	0	3	0	0	66
Total	133	32	1	5	0	0	171

Table 10-12. Critical Infrastructure in the 500-Year Floodplain

	Transportation Systems	Water Supply	Wastewater	Power	Communications	Other	Total
Boise	66	33	0	2	2	0	103
Eagle	7	13	0	1	0	0	21
Garden City	7	14	0	0	0	0	21
Kuna	4	0	0	0	0	0	4
Meridian	20	3	0	1	0	0	24
Star	3	1	1	0	0	0	5
Unincorporated	63	8	0	3	0	0	74
Total	170	72	1	7	2	0	252

Tier II Facilities

Tier II facilities are those that use or store materials that can harm the environment if damaged by a flood. Four businesses in the 100-year floodplain and eight businesses in the 500-year floodplain report having Tier II hazardous materials. During a flood event, containers holding these materials can rupture and leak into the surrounding area, having a disastrous effect on the environment as well as residents.

Utilities and Infrastructure

Roads or railroads that are blocked or damaged can isolate residents and can prevent access throughout the county, including for emergency service providers needing to get to vulnerable populations or to make repairs. Bridges washed out or blocked by floods or debris also can cause isolation. Water and sewer systems can be flooded or backed up, causing health problems. Underground utilities can be damaged. Dikes can fail or be overtopped, inundating the land that they protect. The following sections describe specific types of critical infrastructure.

Roads

The following major roads in Ada County pass through the 100-year floodplain and thus are exposed to flooding:

- 8th Street
- Broadway Avenue
- Capitol Blvd.
- Eagle Road
- Eckert Road
- Glenwood Street
- Highway 21
- Highway 44
- Highway 55
- Interstate 84 (Connector)
- Linder Road
- Veterans Memorial Parkway

Some of these roads are built above the flood level, and others function as levees to prevent flooding. Still, in severe flood events these roads can be blocked or damaged, preventing access to some areas.

Bridges

Flooding events can significantly impact road bridges. These are important because often they provide the only ingress and egress to some neighborhoods. An analysis showed that there are 97 bridges that are in or cross over the 100-year floodplain and 142 bridges in the 500-year floodplain.

Water and Sewer Infrastructure

Water and sewer systems can be affected by flooding. Floodwaters can back up drainage systems, causing localized flooding. Culverts can be blocked by debris from flood events, also causing localized urban flooding. Floodwaters can get into drinking water supplies, causing contamination. Sewer systems can be backed up, causing wastewater to spill into homes, neighborhoods, rivers and streams. An analysis showed that there are 26 water/wastewater facilities within the 100-year floodplain and 63 facilities within the 500-year floodplain.

Canals

There are more than two dozen canal systems that extend approximately 400 miles within the planning area. Information on these facilities is very limited. Therefore the true exposure and vulnerability of these facilities is not known at this time.

10.4.4 Environment

Flooding is a natural event, and floodplains provide many natural and beneficial functions. Nonetheless, with human development factored in, flooding can impact the environment in negative ways. Migrating fish can wash into roads or over dikes into flooded fields, with no possibility of escape. Pollution from roads, such as oil, and hazardous materials can wash into rivers and streams. During floods, these can settle onto normally dry soils, polluting them for agricultural uses. Human development such as bridge abutments and levees, and logjams from timber harvesting can increase stream bank erosion, causing rivers and streams to migrate into non-natural courses.

Many species of mammals, birds, reptiles, amphibians and fish live in Ada County in plant communities that are dependent upon streams, wetlands and floodplains. Changes in hydrologic conditions can result in a change in the plant community. Wildlife and fish are impacted when plant communities are eliminated or fundamentally altered to reduce habitat. Wildlife populations are limited by shelter, space, food and water. Since water supply is a major limiting factor for many animals, riparian communities are of special importance. Riparian areas are the zones along the edge of a river or stream that are influenced by or are an influence upon the water body. Human disturbance to riparian areas can limit wildlife's access to water, remove breeding or nesting sites, and eliminate suitable areas for rearing young. Wildlife relies on riparian areas in the following ways:

- Mammals depend upon a supply of water for their existence. Riparian communities have a greater diversity and structure of vegetation than other upland areas. Beavers and muskrats are now recolonizing streams, wetlands and fallow farm fields, which are converted wetlands. As residences are built in rural areas, there is an increasing concern with beaver dams causing flooding of low-lying areas and abandoned farm ditches being filled in, which can lead to localized flooding.
- A great number of birds are associated with riparian areas. They swim, dive, feed along the shoreline, or snatch food from above. Rivers, lakes and wetlands are important feeding and resting areas for migratory and resident waterfowl. Threatened or endangered species such as the bald eagle or the peregrine falcon eat prey from these riparian areas.
- Amphibians and reptiles are some of the least common forms of wildlife in riparian areas, but species such as the western pond turtle and the spotted frog are known to inhabit the waterways and wetlands.
- Fish habitat throughout the county varies widely based on natural conditions and human influence.

10.5 VULNERABILITY

Many of the areas exposed to flooding may not experience serious flooding or flood damage. This section describes vulnerabilities in terms of population, property, infrastructure and environment.

10.5.1 Population

Vulnerable Groups

A geographic analysis of demographics, using the Hazus-MH model and data from the U.S. Census Bureau and Dun & Bradstreet, identified populations vulnerable to the flood hazard as follows:

- **Economically Disadvantaged Populations**—It is estimated that 7 percent of the people within the 100-year floodplain are economically disadvantaged, defined as having household incomes of $10,000 or less.
- **Population over 65 Years Old**—It is estimated that 5 percent of the population in the census blocks that intersect the 100-year floodplain are over 65 years old. Approximately 2 percent of the over-65 population in the floodplain also have incomes considered to be economically disadvantaged and are considered to be extremely vulnerable.
- **Population under 16 Years Old**—It is estimated that 12 percent of the population within census blocks in or near the 100-year floodplain are under 16 years of age.

Displacement and Shelter Needs

Hazus estimated that a 100-year flood could displace up to 4,530 people, with 4,130 of those people needing short-term shelter. For a 500-year event, Hazus estimated that up to 29,000, people could be displaced, with 26,541 needing short-term shelter

Public Health and Safety

Floods and their aftermath present the following threats to public health and safety:

- **Unsafe food—**Floodwaters contain disease-causing bacteria, dirt, oil, human and animal waste, and farm and industrial chemicals. Their contact with food items, including food crops in agricultural lands, can make that food unsafe to eat. Refrigerated and frozen foods are affected during power outages caused by flooding. Foods in cardboard, plastic bags, jars, bottles, and paper packaging may be unhygienic with mold contamination.
- **Contaminated drinking and washing water and poor sanitation—**Flooding impairs clean water sources with pollutants. The pollutants also saturate into the groundwater. Flooded wastewater treatment plants can be overloaded, resulting in backflows of raw sewage. Private wells can be contaminated by floodwaters. Private sewage disposal systems can become a cause of infection if they or overflow.
- **Mosquitoes and animals—**Floods provide new breeding grounds for mosquitoes in wet areas and stagnant pools. The public should dispose of dead animals that can carry viruses and diseases only in accordance with guidelines issued by local animal control authorities. Leptospirosis—a bacterial disease associated predominantly with rats—often accompanies floods in developing countries, although the risk is low in industrialized regions unless cuts or wounds have direct contact with disease-contaminated floodwaters or animals.
- **Mold and mildew—**Excessive exposure to mold and mildew can cause flood victims—especially those with allergies and asthma—to contract upper respiratory diseases, triggering cold-like symptoms. Molds grow in as short a period as 24 to 48 hours in wet and damp areas of buildings and homes that have not been cleaned after flooding, such as water-infiltrated walls, floors, carpets, toilets and bathrooms. Very small mold spores can be easily inhaled by human bodies and, in large enough quantities, cause allergic reactions, asthma episodes, and other respiratory problems. Infants, children, elderly people and pregnant women are considered most vulnerable to mold-induced health problems.
- **Carbon monoxide poisoning—**In the event of power outages following floods, some people use alternative fuels for heating or cooking in enclosed or partly enclosed spaces, such as small gasoline engines, stoves, generators, lanterns, gas ranges, charcoal or wood. Built-up carbon monoxide from these sources can poison people and animals.
- **Hazards when reentering and cleaning flooded homes and buildings—**Flooded buildings can pose significant health hazards to people entering them. Electrical power systems can become hazardous. Gas leaks can trigger fire and explosion. Flood debris—such as broken bottles, wood, stones and walls—may cause injuries to those cleaning damaged buildings. Containers of hazardous chemicals may be buried under flood debris. Hazardous dust and mold can circulate through a building and be inhaled by those engaged in cleanup and restoration.
- **Mental stress and fatigue—**People who live through a devastating flood can experience long-term psychological impact. The expense and effort required to repair flood-damaged homes places severe financial and psychological burdens on the people affected. Post-flood recovery can cause, anxiety, anger, depression, lethargy, hyperactivity, and sleeplessness. There is also a long-term concern among the affected that their homes can be flooded again in the future.

Current loss estimation models such as Hazus are not equipped to measure public health impacts such as these. The best level of mitigation for these impacts is to be aware that they can occur, educate the public on prevention, and be prepared to deal with them in responding to flood events.

10.5.2 Property

Hazus-MH calculates losses to structures from flooding by looking at depth of flooding and type of structure. Using historical flood insurance claim data, Hazus-MH estimates the percentage of damage to structures and their contents by applying established damage functions to an inventory. For this analysis, local data on facilities was used instead of the default inventory data provided with Hazus-MH.

The analysis is summarized in Table 10-13. It is estimated that there would be up to $159.9 million of flood loss from a 100-year flood event in the planning area. This represents 4.97 percent of the total exposure to the 100-year flood and 0.19 percent of the total assessed value for the county. It is estimated that there would be $1.892 billion of flood loss from a 500-year flood event, representing 16.73 percent of the total exposure to a 500-year flood event and 2.26 percent of the total assessed value.

Table 10-13. Estimated Flood Loss for the 100-Year and 500-Year Flood Events

	Structures Impacted[a]	Estimated Flood Loss			% of Total Assessed Value
		Structural	Contents	Total	
100-Year Flood					
Boise	539	$43,464,974	$24,277,805	$67,742,779	0.15%
Eagle	258	$13,428,314	$7,950,047	$21,378,361	0.36%
Garden City	495	$19,651,136	$13,868,259	$33,519,395	1.14%
Kuna	6	$261,936	$101,495	$363,431	0.02%
Meridian	156	$5,879,123	$6,842,483	$12,721,605	0.07%
Star	168	$7,877,250	$3,338,550	$11,215,800	0.95%
Unincorporated	122	$7,759,438	$5,186,600	$12,946,038	0.14%
Total	1,744	$98,322,171	$61,565,239	$159,887,409	0.19%
500-Year Flood					
Boise	8,556	$622,337,426	$582,915,587	$1,205,253,013	2.64%
Eagle	1,013	$73,766,553	$111,180,185	$184,946,738	3.16%
Garden City	2,635	$153,330,363	$152,858,473	$306,188,836	10.40%
Kuna	5	$237,997	$102,265	$340,262	0.02%
Meridian	872	$65,586,307	$50,571,279	$116,157,586	0.68%
Star	501	$24,922,030	$18,067,464	$42,989,493	3.63%
Unincorporated	250	$16,189,463	$20,685,172	$36,874,635	0.40%
Total	13,832	$956,370,139	$936,380,425	$1,892,750,563	2.26%

a. Impacted structures are those structures with finished floor elevations below the 100-year water surface elevation. These structures are the most likely to receive significant damage in a 100-year flood event

National Flood Insurance Program

Table 10-14 lists flood insurance statistics that help identify vulnerability in Ada County. Seven communities in the planning area participate in the NFIP, with 1,950 flood insurance policies providing $551 million in insurance coverage. According to FEMA statistics, 77 flood insurance claims were paid between January 1, 1978 and May 31, 2016, for a total of $205,425 an average of $2,668 per claim.

Table 10-14. Flood Insurance Statistics for Ada County

Jurisdiction	Date of Entry Initial FIRM Effective Date	# of Flood Insurance Policies as of 5/31/2016	Insurance In Force	Total Annual Premium	Claims, 11/1978 to 5/31/2016	Value of Claims paid, 11/1978 to 5/31/2016
Boise	4/17/1984	731	$206,062,400	$536,070	43	$95,741
Eagle	3/04/1980	285	$99,930,100	$169,578	2	$19,227
Garden City	5/15/1980	484	$131,922,800	$313,091	12	$25,661
Kuna	10/02/2003	1	$170,300	$962	0	$0
Meridian	9/27/1991	112	$24,336,800	$91,120	1	$23,747
Star	12/18/1984	31	$6,369,000	$31,266	0	$0
Unincorporated	12/18/1984	306	$81,786,000	$181,108	19	$41,049
Total		1,950	$550,577,400	$1,323,195	77	$205,425

The following information from flood insurance statistics is relevant to reducing flood risk:

- The flood insurance policy base decreased by 7 percent over the performance period of the 2011 plan.
- The average cost of a flood insurance policy increased by over $145 per policy (27.6 percent). This increase could be attributed to flood insurance reform initiated in 2012.
- Nine claims were filed during the performance period, for a total payout of $11,268 ($1,252 per claim). Three of the nine claims were outside the SFHA.
- The use of flood insurance in Ada County is above the national average. Approximately 51.7 percent of insurable buildings in the county are covered by flood insurance. According to an NFIP study, about 49 percent of single-family homes in special flood hazard areas are covered by flood insurance nationwide.
- The average claim paid in the planning area represents less than 1 percent of the 2011 average assessed value of structures in the floodplain.
- The types of flood events triggering flood insurance activity do not appear to be significant.
- The percentage of policies and claims outside a mapped floodplain suggests that not all of the flood risk in the planning area is reflected in current mapping. Based on information from the NFIP, 48.6 percent of policies in the planning area are on structures within an identified SFHA, and 51.4 percent are for structures outside such areas. Of total claims paid, 19.1 percent were for properties outside an identified 100-year floodplain.

Repetitive Loss

A repetitive loss property is defined by FEMA as an NFIP-insured property that has experienced any of the following since 1978, regardless of any changes in ownership:

- Four or more paid losses in excess of $1,000
- Two paid losses in excess of $1,000 within any rolling 10-year period
- Three or more paid losses that equal or exceed the current value of the insured property.

Repetitive loss properties make up 1 to 2 percent of flood insurance policies in force nationally, yet they account for 40 percent of the nation's flood insurance claim payments. The government has instituted programs encouraging communities to identify and mitigate the causes of repetitive losses. A recent report on repetitive losses by the National Wildlife Federation found that 20 percent of these properties are outside any mapped 100-year floodplain. The key identifiers for repetitive loss properties are the existence of flood insurance policies and claims paid by the policies.

FEMA-sponsored programs, such as the CRS, require participating communities to identify repetitive loss areas. A repetitive loss area is the portion of a floodplain holding structures that FEMA has identified as meeting the definition of repetitive loss. Identifying repetitive loss areas helps to identify structures that are at risk but are not on FEMA's list of repetitive loss structures because no flood insurance policy was in force at the time of loss. Based on data provided by the IDWR, there were no identified repetitive loss properties within the planning area as of May 31, 2016.

10.5.3 Critical Facilities and Infrastructure

Hazus-MH was used to estimate the flood loss potential to critical facilities exposed to the flood risk. Using depth/damage function curves to estimate the percent of damage to the building and contents of critical facilities, Hazus-MH correlates these estimates into an estimate of functional down-time (the estimated time it will take to restore a facility to 100 percent of its functionality). This helps to gauge how long the planning area could have limited usage of facilities deemed critical to flood response and recovery. The Hazus critical facility results are as follows:

- 100-year flood event—On average, critical facilities would receive 4.78 percent damage to the structure and 21.9 percent damage to the contents during a 100-year flood event. The estimated time to restore these facilities to 100 percent of their functionality is 480 days.
- 500-year flood event—A 500-year flood event would damage the structures an average of 9.6 percent and the contents an average 52.9 percent. The estimated time to restore these facilities to 100 percent of their functionality after a 500-year event is 539 days.

10.6 DEVELOPMENT TRENDS

The value of planning area properties exposed to the 100-year flood hazard has increased by 5.6 percent ($1.5 billion) since the last hazard mitigation plan update in 2011. The value exposed to the 500-year flood hazard has increased by 33 percent. This increase in risk exposure can be attributed to the population growth of 10.7 percent in the same period and property value increases associated with continued economic recovery from the 2008 economic downturn (see Section 4.5.3).

Current comprehensive planning in the planning area appears to be adequately equipped to dictate sound land use practices within the designated floodplain. The key to this will be to identify flood hazard areas that accurately reflect the true flood risk within the planning area. Ada County is in the process of finalizing new flood maps through FEMA's Risk MAP (Risk Mapping, Assessment and Planning) program. The new maps will be based on the abundance of available information on flood risk from creditable agencies such as IDWR and the Corps of Engineers.

All municipal planning partners for this plan are participants in the NFIP and have adopted flood damage prevention ordinances in response to its requirements. With 71 percent of communities in the county participating in the CRS program, there is incentive to adopt consistent, appropriate, higher regulatory standards in communities with the highest degree of flood risk. All municipal planning partners have committed to maintaining their good standing under the NFIP through actions identified in this plan. Communities participating or considering participation in the CRS program will be able to refine this commitment using CRS programs and templates as a guide.

10.7 SCENARIO

The primary water courses in Ada County have the potential to flood at irregular intervals, generally in response to a succession of intense thunderstorms in summer or rain-on-snowpack events in winter. Storm patterns of warm, moist air usually occur between early November and late March. A series of such weather events can cause severe flooding in the planning area. The worst-case scenario is a series of storms that flood numerous drainage basins in a short time. This could overwhelm the response and floodplain management capability within the planning area. Major roads could be blocked, preventing critical access for many residents and critical functions. High in-channel flows could cause water courses to scour, possibly washing out roads and creating more isolation problems.

Additionally, the potential impacts of climate change on the operations of Lucky Peak Dam are real. The Boise River could see increased flows in response to a changing hydrograph that dictates dam operations.

10.8 ISSUES

The planning team has identified the following flood-related issues relevant to the planning area:

- Flood hazard maps should be updated with the best available data, science and technology to reflect actual flood risk.
- The extent of the flood-protection currently provided by flood control facilities (dams, dikes and levees) is not known due to the lack of an established national policy on flood protection standards.
- The risk associated with the flood hazard overlaps the risk associated with other hazards such as earthquake, landslide and fishing losses. This provides an opportunity to seek mitigation alternatives with multiple objectives that can reduce risk for multiple hazards.
- Additional efforts to coordinate land-use practices across all affected jurisdictions within the planning area are needed to expand floodplain management practices beyond the minimum requirements of the NFIP.
- Potential climate change could alter flood conditions in Ada County.
- More information is needed on flood risk to support the concept of risk-based analysis of capital projects.
- There needs to be a sustained effort to gather historical damage data, such as high water marks on structures and damage reports, to measure the cost-effectiveness of future mitigation projects.
- Ongoing flood hazard mitigation will require funding from multiple sources.
- There needs to be a coordinated hazard mitigation effort between jurisdictions affected by flood hazards in the county.
- Floodplain residents need to continue to be educated about flood preparedness and the resources available during and after floods.
- The concept of residual risk should be considered in the design of future capital flood control projects and should be communicated with residents living in the floodplain.
- The promotion of flood insurance as a means of protecting private property owners from the economic impacts of frequent flood events should continue.
- Existing floodplain-compatible uses such as agricultural and open space need to be maintained. There is constant pressure to convert these existing uses to more intense uses within the planning area during times of moderate to high growth.
- The economy affects a jurisdiction’s ability to manage its floodplains. Budget cuts and personnel losses can strain resources needed to support floodplain management.
- A buildable-lands analysis that looks at vacant lands and their designated land use would be a valuable tool in helping decision-makers make wise decisions about future development.
- The risk associated with flooding due to canal failure is unknown at this time. Data on this risk need to be gathered to better support communities’ preparedness and response efforts.

11. LANDSLIDE

11.1 GENERAL BACKGROUND

A landslide is a mass of rock, earth or debris moving down a slope. Landslides may be minor or very large, and can move at slow to very high speeds. They can be initiated by storms, earthquakes, fires, volcanic eruptions or human modification of the land.

Mudslides are rivers of rock, earth, organic matter and other soil materials saturated with water. They develop in the soil overlying bedrock on sloping surfaces when water rapidly accumulates in the ground, such as during heavy rainfall or rapid snowmelt. Water pressure in the pore spaces of the material increases to the point that the internal strength of the soil is drastically weakened. The soil's reduced resistance can then easily be overcome by gravity, changing the earth into a flowing river of mud or "slurry." A mudslide can move rapidly down slopes or through channels, and can strike with little or no warning at avalanche speeds. The slurry can travel miles from its source, growing as it descends, picking up trees, boulders, cars and anything else in its path. Although these slides behave as fluids, they convey many times the hydraulic force of water due to the mass of material included in them. They can be some of the most destructive events in nature.

All mass movements are caused by a combination of geological and climate conditions, as well as the encroaching influence of urbanization. Vulnerable natural conditions are affected by human residential, agricultural, commercial and industrial development and the infrastructure that supports it. Slides and earth flows can pose serious hazard to property in hillside terrain. When they move—in response to such changes as increased water content, earthquake shaking, addition of load, or removal of downslope support—they deform and tilt the ground surface. The result can be destruction of foundations, offset of roads, breaking of underground pipes, or overriding of downslope property and structures.

11.1.1 Landslide Causes

Landslides are caused by one or a combination of the following factors: change in slope of the terrain, increased load on the land, shocks and vibrations, change in water content, groundwater movement, frost action, weathering of rocks, and removing or changing the type of vegetation covering slopes. In general, landslide hazard areas are where the land has characteristics that contribute to the risk of the downhill movement of material, such as the following:

- A slope greater than 33 percent
- A history of landslide activity or movement during the last 10,000 years
- Stream or wave activity, which has caused erosion, undercut a bank or cut into a bank to cause the surrounding land to be unstable
- The presence or potential for snow avalanches
- The presence of an alluvial fan, indicating vulnerability to the flow of debris or sediments
- The presence of impermeable soils, such as silt or clay, mixed with granular soils, such as sand and gravel.

11.1.2 Landslide Types

Flows and slides are commonly categorized by the form of initial ground failure. Common types of slides are shown in Figure 11-1 through Figure 11-4. The most common is the shallow colluvial slide, occurring particularly in response to intense, short-duration storms. The largest and most destructive are deep-seated slides, although they are less common than other types.

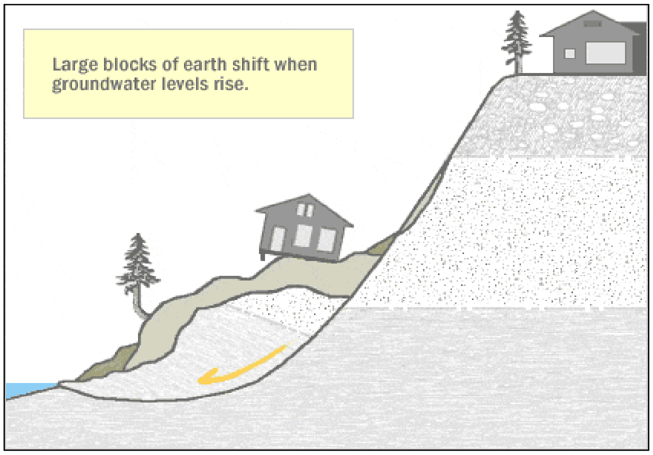


Figure 11-1. Deep Seated Slide

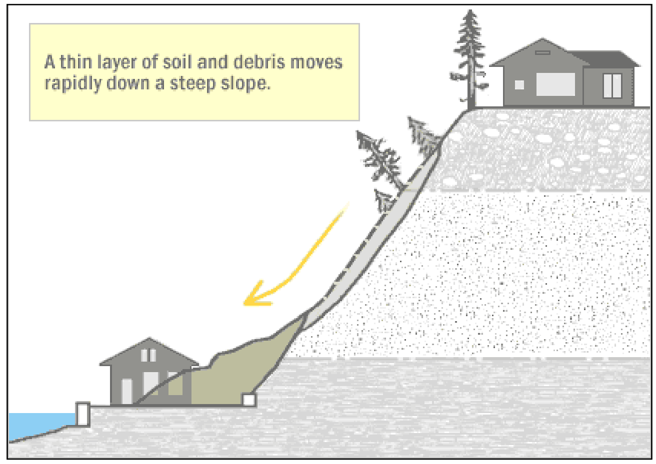


Figure 11-2. Shallow Colluvial Slide

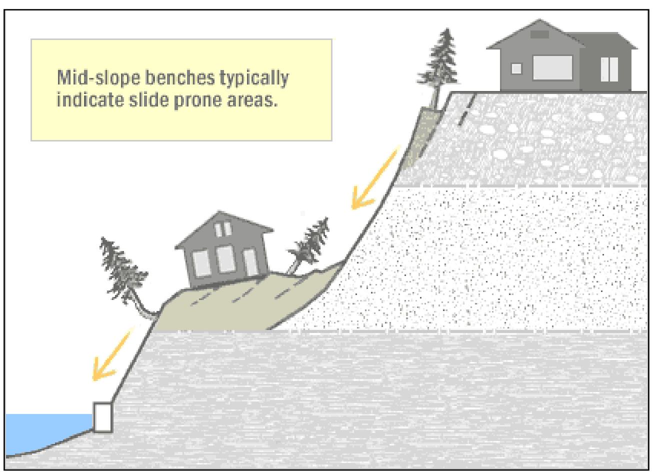


Figure 11-3. Bench Slide

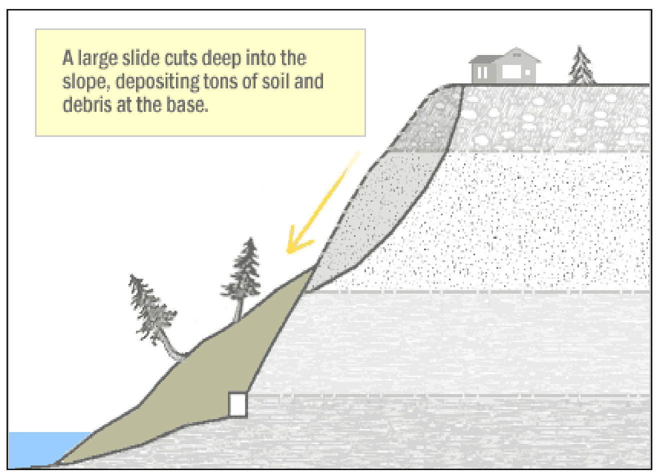


Figure 11-4. Large Slide

11.1.3 Landslides and Geology

Certain combinations of earth materials and steep topography increase the likelihood of slope failure. In Idaho, examples include basalt with sedimentary interbeds, altered volcanic rocks, fractured metamorphic rocks, glacial and lake deposits, and weathered granite. Basalt lava flows exposed in canyons hundreds of feet deep occur throughout the Snake River Plain and Columbia Plateau. Large landslides tend to form where the basalts are underlain by unconsolidated sediments. In some cases, irrigation increases the landslide potential. At Salmon Falls Creek south of Buel, translational and rotational slides and multiple lateral spreads have occurred where basalt overlies lake and fluvial sediments. On steep slopes in Idaho's river canyons, metamorphic rocks fractured by faulting and folding are prone to fail as falls, topples, and translational slides. Such landslides are common along the Salmon River and in Hells Canyon.

11.2 HAZARD PROFILE

11.2.1 Past Events

Ada County has seen landslides primarily in the Boise Foothills. This area is most prone to landslides following large wildfires or heavy rain events. There are no records in the County of fatalities attributed to mass movement. However, deaths have occurred across the western U.S. as a result of slides and slope collapses. Events that have caused property damage within the planning area are summarized below.

April 2003

Mud slid down a 400-yard embankment, crushed a 4-foot wooden fence and ripped a back door from its hinges on the 3800 block of McGonigull Street in Boise (see Figure 11-5 through Figure 11-8).

Figure 11-5. McGonigull Street Slide

Figure 11-6. McGonigull Street Slide

Figure 11-7. McGonigull Street Slide

Figure 11-8. McGonigull Street Slide

December 1996

During the last days of 1996, warm unsettled air from the Pacific Ocean crossed into North Central Idaho dropping rain, snow, frozen rain, sleet and hail. Warming temperatures melted snow and saturated the soil of the area. The result was unstable soil conditions that led to mudslides along miles of the state's primary roadways between Boise and Lewiston. Although the catastrophic mudslides north of Ada County received much of the press, smaller scale mudslides impacted the homes, driveways, and surface streets where cut banks had been created to site area roads.

March – May, 1973

Landslides along Warm Springs Mesa, some over 100 yards long, closed Starcrest Drive several times over a three-month period. The area was stabilized by installing 17 horizontal drains to release water.

August 20, 1959

During severe thunderstorms in the northeast Boise Foothills, estimated to be a 50- to 100-year rainfall event, 0.30 inches of rain fell in 5 minutes at Deer Point. The peak flow on Cottonwood Creek was 3,000 cfs. Floodwaters were carried by other Foothills creeks draining Shaw Mountain and Aldape Summit. Earlier Lucky Peak fires had denuded the Foothills of vegetation.

Debris flows over 10 inches deep filled basements and yards in north and east Boise. Floodwaters were diverted along Broadway Avenue to the Boise River. Approximately 500 houses were damaged by mud up to 10 inches deep; over 160 acres were covered by silt and debris flows. Hardest hit areas were Reserve Street, East Jefferson, East State, Krall and East Bannock, and Avenues D and E and Warm Springs Avenue. The agriculture area between Lucky Peak Dam and East Boise suffered extensive property, crop and livestock losses. The Boise police clubhouse on Mountain Cove Road was destroyed, and the Idaho National Guard headquarters on Reserve Street was inundated, breaking out the windows, filling the basement with several feet of water, and destroying equipment and records.

11.2.2 Location

Landslides are typically a function of soil type and steepness of slope. Soil type is a key indicator for landslide potential and is used by geologist and geotechnical engineers to determine soil stability for construction standards. Soils mapping is lacking for the Ada County planning area.

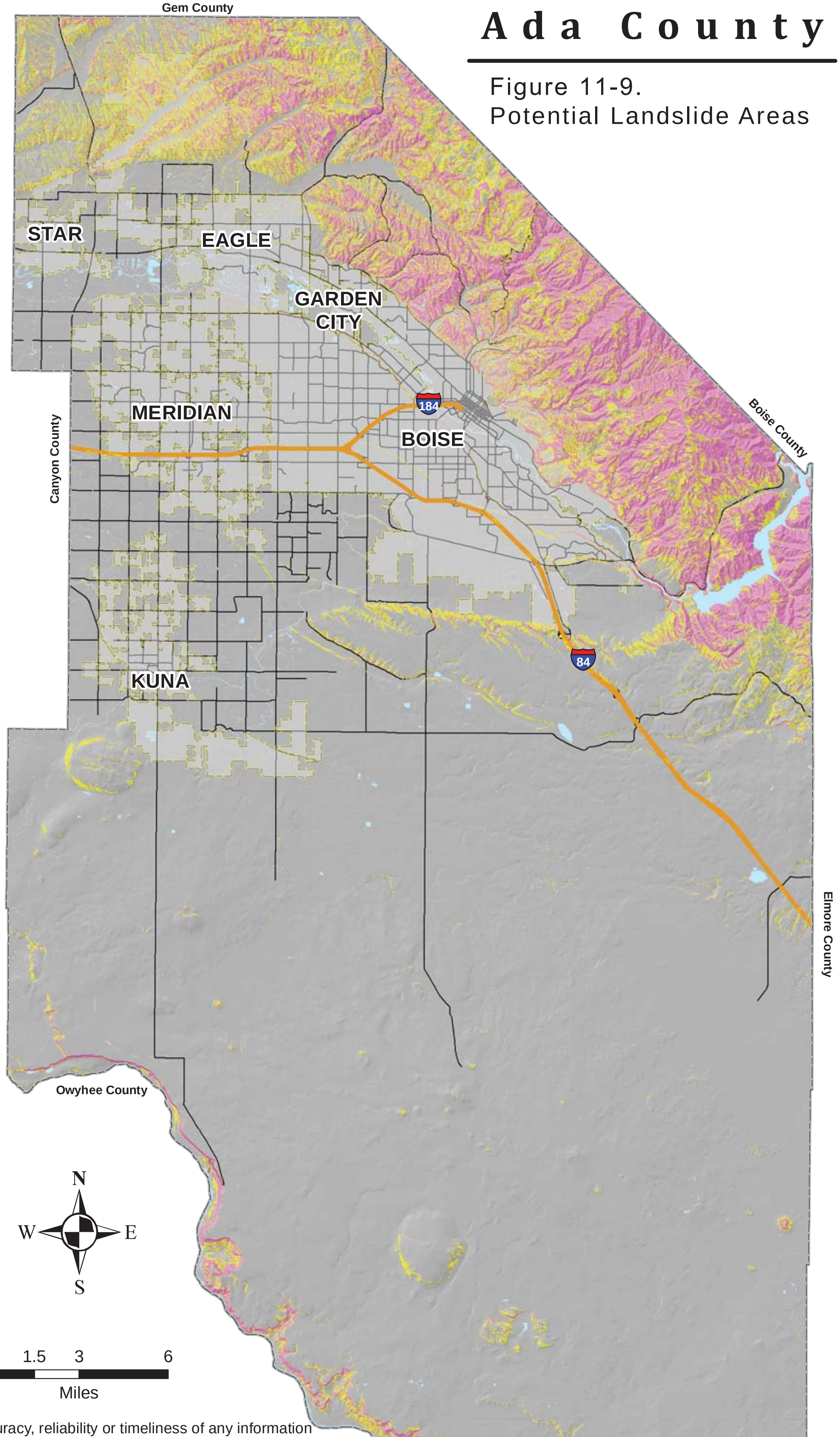
The best available predictor of where movement of slides and earth flows might occur is the location of past movements. Past landslides can be recognized by their distinctive topographic shapes, which can remain in place for thousands of years. Most landslides recognizable in this fashion range from a few acres to several square miles. Most show no evidence of recent movement and are not currently active. A small proportion of them may become active in any given year, with movements concentrated within all or part of the landslide masses or around their edges.

The recognition of ancient dormant mass movement sites is important in the identification of areas susceptible to flows and slides because they can be reactivated by earthquakes or by exceptionally wet weather. Also, because they consist of broken materials and frequently involve disruption of groundwater flow, these dormant sites are vulnerable to construction-triggered sliding.

To assess the location of potential landslide hazard areas, a dataset of steep slopes was generated using a combination of Boise Foothills 1-foot LiDAR and the USGS 10-meter digital elevation model. Two slope classifications were created: 15 to 30 percent; and greater than 30 percent. Figure 11-9 shows the estimated landslide hazard areas in the Ada County planning area, based on slopes.

Ada County

Figure 11-9.
Potential Landslide Areas



Legend

Slope

- 15 - 30%
- Greater than 30%

The landslide areas presented in this map are a based on slope analysis using a combination of Boise Foothills 1 foot LiDAR and USGS 10 meter digital elevation maps.

Base Map Data Sources:
Ada County, U.S. Geological Survey

N W E S

0 1.5 3 6
Miles

Ada County does not warrant the accuracy, reliability or timeliness of any information on this map, and shall not be held liable for losses caused by using this information.

11.2.3 Frequency

Landslides are often triggered by other natural hazards such as earthquakes, heavy rain, floods or wildfires, so landslide frequency is often related to the frequency of these other hazards. In Ada County, landslides typically occur during and after major storms, so the landslide potential largely coincides with the potential for sequential severe storms that saturate steep, vulnerable soils. Until better data is generated specifically for landslide hazards, this severe storm frequency is appropriate for the purpose of ranking risk associated with the landslide hazard.

Landslides are most likely during periods of higher than average rainfall. The ground must be saturated prior to the onset of a major storm for significant landslides to occur. Most local landslides occur in January after the water table has risen during November and December. Water is involved in nearly all cases; and human influence has been identified in more than 80 percent of reported slides.

11.2.4 Severity

Landslides destroy property and infrastructure and can take the lives of people. Slope failures in the United States result in an average of 25 lives lost per year and an annual cost to society of about $1.5 billion. There are no records in Ada County of fatalities attributed to landslides. The biggest assets at risk to landslides are roads and infrastructure in landslide-prone area. Landslides can isolate populations due to road closures.

11.2.5 Warning Time

Landslide velocity can range from inches per year to many feet per second, depending on slope angle, material and water content. Some methods used to monitor mass movements can provide an idea of the time prior to failure. It is also possible to determine areas at risk during general time periods. Assessing the geology, vegetation and amount of predicted precipitation for an area can help in these predictions. However, there is no practical warning system for individual landslides. The current procedure is to monitor situations on a case-by-case basis and respond after the event has occurred. Generally accepted warning signs for landslide activity include:

- Springs, seeps, or saturated ground in areas that have not typically been wet before
- New cracks or unusual bulges in the ground, street pavements or sidewalks
- Soil moving away from foundations
- Ancillary structures such as decks and patios tilting and/or moving relative to the main house
- Tilting or cracking of concrete floors and foundations
- Broken water lines and other underground utilities
- Leaning telephone poles, trees, retaining walls or fences
- Offset fence lines
- Sunken or down-dropped road beds
- Rapid increase in creek water levels, possibly accompanied by increased soil content
- Sudden decrease in creek water levels though rain is still falling or recently stopped
- Sticking doors and windows or visible open spaces indicating jambs and frames out of plumb
- A faint rumbling sound that increases in volume as the landslide nears
- Unusual sounds, such as trees cracking or boulders knocking together.

11.3 SECONDARY HAZARDS

Landslides can cause secondary effects such as blocking access to roads, which can isolate residents and businesses and delay transportation. This could result in economic losses for businesses. Other potential problems are power and communication failures. Vegetation or poles on slopes can be knocked over, resulting in possible losses to power and communication lines. Landslides also have the potential of destabilizing the foundation of structures, which may result in monetary loss for residents. They also can damage rivers or streams, potentially harming water quality, fisheries and spawning habitat.

11.4 EXPOSURE

11.4.1 Population

Population could not be examined by landslide hazard area because census block group areas do not coincide with the hazard areas. A population estimate was made using the structure count of buildings within the landslide hazard areas. Using this approach, the estimated population living in steep slope areas is 8,250, or 1.94 percent of the total population for the planning area.

11.4.2 Property

Table 11-1 summarizes structures exposed to the landslide risk. There are 2,707 structures on parcels located on steep slopes of 15 percent or greater. The estimated value of these structures is $1.461 billion, or 1.74 percent of the total assessed valuation for the planning area. The predominant land uses in cities are single-family, vacant and manufactured homes. Table 11-2 shows the general land use of parcels exposed to landslides in unincorporated portions of the County. Lands zoned for agricultural uses are most vulnerable because they expose the soils to the factors that can induce landslides or earth movements.

Table 11-1. Ada County Structures in Landslide Risk Areas (Slopes>15%)

	Buildings Exposed	Assessed Value			% of AV
		Structure	Contents	Total	
Boise	2,090	$694,793,728	$355,765,199	$1,050,558,927	2.30%
Eagle	87	$45,367,860	$22,683,930	$68,051,791	1.16%
Garden City	3	$1,819,716	$1,819,716	$3,639,431	0.12%
Kuna	0	$0	$0	$0	0%
Meridian	14	$4,062,023	$2,699,320	$6,761,343	0.04%
Star	2	$526,872	$263,436	$790,307	0.07%
Unincorporated	511	$218,374,754	$113,368,115	$331,742,869	3.58%
Total	2,707	$964,944,953	$496,599,716	$1,461,544,668	1.74

Table 11-2. Land Use in Landslide Risk Areas of the Ada County Planning Area

Land Use	15% to 30% Slope areas		Greater than 30% slope areas	
	Area (acres)	% of total	Area (acres)	% of total
Agriculture	2,1124.20	44.06%	14,269.60	31.11%
Agriculture Prime Farmland	288.16	0.60%	19.95	0.04%
Commercial Retail and Office	157.22	0.33%	113.83	0.25%
Industrial	2.99	0.01%	0	0%
Open Space	1,039.77	2.17%	1,009.24	2.20%
Other	2,617.08	5.46%	1,709.29	3.73%
Public/Government	18,958.22	39.55%	2,6636.31	58.07%
Residential	3,711.76	7.74%	2,097.82	4.57%
Residential TOD Density	14.03	0.03%	2.26	0%
Schools	27.06	0.06%	7.58	0.02%
Total	47,940.49	100%	45,865.88	100%

11.4.3 Critical Facilities and Infrastructure

Table 11-3 summarizes the critical facilities exposed to the landslide hazard. No loss estimation of these facilities was performed due to the lack of established damage functions for the landslide hazard. A significant amount of infrastructure can be exposed to mass movements:

- **Roads**—Access to major roads is crucial to life-safety after a disaster event and to response and recovery operations. Landslides can block egress and ingress on roads, causing isolation for neighborhoods, traffic problems and delays for public and private transportation. This can result in economic losses for businesses.
- **Bridges**—Mass movements can knock out bridge abutments or significantly weaken the soil supporting them, making them hazardous for use.
- **Power Lines**—Power line towers can be subject to landslides. A landslide could trigger failure of the soil underneath a tower, causing it to collapse and ripping down the lines. Power and communication failures due to landslides can create problems for vulnerable populations and businesses.

Table 11-3. Critical Facilities Exposed to Landslide Hazards

	Number of Exposed Critical Facilities in Risk Area	
	Slope 15% to 30%	Slope Greater than 30%
Medical and Health Services	0	0
Government Function	0	1
Protective Function	0	1
Schools	0	0
Hazmat	1	0
Other Critical Function	4	3
Bridges	11	7
Water	4	0
Wastewater	4	5
Communications	1	0
Total	25	17

11.4.4 Environment

Environmental problems as a result of mass movements can be numerous. Landslides that fall into streams may significantly impact fish and wildlife habitat, as well as affecting water quality. Hillsides that provide wildlife habitat can be lost for prolonged periods of time due to landslides.

11.5 VULNERABILITY

11.5.1 Population

Due to the nature of census block group data, it is difficult to determine demographics of populations vulnerable to mass movements. In general, all of the estimated 8,251 persons, or 1.9 percent of the total planning area population, exposed to higher risk landslide areas are considered to be vulnerable. Increasing population and the fact that many homes are built on view property atop or below bluffs and on steep slopes subject to mass movement increases the number of lives endangered by this hazard.

11.5.2 Property

Loss estimations for the landslide hazard are not based on modeling using damage functions, because no such damage functions have been generated. Instead, loss estimates were developed representing 10 percent, 30 percent and 50 percent of the assessed value of exposed structures. This allows emergency managers to select a range of economic impact based on an estimate of the percent of damage to the general building stock. Damage in excess of 50 percent is considered to be substantial by most building codes and typically requires total reconstruction of the structure. Table 11-4 shows the general building stock loss estimates in landslide risk areas.

Table 11-4. Estimated Building Losses in the Steep Slope Areas

	Building Count	Assessed Value	10% Damage	30% Damage	50% Damage
Boise	2,090	$1,050,558,927.49	$105,055,892.75	$315,167,678.25	$525,279,463.75
Eagle	87	$68,051,790.71	$6,805,179.07	$20,415,537.21	$34,025,895.35
Garden City	3	$3,639,431.25	$363,943.13	$1,091,829.38	$1,819,715.63
Kuna	0	$0	$0	$0	$0
Meridian	14	$6,761,343.09	$676,134.31	$2,028,402.93	$3,380,671.54
Star	2	$790,307.26	$79,030.73	$237,092.18	$395,153.63
Unincorporated	511	$331,742,868.59	$33,174,286.86	$99,522,860.58	$165,871,434.29
Total	2,707	$1,461,544,668	$146,154,467	$438,463,401	$730,772,334

11.5.3 Critical Facilities and Infrastructure

There are 42 critical facilities and critical infrastructure facilities with potential exposure to landslides due to their location on steep slopes. A more in-depth analysis of the mitigation measures taken by these facilities to prevent damage from mass movements should be done to determine if they could withstand impacts of a mass movement.

Several types of infrastructure are exposed to mass movements, including transportation, water and sewer and power infrastructure. Highly susceptible areas of the county include mountain and coastal roads and transportation infrastructure. At this time, all infrastructure and transportation corridors identified as exposed to the landslide hazard are considered vulnerable until more information becomes available.

11.5.4 Environment

The environment vulnerable to landslide hazard is the same as the environment exposed to the hazard.

11.6 DEVELOPMENT TRENDS

The value of planning area properties exposed to the landslide hazard has increased by 14.3 percent ($370.3 million) since the last hazard mitigation plan update in 2011. This increase in risk exposure can be attributed to the expansion of the risk assessment to include properties on slopes of 30 percent or greater, a population growth of 10.7 percent in the same period, and property value increases associated with continued economic recovery from the 2008 economic downturn (see Section 4.5.3).

While landslides are not generally hazards addressed in comprehensive plans, the risk assessment in this plan creates an opportunity for Ada County and its planning partners to consider the inclusion of landslide hazards in their comprehensive plans. A key component to support this action would be the availability of good sub-surface soil mapping using the best available data, science and technology. It is anticipated that this data will be available in the near future. In the meantime, Ada County and its planning partners are equipped to deal with new development on a case-by-case basis through enforcement of the International Building Code (IBC). The IBC includes provisions for geotechnical analyses in steep slope areas that have soil types susceptible to landslides. These provisions ensure that new construction is built to standards that reduce the vulnerability to landslides.

11.7 SCENARIO

Major landslides in Ada County occur as a result of soil conditions that have been affected by severe storms, groundwater or human development. The worst-case scenario for landslide hazards in the planning area would generally correspond to a severe storm that had heavy rain and caused flooding. Landslides are most likely during late winter when the water table is high. After heavy rains from November to December, soils become saturated with water. As water seeps downward through upper soils that may consist of permeable sands and gravels and accumulates on impermeable silt, it will cause weakness and destabilization in the slope. A short intense storm could cause saturated soil to move, resulting in landslides. As rains continue, the groundwater table rises, adding to the weakening of the slope. Gravity, poor drainage, a rising groundwater table and poor soil exacerbate hazardous conditions.

Mass movements are becoming more of a concern as development moves outside of city centers and into areas less developed in terms of infrastructure. Most mass movements would be isolated events affecting specific areas. It is probable that private and public property, including infrastructure, will be affected. Mass movements could affect bridges that pass over landslide prone ravines and knock out rail service through the county. Road obstructions caused by mass movements would create isolation problems for residents and businesses in sparsely developed areas. Property owners exposed to steep slopes may suffer damage to property or structures. Landslides carrying vegetation such as shrubs and trees may cause a break in utility lines, cutting off power and communication access to residents.

Continued heavy rains and flooding will complicate the problem further. As emergency response resources are applied to problems with flooding, it is possible they will be unavailable to assist with landslides occurring all over Ada County.

11.8 ISSUES

Important issues associated with landslides in Ada County include the following:

- Sub-surface soils mapping is needed to better understand the landslide risk potential within the planning area.
- There are existing homes in landslide risk areas throughout the county. The degree of vulnerability of these structures depends on the codes and standards the structures were constructed to. Information to this level of detail is not currently available.
- Future development could lead to more homes in landslide risk areas, especially as development moves into the Boise Foothills.
- Mapping and assessment of landslide hazards are constantly evolving. As new data and science become available, assessments of landslide risk should be reevaluated.
- The impact of climate change on landslides is uncertain. If climate change impacts atmospheric conditions, then exposure to landslide risks is likely to increase.
- Landslides may cause negative environmental consequences, including water quality degradation.
- The risk associated with the landslide hazard overlaps the risk associated with other hazards such as earthquake, flood and wildfire. This provides an opportunity to seek mitigation alternatives with multiple objectives that can reduce risk for multiple hazards.
- A buildable-lands analysis that looks at vacant lands and their designated land use would be a valuable tool in helping decision-makers make wise decisions about future development.

12. SEVERE WEATHER

12.1 GENERAL BACKGROUND

Severe weather refers to any dangerous meteorological phenomena with the potential to cause damage, serious social disruption, or loss of human life. It includes thunderstorms, hail storms, damaging winds, tornadoes, excessive heat, snowstorms, ice storms, blizzards, and extreme cold

Severe weather can be categorized into two groups: systems that form over wide geographic areas are classified as general severe weather; those with a more limited geographic area are classified as localized severe weather. Severe weather, technically, is not the same as extreme weather, which refers to unusual weather events at the extremes of the historical distribution for a given area.

The most common severe weather events that impact the planning area are thunderstorms, damaging winds and hail storms. These types of severe weather, as well as excessive heat events and tornadoes, are described in the following sections.

12.1.1 Thunderstorms, Lightning and Hail

A thunderstorm is a rain event that includes thunder and lightning. A thunderstorm is classified as “severe” when it contains one or more of the following: hail with a diameter of three-quarter inch or greater, winds gusting in excess of 50 knots (57.5 mph), or tornado. Approximately 10 percent of the 100,000 thunderstorm that occur nationally every year are classified as severe (NOAA, 2014).

Storm Development

Three factors cause thunderstorms to form: moisture, rising unstable air (air that keeps rising when disturbed), and a lifting mechanism to provide the disturbance. The sun heats the surface of the earth, which warms the air above it. If this warm surface air is forced to rise (hills or mountains can cause rising motion, as can the interaction of warm air and cold air or wet air and dry air) it will continue to rise as long as it weighs less and stays warmer than the air around it. As the air rises, it transfers heat from the surface of the earth to the upper levels of the atmosphere (the process of convection). The water vapor it contains begins to cool and it condenses into a cloud.

The cloud eventually grows upward into areas where the temperature is below freezing. Some of the water vapor turns to ice and some of it turns into water droplets. Both have electrical charges. Ice particles usually have positive charges, and rain droplets usually have negative charges. When the charges build up enough, they are discharged in a bolt of lightning, which causes the sound waves we hear as thunder. Thunderstorms have three stages (see Figure 12-1):

- The *developing stage* of a thunderstorm is marked by a cumulus cloud being pushed upward by a rising column of air (updraft). The cumulus cloud soon looks like a tower. There is little to no rain during this stage but occasional lightning. The developing stage lasts about 10 minutes.
- As the updraft continues, the thunderstorm enters the *mature stage* when precipitation begins to fall and a downdraft begins (a column of air pushing downward). When the downdraft and rain-cooled air spread out along the ground, they form a gust front, or a line of gusty winds. The mature stage is the most likely

time for hail, heavy rain, frequent lightning, strong winds, and tornadoes. The storm occasionally has a black or dark green appearance.

- Eventually, a large amount of precipitation is produced and the updraft is overcome by the downdraft beginning the *dissipating stage*. At the ground, the gust front moves out a long distance from the storm and cuts off the warm moist air that was feeding the thunderstorm. Rainfall decreases in intensity, but lightning remains a danger.

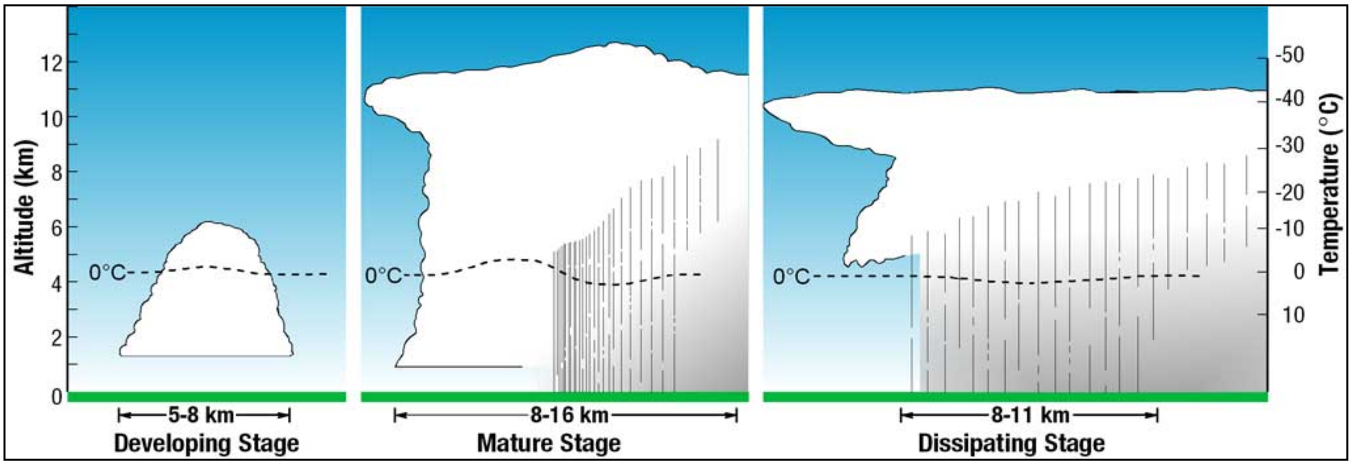


Figure 12-1. The Thunderstorm Life Cycle

Storm Types

There are four types of thunderstorms:

- **Single-Cell Thunderstorms—**Single-cell thunderstorms usually last 20 to 30 minutes. A true single-cell storm is rare, because the gust front of one cell often triggers the growth of another. Most single-cell storms are not usually severe, but a single-cell storm can produce a brief severe weather event. When this happens, it is called a pulse severe storm.
- **Multi-Cell Cluster Storm—**A multi-cell cluster is the most common type of thunderstorm. The multi-cell cluster consists of a group of cells, moving as one unit, with each cell in a different phase of the thunderstorm life cycle. Mature cells are usually found at the center of the cluster and dissipating cells at the downwind edge. Multi-cell cluster storms can produce moderate-size hail, flash floods and weak tornadoes. Each cell in a multi-cell cluster lasts only about 20 minutes; the multi-cell cluster itself may persist for several hours. This type of storm is usually more intense than a single cell storm.
- **Multi-Cell Squall Line—**A multi-cell line storm, or squall line, consists of a long line of storms with a continuous well-developed gust front at the leading edge. The line of storms can be solid, or there can be gaps and breaks in the line. Squall lines can produce hail up to golf-ball size, heavy rainfall, and weak tornadoes, in addition to strong downdrafts. Occasionally, a strong downburst will accelerate a portion of the squall line ahead of the rest of the line to produce a bow echo. Bow echoes can develop with isolated cells as well as squall lines. Bow echoes are easily detected on radar but are difficult to observe visually.
- **Super-Cell Storm—**A super-cell is similar to a single-cell storm in that it has one main updraft, but the updraft is extremely strong, reaching speeds of 150 to 175 miles per hour. Super-cells are rare. The main characteristic that sets them apart from other thunderstorms is the presence of rotation. The rotating updraft of a super-cell (called a mesocyclone when visible on radar) helps the super-cell to produce extreme weather events, such as giant hail (more than 2 inches in diameter), strong downbursts of 80 miles an hour or more, and strong to violent tornadoes.

Lightning

Lightning is an electrical discharge between positive and negative regions of a thunderstorm. A lightning flash is composed of a series of strokes, with an average of about four. The average duration of each stroke is about 30 microseconds. Lightning occurs in all thunderstorms. There are two main types of lightning: intra-cloud lightning and cloud-to-ground lightning (NWS, 2014).

Lightning is one of the more dangerous weather hazards in the United States. Each year, lightning is responsible for deaths, injuries, and millions of dollars in property damage, including damage to buildings, communications systems, power lines, and electrical systems. Lightning also causes forest and brush fires and deaths and injuries to livestock and other animals. According to the National Lightning Safety Institute, property damage, increased operating costs, production delays, and lost revenue from lightning and secondary effects exceed $6 billion per year (NLSI, 2008). Impacts can be direct or indirect. People or objects can be directly struck, or damage can occur indirectly when the current passes through or near it.

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

Although not as common, cloud-to-ground lightning is the most damaging and dangerous form of lightning. Most flashes originate near the lower-negative charge center and deliver negative charge to earth. However, many flashes carry positive charge to earth, often during the dissipating stage of a thunderstorm's life. Positive flashes are more common as a percentage of total ground strikes during the winter. This type of lightning is particularly dangerous for several reasons. It frequently strikes away from the rain core, either ahead or behind the thunderstorm. It can strike as far as 5 or 10 miles from the storm in areas that most people do not consider to be a threat. Positive lightning also has a longer duration, so fires are more easily ignited. And, when positive lightning strikes, it usually carries a high peak electrical current, potentially resulting in greater damage.

The ratio of cloud-to-ground and intra-cloud lightning can vary significantly from storm to storm. Depending upon cloud height above ground and changes in electric field strength between cloud and earth, the discharge stays within the cloud or makes direct contact with the earth. If the field strength is highest in the lower regions of the cloud, a downward flash may occur from cloud to earth. Using a network of lightning detection systems, the United States monitors an average of 25 million strokes of lightning from the cloud-to-ground every year.

U.S. lightning statistics compiled by the National Oceanic and Atmospheric Administration between 1959 and 1994 indicate that most lightning incidents occur in June, July and August and during the afternoon hours from between 2 and 6 p.m.

Hail

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

Hailstones grow two ways: by wet growth or dry growth. In wet growth, a tiny piece of ice is in an area where the air temperature is below freezing, but not super cold. When the tiny piece of ice collides with a super-cooled drop, the water does not freeze on the ice immediately. Instead, liquid water spreads across tumbling hailstones and slowly freezes. Since the process is slow, air bubbles can escape, resulting in a layer of clear ice. Dry growth hailstones grow when the air temperature is well below freezing and the water droplet freezes immediately as it collides with the ice particle. The air bubbles are "frozen" in place, leaving cloudy ice.

Hailstones can have layers like an onion if they travel up and down in an updraft, or they can have few or no layers if they are "balanced" in an updraft. Hailstones can begin to melt and then re-freeze together, forming large and very irregularly shaped hail.

12.1.2 Damaging Winds

Damaging winds are classified as those exceeding 60 mph. Damage from such winds accounts for half of all severe weather reports in the lower 48 states. Wind speeds can reach up to 100 mph and can produce a damage path extending for hundreds of miles. Isolated wind events in mountainous regions have more localized effects. Windstorms in Idaho typically occur from October through March (Idaho State Hazard Mitigation Plan, 2013). There are seven types of damaging winds:

- **Straight-line winds—**Any thunderstorm wind that is not associated with rotation; this term is used mainly to differentiate from tornado winds. Most thunderstorms produce some straight-line winds as a result of outflow generated by the thunderstorm downdraft.
- **Downdrafts—**A small-scale column of air that rapidly sinks toward the ground.
- **Downbursts—**A strong downdraft with horizontal dimensions larger than 2.5 miles resulting in an outward burst or damaging winds on or near the ground. Downburst winds may begin as a microburst and spread out over a wider area, sometimes producing damage similar to a strong tornado. Although usually associated with thunderstorms, downbursts can occur with showers too weak to produce thunder.
- **Microbursts—**A small concentrated downburst that produces an outward burst of damaging winds at the surface. Microbursts are generally less than 2.5 miles across and short-lived, lasting only 5 to 10 minutes, with maximum wind speeds up to 168 mph. There are two kinds of microbursts: wet and dry. A wet microburst is accompanied by heavy precipitation at the surface. Dry microbursts, common in places like the high plains and the intermountain west, occur with little or no precipitation reaching the ground.
- **Gust front—**A gust front is the leading edge of rain-cooled air that clashes with warmer thunderstorm inflow. Gust fronts are characterized by a wind shift, temperature drop, and gusty winds out ahead of a thunderstorm. Sometimes the winds push up air above them, forming a shelf cloud or detached roll cloud.
- **Derecho—**A derecho is a widespread thunderstorm wind caused when new thunderstorms form along the leading edge of an outflow boundary (the boundary formed by horizontal spreading of thunderstorm-cooled air). The word "derecho" is of Spanish origin and means "straight ahead." Thunderstorms feed on the boundary and continue to reproduce. Derechos typically occur in summer when complexes of thunderstorms form over plains, producing heavy rain and severe wind. The damaging winds can last a long time and cover a large area.
- **Bow Echo—**A bow echo is a linear wind front bent outward in a bow shape. Damaging straight-line winds often occur near the center of a bow echo. Bow echoes can be 200 miles long, last for several hours, and produce extensive wind damage at the ground.

Windstorms can result in collapsed or damaged buildings, damaged or blocked roads and bridges, damaged traffic signals, streetlights and parks, and other damage. They can also cause direct losses to buildings, people, and vital equipment. There are direct consequences to the local economy resulting from windstorms related to both physical damage and interrupted services.

Wind pressure can create a direct and frontal assault on a structure, pushing walls, doors, and windows inward. Conversely, passing currents can create lift and suction forces that act to pull building components and surfaces outward. As positive and negative forces impact a building's doors, windows and walls, the result can be roof or building component failures and considerable structural damage. The effects of winds are magnified in the upper levels of multi-story structures.

Debris carried along by extreme winds can contribute directly to loss of life and indirectly to the failure of protective building envelopes. Falling trees and branches can damage buildings, power lines, and other property and infrastructure. Tree limbs breaking in winds of only 45 mph can be thrown over 75 feet, so overhead power lines can be damaged even in relatively minor windstorm events. During wet winters, saturated soils cause trees to become less stable and more vulnerable to uprooting from high winds. Utility lines brought down by summer thunderstorms have also been known to cause fires, which start in dry roadside vegetation. Electric power lines falling down to the pavement create the possibility of lethal electric shock.

Downed trees and power lines, and damaged property also can be major hindrances to emergency response and disaster recovery. Emergency response operations can be complicated when roads are blocked or when power supplies are interrupted. Industry and commerce can suffer losses from interruptions in electric service and from extended road closures.

12.1.3 Extreme Temperatures

Excessive Heat Events

Excessive heat events are defined by the U.S. Environmental Protection Agency (EPA) as “summertime weather that is substantially hotter and/or more humid than average for a location at that time of year” (U.S. EPA, 2006). Heat waves are excessive heat events that typically last two or more days (CDC, 2014b). Because extreme heat is relative to the usual weather in a region, criteria that define an extreme heat event may differ among jurisdictions and with the time of year. In general, extreme heat events can be characterized by temperatures greater than 90°F, warm stagnant air masses and consecutive nights with higher-than-usual minimum temperatures (CDC, 2009).

Heat Index

Extreme heat events are often a result of more than ambient air temperature. Heat index tables (see Figure 12-2) are commonly used to provide information about how hot it feels based on several meteorological conditions. Heat index values are for shady, light wind conditions; exposure to full sunshine can increase heat index values by up to 15°F. Strong winds with very hot, dry air also can be extremely hazardous (NWS, 2014b).

Heat Islands

Extreme heat events may be exacerbated in urban areas, where reduced air flow, reduced vegetation and increased generation of waste heat can contribute to temperatures that are several degrees higher than in surrounding rural or less urbanized areas. When urban buildings, roads and other infrastructure replace open land and vegetation, surfaces that were once permeable and moist become impermeable and dry. These changes cause urban areas to become warmer than the surrounding areas, serving as contiguous regions of higher temperatures. This phenomenon is known as urban heat island effect. Heat islands can affect communities by increasing peak summer energy demand, air pollution, greenhouse gas emissions, heat-related illness and death, and water quality degradation.

Extreme Cold and Wind Chill

Weather that constitutes extreme cold varies across different parts of the U.S. In regions relatively unaccustomed to winter weather, near freezing temperatures are considered extreme cold (CDC, 2014a). Extreme cold can often accompany severe winter storms. Wind can exacerbate the effects of cold temperatures by carrying heat away from the body more quickly, thus making it feel colder than is indicated by the temperature. This phenomenon is known as wind chill. Wind chill is the temperature that your body feels when the air temperature is combined with wind speed (CDC, 2014a). Figure 12-3 shows the value of wind chill based on ambient temperature and wind speed.

Source: National Weather Service/NOAA

Temperature (°F)

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

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution Extreme Caution Danger Extreme Danger

Figure 12-2. Heat Index Chart

Source: National Weather Service/NOAA

Temperature (°F)

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

Frostbite Times 30 minutes 10 minutes 5 minutes

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

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

Effective 11/01/01

Figure 12-3. Wind Chill Chart

12.1.4 Severe Winter Weather

Blizzards and Snowstorms

The National Weather Service defines a winter storm as having significant snowfall, ice and/or freezing rain; the quantity of precipitation varies by elevation. Heavy snowfall is 4 inches or more in a 12-hour period, or 6 inches or more in a 24-hour period in non-mountainous areas; and 12 inches or more in a 12-hour period or 18 inches or more in a 24-hour period in mountainous areas. There are three key ingredients to a severe winter storm:

- Cold Air—Below-freezing temperatures in the clouds and near the ground are necessary to make snow and/or ice.
- Moisture—Moisture is required in order to form clouds and precipitation. Air blowing across a body of water, such as a large lake or the ocean, is a typical source of moisture.
- Lift—Lift is required in order to raise the moist air to form the clouds and cause precipitation. An example of lift is warm air colliding with cold air and being forced to rise over the cold dome. The boundary between the warm and cold air masses is called a front. Another example of lift is air flowing up a mountain side.

Areas most vulnerable to winter storms are those affected by convergence of dry, cold air from the interior of the North American continent and warm, moist air off the Pacific Ocean. When strong storms crossing the Pacific arrive at the coast, if the air is cold enough, snow falls. As the moisture rises into the mountains, heavy snow closes mountain passes and can cause avalanches. Cold air from the north has to filter through mountain canyons into basins and valleys to the south. If the cold air is deep enough, it can spill over a mountain ridge. As the air funnels through canyons and over ridges, wind speeds can reach 100 mph. High winds with snow results in a blizzard.

Ice Storms

The National Weather Service defines an ice storm as a storm that results in the accumulation of at least 0.25 inches of ice on exposed surfaces. Ice storms occur when rain falls from a warm, moist, layer of atmosphere into a below freezing, drier layer near the ground. The rain freezes on contact with the cold ground and exposed surfaces, causing damage to trees, utility wires, and structures (see Figure 12-4).

Ice accretion generally ranges from a trace to 1 inch. Accumulations between 1/4-inch and 1/2-inch can cause small branch and faulty limb breakage. Accumulations of 1/2-inch to 1 inch can cause significant breakage. Strong winds increase the potential for damage from ice accumulation.

12.1.5 Tornado

A tornado is a violently rotating column of air extending between, and in contact with, a cloud and the surface of the earth. Tornadoes are often (but not always) visible as a funnel cloud. On a local-scale, tornadoes are the most intense of all atmospheric circulations, with wind that can reach speeds of more than 300 mph. A tornado's vortex is typically a few hundred meters in diameter, and damage paths can be up to 1 mile wide and 50 miles long. Tornadoes can occur throughout the year at any time of day but are most frequent in the spring during the late afternoon. Figure 12-5 illustrates the potential impacts and damage from tornadoes of different magnitudes.

As shown in Figure 12-6, Idaho has a relatively low risk of tornadoes compared to states in the Midwestern and Southern U.S. Washington has experienced tornadoes on occasion. Some have produced significant damage, injury or death. Washington's tornadoes can be formed in association with large Pacific storms arriving from the west. Most of them, however, are caused by intense local thunderstorms. These storms also produce lightning, hail and heavy rain, and are more common during the warm season from April to October.

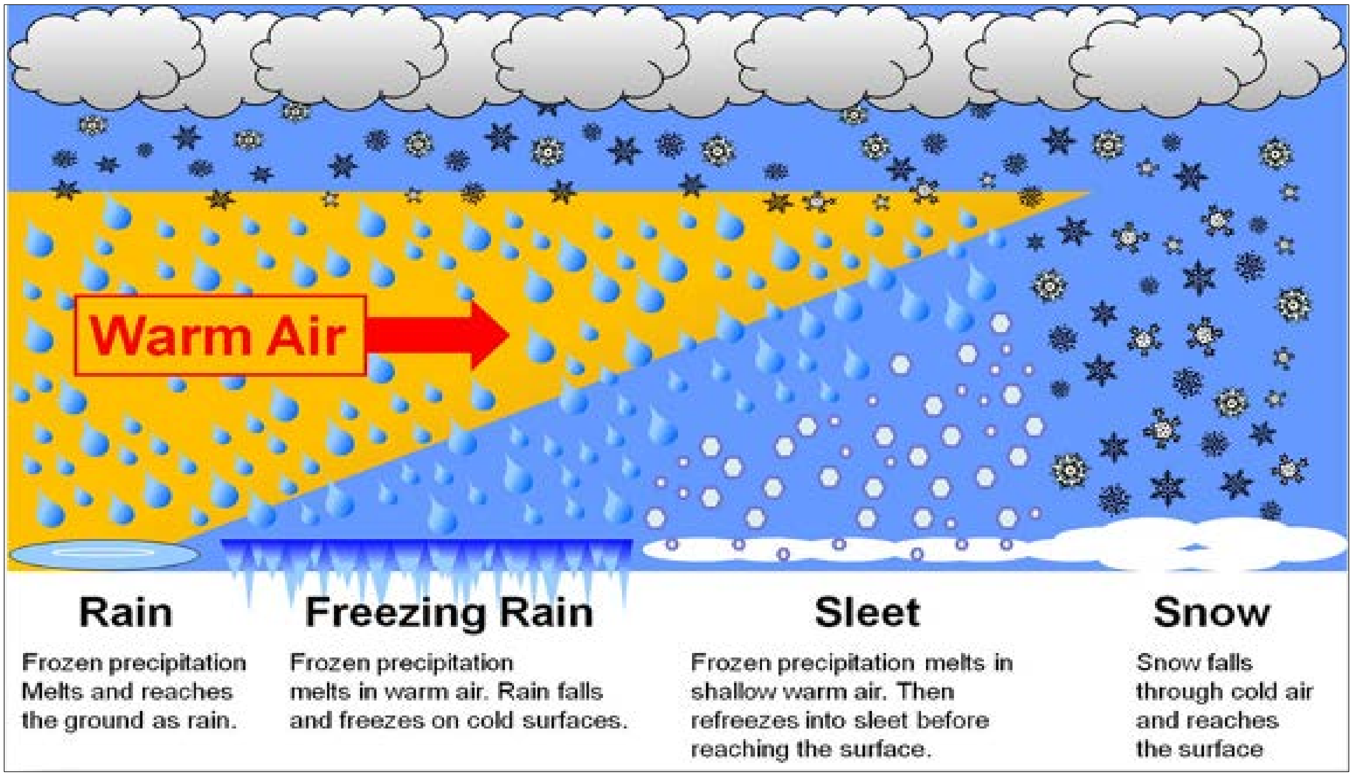
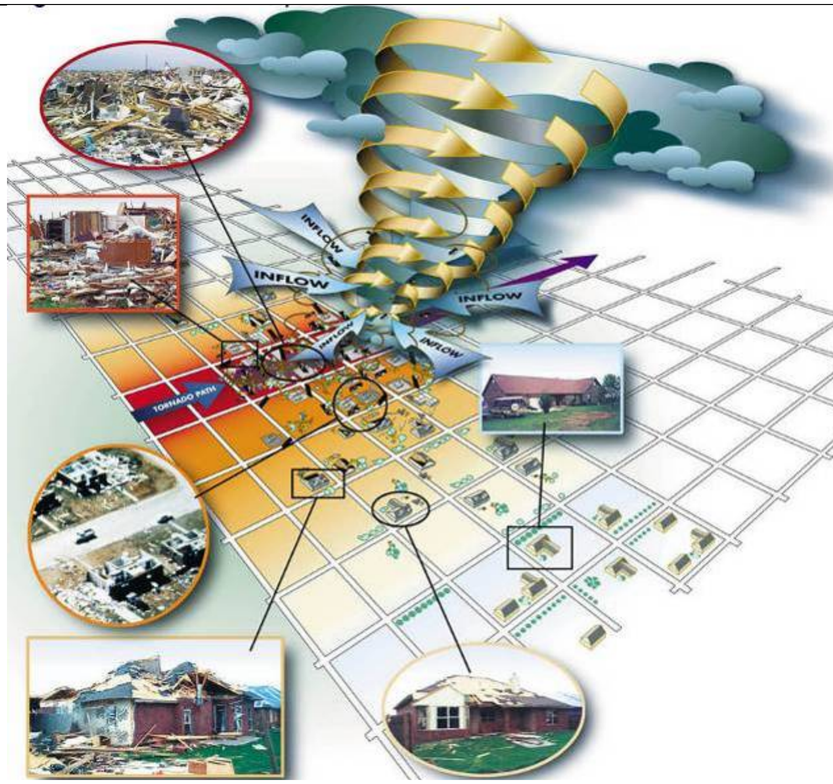


Figure 12-4. The Formation of Different Kinds of Precipitation



Managing Risk	Damage Color Code	Description of Damage
The Threat to Property and Personal Safety Can Be Minimized Through Compliance With Up-To-Date Model Building Codes and Engineering Standards	(light blue)	Some damage can be seen to poorly maintained roofs. Unsecured light-weight objects, such as trash cans, are displaced.
	(cream)	Minor damage to roofs and broken windows occur. Larger and heavier objects become displaced. Minor damage to trees and landscaping can be observed.
Property and Personal Protection Can Be Improved Through Wind Hazard Mitigation Techniques Not Normally Required by Current Building Codes	(light orange)	Roofs are damaged, including the loss of shingles and some sheathing. Manufactured homes, on nonpermanent foundations can be shifted off their foundations. Trees and landscaping either snap or are blown over. Medium-sized debris becomes airborne, damaging other structures.
	(yellow)	Roofs and some walls, especially unreinforced masonry, are torn from structures. Small ancillary buildings are often destroyed. Manufactured homes on nonpermanent foundations can be overturned. Some trees are uprooted.
Personal Protection Can Only Be Achieved Through Use of a Specially Designed Extreme Wind Refuge Area, Shelter, or Safe Room	(orange)	Well constructed homes, as well as manufactured homes, are destroyed, and some structures are lifted off their foundations. Automobile-sized debris is displaced and often tumbles. Trees are often uprooted and blown over.
	(red)	Strong frame houses and engineered buildings are lifted from their foundations or are significantly damaged or destroyed. Automobile-sized debris is moved significant distances. Trees are uprooted and splintered.

Figure 12-5. Potential Impact and Damage from a Tornado

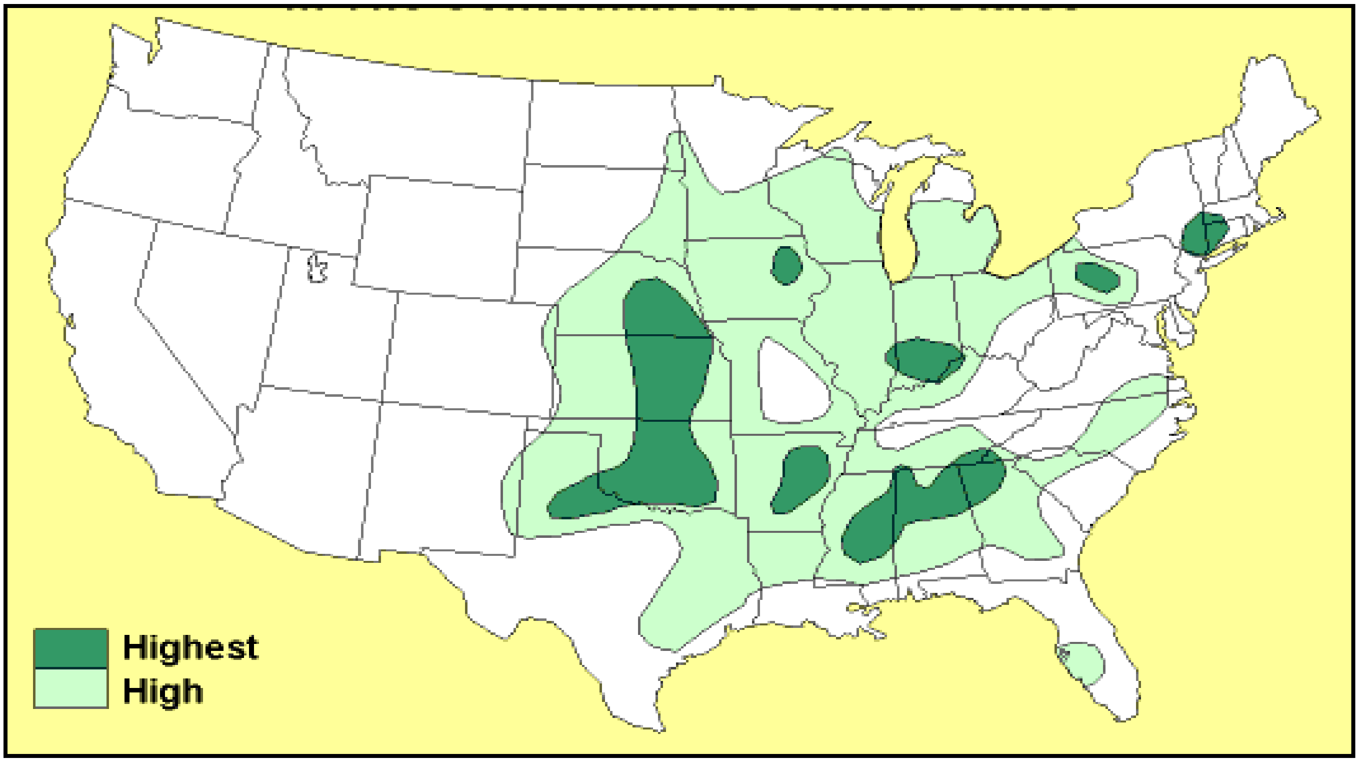


Figure 12-6. Tornado Risk Areas in the United States

12.2 HAZARD PROFILE

12.2.1 Past Events

Table 12-1 summarizes severe weather events in Ada County since 1970 that caused property damage, as recorded by the National Oceanic and Atmospheric Administration (NOAA).

Table 12-1. Severe Weather Events Impacting Planning Area Since 1970

Date	Type	Deaths or Injuries	Property Damage
3/21/2016	Hail	0	None reported
An Upper level trough and a strong upper level jet of 110 knots was the focus for severe thunderstorms across parts of Southwest Idaho. A NWS employee reported one inch hail at Star, Idaho.			
8/10/2015	Thunderstorm Wind	0	None reported
Monsoon moisture moved northward out of Arizona creating conditions for severe convection over Southwest Idaho. A 61 MPH wind gust was recorded at the Boise Automated Surface Observing System and numerous reports of damage were received by the NWS.			
3/17/2014	Thunderstorm Wind	0	None reported
A powerful cold front raced through Southwest and South Central Idaho on the 17th with numerous reports of damage and power outages. Numerous reports of power outages reported by Idaho Power.			
9/5/2013	Hail	0	None reported
A strong upper level jet moving through the area brought severe thunderstorms to parts of Southeast Oregon and Southwest Idaho. Spotters in Meridian and Eagle reported large hail up to an inch and a half across the area.			

Date	Type	Deaths or Injuries	Property Damage
3/6/2013	Thunderstorm Wind	0	None reported
A trough rotating around a large, cold, upper level low centered off the Oregon coast swept across Southwest Idaho on the afternoon of the 6th. Strong to severe thunderstorms developed along the associated front bringing damaging winds and hail up to three quarters of an inch to the area. A NWS storm survey estimated a 60 to 65 MPH wind gust destroyed an announcers booth at the Meridian Lions Club rodeo grounds. In addition, four sets of unsecured grandstand bleachers were flipped upside down and rolled over a fence into the middle of the rodeo grounds.			
2/06/2013	Fog/Freezing Rain	1 injury	None reported
Dense fog and a brief period of freezing rain in the Treasure Valley of Southwest Idaho caused numerous accidents throughout the area. Numerous reports of slide offs, roll overs and crashes due to dense fog and freezing rain in the area.			
8/06/2012	Thunderstorm	0	None reported
Thunderstorms developed across the Intermountain West on the 6th leading to wind damage in parts of Ada County in Southwest Idaho. Thunderstorms that moved across Ada County caused damage around the Boise area, including tree tops torn off, a large tree snapped at its base, and residential fences blown down.			
4/24/2012	Hail	0	None reported
A line of severe thunderstorms moved through parts of Southwest Idaho on the 24th producing large hail and damaging winds. A trained spotter reported half dollar size hail and wind gusts to 75 MPH.			
1/18/2012	Heavy Snow	0	None reported
A major winter storm slammed into the Pacific Northwest and spread heavy snow across parts of Eastern Oregon and Southwest Idaho on the 17th and 18th. Impacts were felt in many of the major population centers including the Boise metro area and along the Interstate 84 corridor. The storm continued in the mountains through the 20th where two to three feet of snow fell over a four day period. Four to Eight inches of new snow were reported by various sources in the Treasure Valley and nine inches at Mountain Home.			
4/25/2011	Thunderstorm Wind	0	None reported
A strong cold front produced high winds and isolated severe convection leading to significant wind damage to locations in the Treasure Valley of Southwest Idaho on the 25th. KTVB reported wind damage near Rocky Mountain High School in Meridian and around the Kuna area. Hail was covering the ground in the affected areas.			
8/21/2010	Thunderstorm Wind	70 (injuries)	$10,000
A dry cold front moving across Eastern Oregon and Idaho set off a series of mainly dry thunderstorms generating severe outflow winds in the Treasure Valley, including Boise, and the Snake River plain throughout the evening of the 21st. Minor injuries were reported from the Western Idaho Fair as a result of temporary structures collapsing.			
6/4/2010	Thunderstorm Wind	0	$10,000
The Boise Automated Surface Observing Systems measured a wind gust of 59 MPH and NWS employees reported downed trees and fences in Southeast Boise along Surprise Valley Way. Ada County Emergency Manager reported power lines down in Southwest Boise and trees and traffic lights down in Garden City.			
6/29/2006	Thunderstorm Wind	0	$5,000
Very moist air mass combined with a well-defined vortices center and maximum day time heating to produce widespread pulse thunderstorms yielding numerous reports of nickel size hail and wind damage including downed trees and power lines			
1/30/2004	Thunderstorm Wind	0	$15,000
During the morning of January 30th a fast moving cold front produced several severe thunderstorms, very strong (in excess of 60 MPH) winds and snow showers as it moved eastward across Eastern Oregon and Southwestern Idaho. Fairly large trees were blown down in Payette in Payette County and in Nampa in Canyon County. There were also reports of trees down in Baker and Malheur counties in Oregon. Power was briefly knocked out in northern Owyhee County as the line of thunderstorms moved across the county..			
8/3/2000	Tornado	0	None reported
A series of thunderstorms moved though the Treasure Valley with 4 confirmed tornadoes in Ada County. One touched down near Hidden Springs with 2 large trees being uprooted. The path of the tornado was 10 yards wide and less than one-tenth of a mile in length. Another touched down near the intersection of Lake Hazel Road and 5 Mile Road. Damage was confined to one home where a flag pole was bent in half and a board was imbedded in the outer wall of the home. No injuries occurred and damage estimates were unavailable. The other 2 tornadoes touched down briefly south of the airport in open country. These were observed by off-duty NWS meteorologists and a trained spotter. These tornadoes caused no damage.			

Date	Type	Deaths or Injuries	Property Damage
1/16/1999	Thunderstorm Wind	0	$5,000
During the morning of January 16th a line of strong rain showers and ice pellet showers produced severe wind gusts near Boise. A spotter reported the roof of a small barn was blown off and a tree was uprooted. A second spotter reported a small outbuilding was blown 50 yards and power lines were downed.			
9/7/1998	Thunderstorm Wind	0	$20,000
Scattered thunderstorms produced heavy rains and isolated wet microbursts in the Boise area. Numerous reports of street flooding were received from around the city. Lightning caused a structure fire in Boise while about 3000 people were without power due to trees falling on power lines. At Shadow Valley on the outskirts of Boise, winds ripped two sections of roof off of an elementary school.			
9/7/1998	Lightning	0	$10,000
Scattered thunderstorms produced heavy rains and isolated wet microbursts in the Boise area. Numerous reports of street flooding were received from around the city. Lightning caused a structure fire in Boise while about 3000 people were without power due to trees falling on power lines. At Shadow Valley on the outskirts of Boise, winds ripped two sections of roof off of an elementary school.			
9/6/1998	Thunderstorm Wind	0	$8,000
During the evening of September 6th scattered thunderstorms moved through the Treasure Valley and Boise Mountains with heavy rain and isolated wet microbursts. In and around Boise numerous reports of street flooding were received while in Boise County a number of small mud slides covered the road between Garden Valley and Lowman. Winds gusted to an estimated 60 to 70 mph at the NWS office in Boise, while numerous reports of trees down were received from around the city. Winds toppled a tree onto a car and caused scattered power outages			
4/23/1998	Thunderstorm/ Wind/Hail	0	$20,000
A severe thunderstorm cut a path of damage from Owyhee Count through the Boise area and into the Boise Mountains. As the storm crossed into Ada County numerous reports of large hail up to golf ball size were received along with damaging winds up to 59 mph. Many trees were blown down and a greenhouse sustained heavy damage from large hail. In Canyon County and Gem County golf ball hail was reported. As the storm moved into Boise County golf ball size hail was reported by spotters in Horseshoe Bend and winds damaged a mobile home. Windblown debris smashed a car window. A wind gust of 74 mph was reported south of Idaho City.			
9/3/1995	Lightning	0	$50,000
In Gooding, high winds uprooted trees, downed power lines, and damaged several structures in the area. A thunderstorm that moved through the Boise area produced lightning igniting a house on fire. This storm also produced high winds downing power lines causing several power outages throughout the Treasure Valley.			
7/28/1995	Lightning	2	$50,000
Thunder storm in the Kuna area of Ada County caused 2 fatalities and approximately $5,000 in property damage			
8/15/1993	Lightning	0	$50,000
A lightning bolt did extensive damage to a home in Eagle, 10 miles northwest of Boise. The bolt punctured a hole in the roof, then traveled around the inside of the house damaging walls and knocking electrical outlets and telephones out of the walls. The bolt finally grounded on a telephone utility box and completely destroyed it.			
5/20/1993	Lightning	0	$5,000
Lightning from a morning thunderstorm struck two trees sending bark into two windows of a house. The two windows were shattered, and one tree was split.			
10/26/1984	Tornado	0	$25,000
An F1 tornado was reported in Ada County causing approximately $25,000 in Property damage.			

12.2.2 Location

Severe weather events have the potential to happen anywhere in the planning area. Communities in low-lying areas next to streams or lakes are more susceptible to flooding. Wind events are most damaging to areas that are heavily wooded. The distribution of average weather conditions over Ada County is shown on Figure 4-1 through Figure 4-4.

Damaging Winds

All of Ada County is subject to high winds from thunderstorms and other severe weather events. According to FEMA, Ada County is located in Wind Zone I, where wind speeds can reach up to 130 mph. Figure 12-7 indicates how the frequency and strength of windstorms impacts the United States and the general location of the most wind activity. This is based on 40 years of tornado data and 100 years of hurricane data collected by FEMA.

Source: FEMA 2010

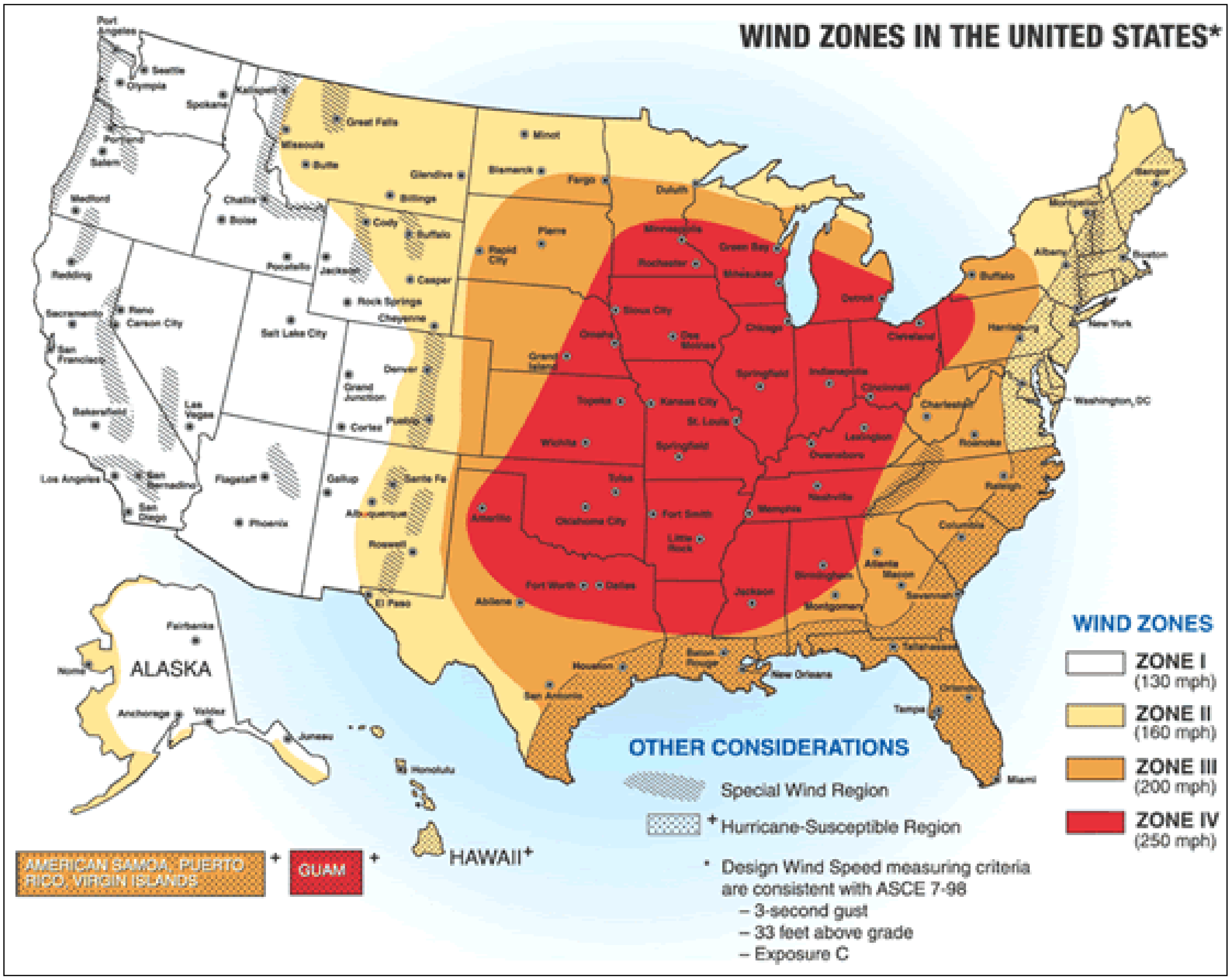


Figure 12-7. Wind Zones in the United States

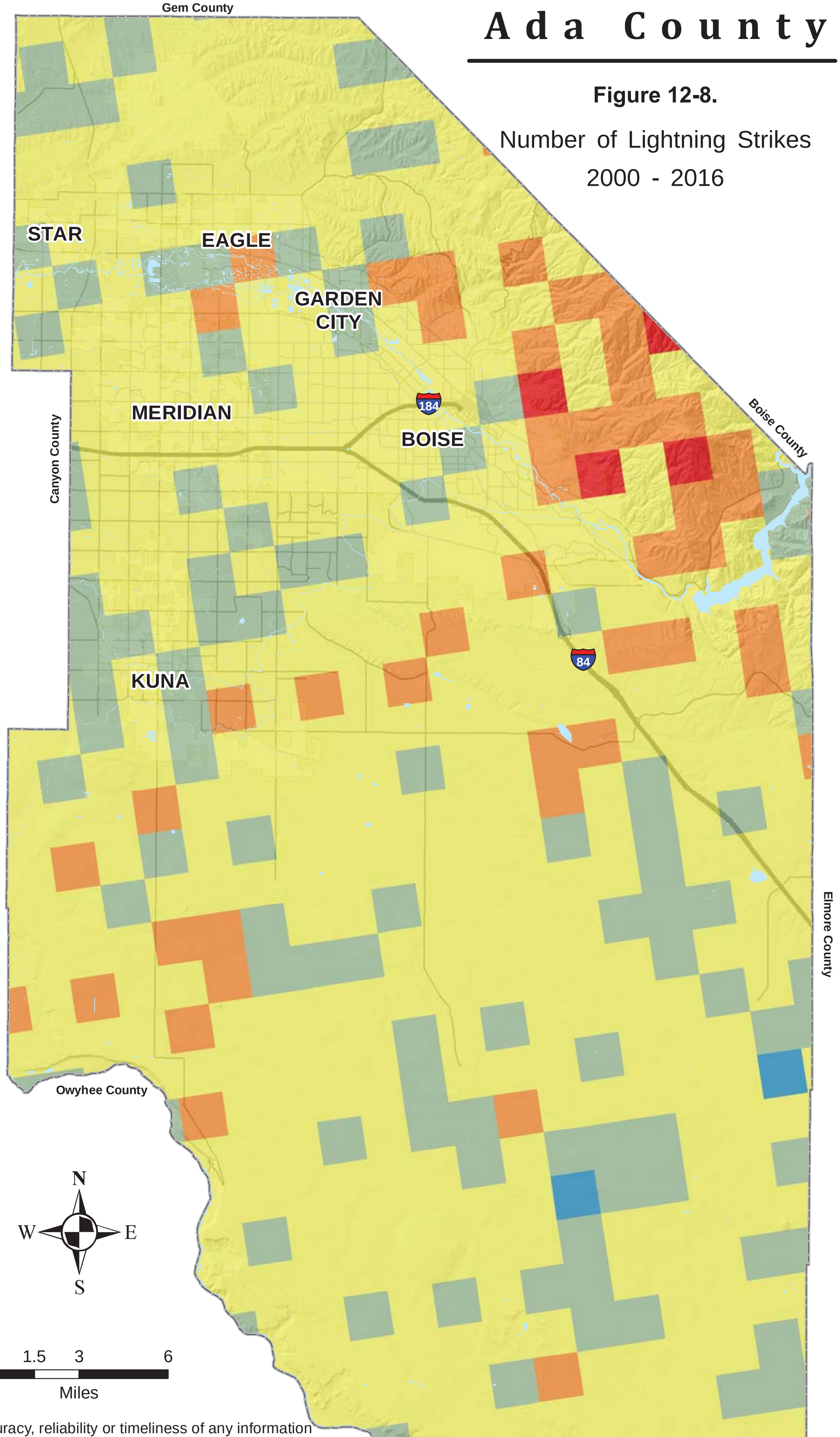
Lightning

Lightning strikes during severe thunderstorms have historically posed significant threats to the planning area. Figure 12-8 shows the distribution of lightning strikes across the planning area from 2000 through 2016.

Ada County

Figure 12-8.

Number of Lightning Strikes 2000 - 2016



Legend

No of Strikes per Square Mile

- 0 - 2.5
- 2.5 - 5
- 5 - 10
- 10 - 15
- 15+

Lightning strike data from National Weather Service

Base Map Data Sources:
Ada County, U.S. Geological Survey

TETRA TECH

12.2.3 Frequency

The severe weather events for Ada County shown in Table 12-1 are often related to high winds associated with winter storms and thunderstorms. The planning area can expect to experience exposure to some type of severe weather event at least annually.

12.2.4 Severity

The most common problems associated with severe storms are immobility and loss of utilities. Fatalities are uncommon, but can occur. Roads may become impassable due to flooding, downed trees or a landslide. Power lines may be downed due to high winds or ice accumulation, and services such as water or phone may not be able to operate without power. Lightning can cause severe damage and injury. Physical damage to homes and facilities can be caused by wind or accumulation of snow or ice. Even a small accumulation of snow can cause havoc on transportation systems due to a lack of snow clearing equipment and experienced drivers and the hilly terrain.

Windstorms can be a frequent problem in the planning area and have been known to cause damage to utilities. The predicted wind speed given in wind warnings issued by the National Weather Service is for a one-minute average; gusts may be 25 to 30 percent higher. Lower wind speeds typical in the lower valleys are still high enough to knock down trees and power lines and cause other property damage. Mountainous sections of the county experience much higher winds under more varied conditions.

Ice storms accompanied by high winds can have especially destructive impacts, especially on trees, power lines, and utility services. While sleet and hail can create hazards for motorists when they accumulate, freezing rain can cause the most dangerous conditions in the planning area. Ice buildup can bring down trees, communication towers and wires, creating hazards for property owners, motorists and pedestrians. Rain can fall on frozen streets, cars, and other sub-freezing surfaces, creating dangerous conditions.

The severity of an extreme heat event depends on the number of consecutive days it lasts (U.S. EPA, 2006). Urban heat island effect can exacerbate the severity of an extreme heat event. Impacts of an extreme heat event may include increased energy consumption, elevated emissions of air pollutants and greenhouse gases, compromised human health and comfort, and impaired water quality (U.S. EPA, 2015). Extreme heat can also impact infrastructure by warping bridges, causing roads to buckle, and melting runways.

Lightning severity is typically assessed based on property damage and life safety (injuries and fatalities). The number of reported injuries from lightning is likely to be low. County infrastructure losses can be up to thousands of dollars each year.

Tornadoes are potentially the most dangerous of local storms, but they are not common in the planning area. If a major tornado were to strike within the populated areas of the county, damage could be widespread. Businesses could be forced to close for an extended period or permanently, fatalities could be high, many people could be homeless for an extended period, and routine services such as telephone or power could be disrupted. Buildings could be damaged or destroyed.

12.2.5 Warning Time

Meteorologists can often predict the likelihood of a severe storm. This can give several days of warning time. However, meteorologists cannot predict the exact time of onset or severity of the storm. Some storms may come on more quickly and have only a few hours of warning time.

12.3 SECONDARY HAZARDS

The most significant secondary hazards associated with severe local storms are floods, falling and downed trees, landslides and downed power lines. Rapidly melting snow combined with heavy rain can overwhelm both natural and man-made drainage systems, causing overflow and property destruction. Landslides occur when the soil on slopes becomes oversaturated and fails.

12.4 EXPOSURE

12.4.1 Population

A lack of data separating severe weather damage from flooding and landslide damage prevented a detailed analysis for exposure and vulnerability. However, it can be assumed that the entire planning area is exposed to some extent to severe weather events. Certain areas are more exposed due to geographic location and local weather patterns. Populations living at higher elevations with large stands of trees or power lines may be more susceptible to wind damage and black out, while populations in low-lying areas are at risk for possible flooding.

12.4.2 Property

According to the Ada County Assessor, there are 146,448 buildings within the census tracts that define the planning area. Most of these buildings are residential. It is estimated that approximately 20 percent of the residential structures were built without the influence of a structure building code with provisions for wind loads. All of these buildings are considered to be exposed to the severe weather hazard, but structures in poor condition or in particularly vulnerable locations (located on hilltops or exposed open areas) may risk the most damage. The frequency and degree of damage will depend on specific locations.

12.4.3 Critical Facilities and Infrastructure

Critical facilities exposed to floods are at risk from severe weather with heavy rain or snowmelt. Critical facilities on higher ground may be exposed to wind damage, damage from falling trees, heavy snow and ice accumulation, tornadoes, lightning strikes and extreme temperatures. The most common problems associated with severe weather are loss of utilities. The following systems also are at risk:

- **Transportation Systems**—High winds can cause significant damage to trees and power lines, disrupting ingress and egress on roads with obstructing debris. Snowstorms significantly impact the transportation system and the availability of public safety services. Of particular concern are roads providing access to isolated areas and bridges, which tend to become icy before and after other areas are clear.
- **Power and Communication Lines**—Ice and severe windstorms can create serious impacts on power and above-ground communication lines. Freezing of power and communication lines can cause them to break, disrupting both electricity and communication for households. They can also break as a result of falling trees. This can result in isolation.
- **Water and Sewer Lines**—Severe local storms can cause water and sewer lines to freeze, which may crack pipes. This could result in a loss of potable water to households or exposed sewage causing public health hazards. However, extreme and prolonged freezing weather is required to cause underground pipes to crack, which is not likely to occur in Ada County. Above-ground pipes leading to and from individual homes are more likely vulnerabilities than large mainlines.

12.4.4 Environment

The environment is highly exposed to severe weather. Natural habitats such as streams and trees are exposed to the elements during a severe storm and risk major damage and destruction. Prolonged rains can saturate soils and lead to slope failure. Flooding events caused by severe weather or snowmelt can produce river channel migration or damage riparian habitat. Storm surges can erode beachfront bluffs and redistribute sediment loads.

12.5 VULNERABILITY

12.5.1 Population

Populations vulnerable to severe weather hazards tend to be the elderly, low income or linguistically isolated populations, people with life-threatening illnesses, residents living in areas that are isolated from major roads, and residents who lack proper shelter. Power outages can be life threatening to those dependent on electricity for life support. Isolation of these populations is a significant concern. These populations face isolation and exposure during severe weather events and could suffer more secondary effects of the hazard. Population vulnerabilities to specific types of severe weather event are as follows:

- **Damaging Winds—**Debris carried by extreme winds and trees felled by gusty conditions can contribute directly to loss of life and indirectly to the failure of protective building envelopes. Utility lines brought down by thunderstorms have also been known to cause fires, which start in dry roadside vegetation. Electric power lines falling down to the pavement create the possibility of lethal electric shock.
- **Extreme Temperatures—**Individuals with physical or mobility constraints, cognitive impairments, economic constraints, or social isolation are typically at greater risk to the adverse effects of excessive heat events. The average summertime mortality for excessive heat events is dependent upon the methodology used to derive such estimates. Certain medical conditions, such as heat stroke, can be directly attributable to excessive heat, while others may be exacerbated by excessive heat, resulting in medical emergencies. Individuals who lack shelter and heating are particularly vulnerable to extreme cold and wind chill.
- **Severe Winter Weather—**Many of the deaths that result from severe winter weather are indirectly related to the actual weather event, including deaths resulting from traffic accidents on icy roads and heart attacks while shoveling snow. Icy road conditions that lead to major traffic accidents can make it difficult for emergency personnel to travel. This may pose a secondary threat to life if police, fire, and medical personnel cannot respond to calls. Homeless populations that lack adequate shelter are also vulnerable to severe winter weather events.
- **Thunderstorms—**Nationally, lighting is one of the leading causes of weather-related fatalities (CDC, 2013). Lightning strikes are far more common in other areas of the country than they are in the Pacific Northwest. The majority of injuries and deaths associated with lighting strikes occur when people are outdoors; however, almost one-third of lightning-related injuries occur indoors. Males are five times more likely than females to be struck by lighting and people between the ages of 15 and 34 account for 41 percent of all lightning strike victims (CDC, 2013).
- **Tornado—**All residents in the path of a tornado are vulnerable, especially if there is not adequate warning that tornado spawning conditions are likely.

12.5.2 Property

All property is vulnerable during severe weather events, but properties in poor condition or in particularly vulnerable locations may risk the most damage. Those in higher elevations and on ridges may be more prone to wind damage. Those that are located under or near overhead lines or near large trees may be vulnerable to falling ice or may be damaged in the event of a collapse.

Loss estimations for the severe weather hazard are not based on damage functions, because no such damage functions have been generated. Instead, loss estimates were developed representing 10 percent, 30 percent and 50 percent of the assessed value of exposed structures. This allows emergency managers to select a range of potential economic impact based on an estimate of the percent of damage to the general building stock. Damage in excess of 50 percent is considered to be substantial by most building codes and typically requires total reconstruction of the structure. Table 12-2 lists the loss estimates to the general building stock.

Table 12-2. Potential Damage to Buildings from Severe Weather Hazard

City	Assessed Value	10% Damage	30% Damage	50% Damage
Boise	$45,642,188,433	$4,564,218,843	$13,692,656,530	$22,821,094,217
Eagle	$5,857,755,422	$585,775,542	$1,757,326,627	$2,928,877,711
Garden City	$2,943,165,591	$294,316,559	$882,949,677	$1,471,582,796
Kuna	$1,883,061,353	$188,306,135	$564,918,406	$941,530,676
Meridian	$17,053,008,618	$1,705,300,862	$5,115,902,585	$8,526,504,309
Star	$1,182,833,889	$118,283,389	$354,850,167	$591,416,944
Unincorporated	$9,269,999,192	$926,999,919	$2,780,999,758	$4,634,999,596
Total	$83,832,012,498	$8,383,201,249	$25,149,603,750	$41,916,006,249

12.5.3 Critical Facilities and Infrastructure

Incapacity and loss of roads are the primary transportation failures resulting from severe weather, mostly associated with secondary hazards. Landslides caused by heavy prolonged rains can block roads. High winds can cause significant damage to trees and power lines, blocking roads with debris, incapacitating transportation, isolating population, and disrupting ingress and egress. Snowstorms in higher elevations can significantly impact the transportation system and the availability of public safety services. Of particular concern are roads providing access to isolated areas and to the elderly.

Prolonged obstruction of major routes due to landslides, snow, debris or floodwaters can disrupt the shipment of goods and other commerce. Large, prolonged storms can have negative economic impacts for an entire region. Severe windstorms, downed trees, and ice can create serious impacts on power and above-ground communication lines. Freezing of power and communication lines can cause them to break, disrupting electricity and communication. Loss of electricity and phone connection would leave certain populations isolated because residents would be unable to call for assistance.

12.5.4 Environment

The vulnerability of the environment to severe weather is the same as the exposure.

12.6 DEVELOPMENT TRENDS

Because all of the planning area is exposed to the severe weather hazard, the increase in exposed population and property since the last hazard mitigation plan update is equal to the countywide trend over that time period: a 10.7-percent increase in population, a 29.2-percent increase in number of general building stock structures, and an 83.5-percent increase in total assessed property value (see Section 4.56.3). However, since the majority of this growth was new development, the increase in vulnerability to severe weather is considered to be minimal due to the influence of strong codes and code enforcement within the planning area.

All future development will be affected by severe storms. The ability to withstand impacts lies in sound land use practices and consistent enforcement of codes and regulations for new construction. All planning partners that have permit authority have adopted the International Building Code. This code is equipped to deal with the impacts of severe weather events. Land use policies identified in comprehensive plans within the planning area also address many of the secondary impacts (flood and landslide) of the severe weather hazard. With these tools, the planning partnership is well equipped to deal with future growth and the associated impacts of severe weather.

12.7 SCENARIO

Severe local storms can occur frequently and impacts can be significant, particularly when secondary hazards of flood and landslide occur. A worst-case event would involve prolonged high winds during a winter storm accompanied by thunderstorms. Such an event would have both short-term and longer-term effects. Initially, schools and roads would be closed due to power outages caused by high winds and downed tree obstructions. In more rural areas, some subdivisions could experience limited ingress and egress. Prolonged rain could produce flooding, overtopped culverts with ponded water on roads, and landslides on steep slopes. Flooding and landslides could further obstruct roads and bridges, further isolating residents.

12.8 ISSUES

Important issues associated with a severe weather in the Ada County planning area include the following:

- Older building stock in the planning area is built to low code standards or none at all. These structures could be highly vulnerable to severe weather events such as windstorms.
- Redundancy of power supply throughout the planning area must be evaluated to better understand what areas may be vulnerable.
- The capacity for backup power generation is limited.
- The County has numerous isolated population centers.
- Public education on dealing with the impacts of severe weather needs to continue so that residents can be better informed and prepared for severe weather events.
- Debris management (downed trees, etc.) must be addressed, because debris can impact the severity of severe weather events, requires coordination efforts, and may require additional funding.
- Older building stock in the planning area is built to low code standards or none at all. These structures could be highly vulnerable to severe winter weather effects such as snow loads or high winds.
- Street tree management programs should be evaluated to help reduce impacts from tree-related damages.
- Priority snow removal routes should continue to be cleared first to ensure navigable routes through and between jurisdictions.

13. VOLCANO (ASH FALL)

13.1 GENERAL BACKGROUND

A volcano is a vent in the earth's crust through which magma, rock fragments, gases and ash are ejected from the earth's interior. Over time, accumulation of these erupted products on the earth's surface creates a volcanic mountain. Figure 13-1 illustrates how Cascade volcanoes were formed.

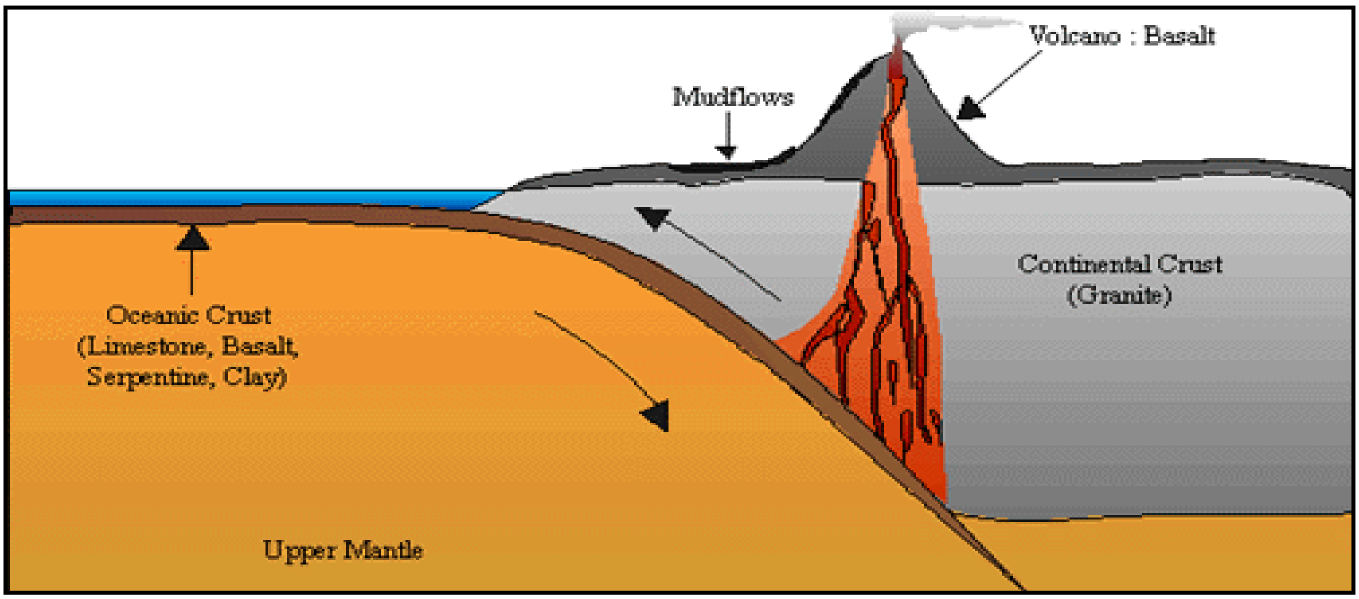


Figure 13-1. How Cascade Volcanoes Are Formed

There are a wide variety of hazards related to volcanoes and volcanic eruptions. The hazards are distinguished by the different ways in which volcanic materials and other debris flow from the volcano. The molten rock that erupts from the volcano (lava) forms a hill or mountain around the vent. The lava may flow out as a viscous liquid, or it may explode from the vent as solid or liquid particles. Ash and fragmented rock material can become airborne and travel far from the erupting volcano to affect distant areas.

Volcanoes can lie dormant for centuries between eruptions. When they erupt, high-speed avalanches of hot ash and rock called pyroclastic flows, lava flows, and landslides can devastate areas 10 or more miles away, while huge mudflows of volcanic ash and debris called ***lahars*** can inundate valleys more than 50 miles downstream. Falling ash from explosive eruptions, called ***tephra,*** can disrupt human activities hundreds of miles downwind, and drifting clouds of fine ash can cause severe damage to the engines of jet aircraft hundreds or thousands of miles away.

16.1.2 Idaho Volcanic Activity

Currently there are no active volcanoes in Idaho, but there is evidence of several types of volcanoes.

Craters of the Moon

Craters of the Moon is a volcanic field of basalt composition, 17,000 to 19,000 feet in elevation, that experienced eight eruptive episodes from 15,000 to 2,000 years ago. Its lava field lies along the northern border of the Snake River Plain, midway between Arco and Carey, Idaho. The Snake River Plain is a volcanic province that was created by a series of cataclysmic caldera-forming super-eruptions that started about 15 million years ago. The Yellowstone hotspot (see Section 9.1.1) was under the Craters of the Moon area some 10 to 11 million years ago but moved as the North American Plate migrated southwestward. Pressure from the hotspot heaves the land surface up, creating fault-block mountains. After the hotspot passes, the pressure is released and the land subsides. Leftover heat from this hotspot was later liberated by Basin and Range-associated rifting and created the overlapping lava flows that make up the Lava Beds of Idaho. The largest rift zone is the Great Rift; it is from the Great Rift fissure system that Craters of the Moon, Kings Bowl, and Wapi lava fields were created.

A typical eruption along the Great Rift and similar basaltic rift systems starts with a curtain of very fluid lava shooting up to 1,000 feet high along a segment of the rift up to 1 mile long. As the eruption continues, pressure and heat decrease and the lava becomes slightly more silica rich. The curtain of lava responds by breaking apart into separate vents. Various types of volcanoes may form at these vents: gas-rich pulverized lava creates cinder cones, and pasty lava blobs form spatter cones. Later stages of an eruption push lava streams out through the side or base of cinder cones, which usually ends the life of the cinder cone. This will sometimes breach part of the cone and carry it away as large and craggy blocks of cinder. Solid crust forms over lava streams, and lava tubes (a type of cave) are created when lava vacates its course.

Geologists feared that a large earthquake that shook Borah Peak, Idaho's tallest mountain, in 1983 would restart volcanic activity at Craters of the Moon, though this proved not to be the case. Geologists predict that the area will experience its next eruption sometime in the next 900 years, with the most likely period in the next 100 years.

Bruneau-Jarbidge Caldera

The Bruneau-Jarbidge caldera (sometimes called a super volcano) is located in present-day southwest Idaho. The volcano erupted during the Miocene, between 10 and 12 million years ago, spreading a thick blanket of ash and forming a caldera. At the time, the caldera was above the Yellowstone hotspot. Prevailing westerly winds deposited distal ash fall over a vast area of the Great Plains. The evolving composition of the erupted material indicates that while it is derived in large part from melted material from the middle or upper crust, it also incorporated a young basaltic component.

Henry's Fork Caldera

The Henry's Fork Caldera in Idaho is located in an area known as Island Park west of Yellowstone National Park. The caldera was formed by a super-volcano in an eruption of more than 67 cubic miles 1.3 million years ago, and is the source of the Mesa Falls Tuff (tuff is a consolidated volcanic ash). The Henry's Fork Caldera is nested inside the Island Park Caldera; the two calderas share a rim on the western side. The older Island Park Caldera is much larger and more oval and extends well into Yellowstone Park. Although much smaller than the Island Park Caldera, the Henry's Fork Caldera is still sizeable at 18 miles long and 23 miles wide and its curved rim is plainly visible from many locations in the Island Park area. Of the many calderas formed by the Yellowstone hotspot, the Henry's Fork Caldera is the only one that is currently clearly visible.

Henry's Fork of the Snake River flows through the Caldera and drops out at Upper and Lower Mesa Falls. The caldera is bounded by Ashton Hill on the south, Big Bend Ridge and Bishop Mountain on the west, Thurburn Ridge on the north and Black Mountain and the Madison Plateau on the east.

Mahogany Mountain

Mahogany Mountain is an ancient caldera volcano on the border of Malheur County Oregon and Owyhee County Idaho. Its last eruption was probably 15.5 million years ago. This eruption ejected layers of volcanic rock tuff, creating formations of rock in the Leslie Gulch. A part of the Basin and Range Province, the volcano's most recent eruptive activity dates to 15 million years ago (the Miocene), forming during a period of active volcanism. It formed around the same time as Three Fingers, Castle Peak, and three other volcanoes. Today the volcano appears gnarled due to erosion and is topped by pine forests. The caldera is narrow and shaped like a ridge, with precipitous slopes and an escarpment on the northwest flank.

Leslie Gulch lies within the depression of the volcano. Layers of ash and tuff are evident in the formation, and leftover volcanic rocks sit in it as well. The gulch features an array of rock formations and ash erupted from the volcano 15.5 million years ago.

Menan Buttes

The North and South Menan Buttes in southeastern Idaho are two of the world's largest volcanic tuff cones. They are located in Madison County, with lower slopes extending westward into Jefferson County. The two cones, with four smaller associated cones, align along a north-northwest line and make up the Menan Complex. The buttes rise about 800 feet above the surrounding Snake River plain and are late Pleistocene in age, dating to 10,000 years ago. The buttes are the remains of the only volcanic eruptions that have occurred in freshwater within the boundaries of the modern United States. The South Menan Butte is currently in private hands, but North Menan Butte is publicly owned and has been designated as a National Natural Landmark and a Research Natural Area by the U.S. Congress. The BLM designated the North Butte as an Area of Critical Environmental Concern.

The volcanoes forming the two major Menan Buttes were created when basaltic magma came into contact with a shallow aquifer or with the precursor of the modern Snake River. Particles of volcanic glass were created as the water turned to steam and explosively fragmented the hot magma. The cone-shaped deposits are fairly uniform and consist primarily of tuff in small stone-sized particles. Some deposit layers preserve indentations made as larger pyroclastic particles landed on soft layers of tuff.

The Menan Buttes stand at an elevation of 5,619 feet and are very similar in size and shape. North Menan Butte is slightly larger and elliptical, with axes 2 and 2.5 miles in length. South Menan Butte measures 2 miles by 1 mile. The crater of the North Menan Butte is about 3,000 feet in diameter and the cone is about 6,000 feet in diameter. The North Butte's volume is 0.16 cubic miles and the South Butte measures at 0.07 cubic miles. In comparison, the better-known tuff cone Diamond Head on Oahu has a volume of 0.15 cubic miles. The larger buttes in the Menan Complex are asymmetrical. Each has a greater accumulation of material on the northeast, presumably due to strong southwest winds during the initial eruption.

Yellowstone Caldera

The Yellowstone Caldera, sometimes referred to as the Yellowstone super-volcano, is located in Yellowstone National Park in the northwest corner of Wyoming. The major features of the caldera measure about 34 miles by 45 miles. The last full-scale eruption of the Yellowstone super-volcano, the Lava Creek eruption nearly 640,000 years ago, ejected 240 cubic miles of rock and dust into the sky.

The upward movement of the Yellowstone caldera floor between 2004 and 2008—almost 3 inches each year, and as much as 8 inches at the White Lake GPS station—was more than three times greater than ever observed since measurements began in 1923. By the end of 2009, the uplift had slowed significantly and appeared to have stopped. In January 2010, the USGS stated "that uplift of the Yellowstone Caldera has slowed significantly" and uplift continues but at a slower pace. Scientists with the Yellowstone Volcano Observatory say there is no evidence that a cataclysmic eruption will occur at Yellowstone in the foreseeable future.

13.2 HAZARD PROFILE

The greatest volcano risk to the planning area is tephra accumulation from Cascade Range eruptions. The Cascade Range extends more than 1,000 miles from southern British Columbia into northern California and includes 13 potentially active volcanic peaks in the U.S. The heart of the Cascade Range lies 320 miles west of the Ada County planning area. Many of these volcanoes are far from the county or not directly upwind of the county.

13.2.1 Past Events

Figure 13-2 summarizes past eruptions in the Cascades. The last major volcanic eruption in the continental United states was the explosion of Mount St. Helens on May 18, 1980. Due to its great distance, and location across the continental divide of the Cascades, the lava and lahar flow from this eruption did not affect the Ada County planning area. West-central and southwestern Idaho did see small amounts (less than 1 inch) of tephra (ash) fall.

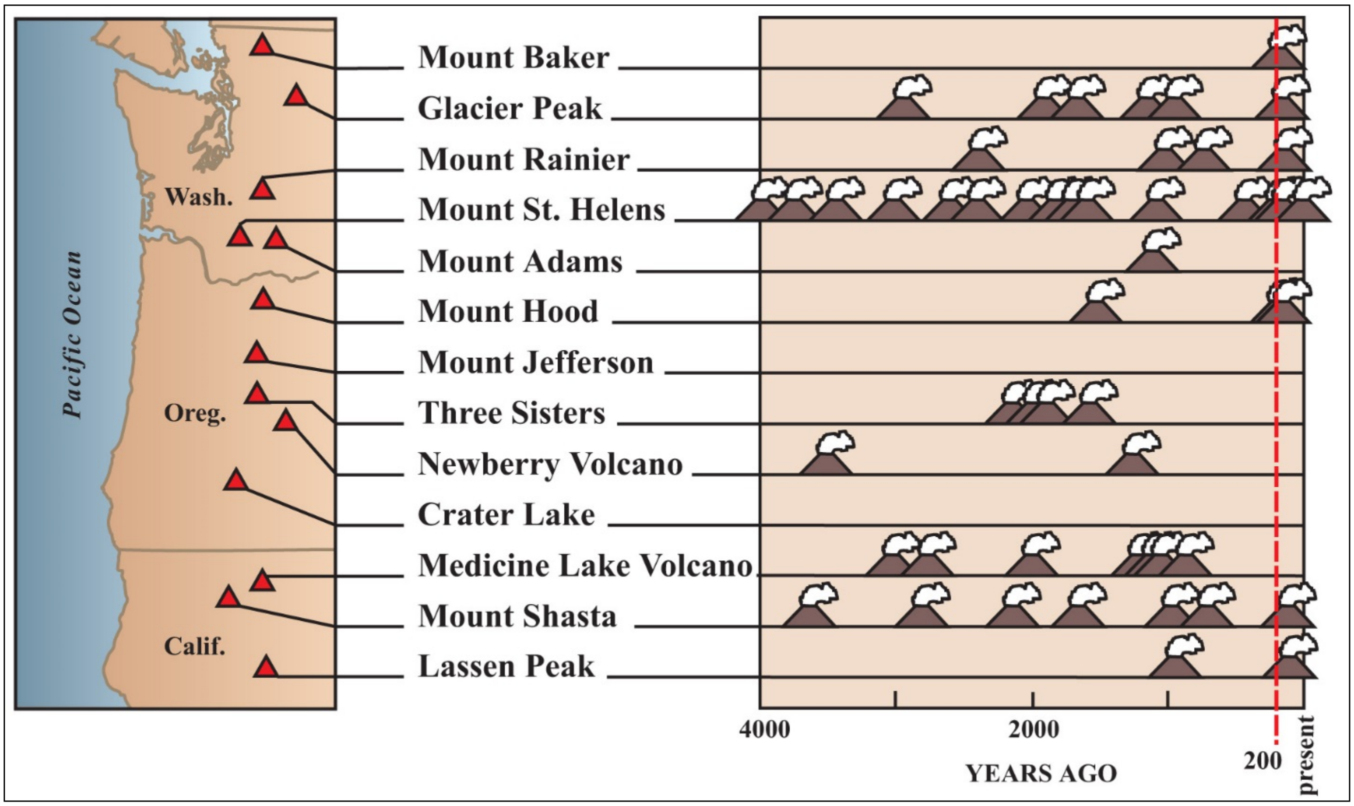


Figure 13-2. Past Eruptions in the Cascade Range

13.2.2 Location

The most hazardous volcanoes are those directly west and southwest of the county (along the direction of prevailing winds). The closest volcanoes due west of the planning area are Sisters, (330 miles) and Newberry Crater (285 miles). Mount Shasta in California is within 500 miles and is southwest of the Ada County planning area. With prevailing wind directions, volcanic eruption of Mount Shasta would put the Ada County planning area in the direct path for significant tephra accumulation. Figure 13-3 shows active volcanoes within the western United States.

Figure 13-3. Potentially Active Volcanoes in the Western U.S.

13.2.3 Frequency

Eruptions in the Cascades have occurred at an average rate of 1 or 2 per century during the last 4,000 years. Mount St. Helens is by far the most active volcano in the Cascades, with four major explosive eruptions in the last 515 years. Still, the probability of an eruption in any given year is extremely low.

13.2.4 Severity

A 1-inch deep layer of ash weighs an average of 10 pounds per square foot, causing danger of structural collapse. Ash is harsh, acidic and gritty, and it has a sulfuric odor. Ash may also carry a high static charge for up to two days after being ejected from a volcano. When an ash cloud combines with rain, sulfur dioxide in the cloud combines with the rainwater to form diluted sulfuric acid that may cause minor, but painful burns to the skin, eyes, nose and throat.

13.2.5 Warning Time

The best warning of a volcanic eruption is one that specifies when and where an eruption is likely and what type and size eruption should be expected. Such accurate predictions are sometimes possible but still rare. The most accurate warnings are those in which scientists indicate an eruption is probably only hours to days away, based on significant changes in a volcano's earthquake activity, ground deformation, and gas emissions. Experience from around the world has shown that most eruptions are preceded by such changes over a period of days to weeks. A volcano may begin to show signs of activity several months to a few years before an eruption. However, a warning that specifies months or years in advance when it might erupt are extremely rare.

13.3 SECONDARY HAZARDS

The secondary hazards associated with volcanic eruptions are mudflows and landslides and possibly seismic activity in the region of the eruption.

13.4 EXPOSURE

The Ada County planning area has no direct volcanic exposure. The planning area is generally downwind of three Cascade Range volcanoes, and could experience the impacts of a tephra fall from any of these. Additionally, there are several dormant volcanic sources in Idaho that could create significant exposure to the planning area should they become active. Using the latest eruption of Mount St. Helens as an indicator, a tephra fall in Ada County could be anywhere from a half-inch to an inch. Nonetheless, some people, property and the environment are vulnerable to the effects of a tephra fall, as discussed below

13.4.1 Population

The whole population of the planning area would be exposed to some degree to the effects of a tephra fall from volcanic eruptions in the Cascade Range or volcanic sites in Idaho. The degree of exposure is highly dependent upon the magnitude of the eruption and the prevailing wind speed and direction.

13.4.2 Property

All property within the planning area could be exposed to the effects of a tephra fall to some degree. The degree of exposure would be highly dependent upon proximity to the event, magnitude of the event and the prevailing wind speed and direction at the time of the event.

13.4.3 Critical Facilities

All critical facilities could have some degree of exposure to tephra accumulation. All transportation routes are exposed to ash fall and tephra accumulation, which could create hazardous driving conditions on roads and highways and hinder evacuations and response

13.4.4 Environment

The environment is highly exposed to the effects of a volcanic eruption. Even if ash from a volcanic eruption were to fall elsewhere, it could be spread throughout the county by the rivers and streams. A volcanic blast would expose the local environment to many effects such as lower air quality, and many other elements that could harm local vegetation and water quality.

13.5 VULNERABILITY

13.5.1 Population

While accumulations of tephra would not be considered to be significant, the populations most vulnerable to the effects of a tephra fall are the elderly, the very young and those already experiencing ear, nose and throat problems. Homeless people, who may lack adequate shelter, are also vulnerable to the effects of a tephra fall, although Ada County has few homeless people who would not be able to find adequate shelter or assistance during an event.

13.5.2 Property

The planning team was not able to generate damage estimates for this hazard because there are no generally accepted damage functions for volcanic hazards in risk assessment platforms such as Hazus-MH. Vulnerable property includes equipment and machinery left out in the open, such as farm equipment, whose parts can become clogged by the fine dust. Since Ada County receives snow every year, and roofs are built to withstand snow loads, most roofs are not vulnerable and would be able to withstand the potential load of ash. Infrastructure, such as drainage systems, is also potentially vulnerable to the effects of a tephra fall, since the fine ash can clog pipes and culverts. This may be more of a problem if an eruption occurs during winter or early spring when precipitation is highest and floods are most likely.

13.5.3 Critical Facilities

Critical facilities in the direction of wind would be vulnerable to tephra accumulations. Water treatment plants, power generation stations and wastewater treatment plants are vulnerable to contamination from ash fall.

13.5.4 Environment

The environment is very vulnerable to the effects of a volcanic eruption, even if the eruption does not directly impact the planning area. This is highly dependent upon the amount of tephra accumulation. Rivers and streams in the Boise River watershed are vulnerable to damage due to ash fall, especially since ash fall can be carried throughout the county by these water courses. The sulfuric acid contained in volcanic ash could be damaging to area vegetation, waters, wildlife and air quality.

13.6 DEVELOPMENT TRENDS

Because all of the planning area is exposed to the volcanic ash fall hazard, the increase in exposed population and property since the last hazard mitigation plan update is equal to the countywide trend over that time period: a 10.7-percent increase in population, a 29.2-percent increase in number of general building stock structures, and an 83.5-percent increase in total assessed property value (see Section 4.56.3). However, since the majority of this growth was new development, the increase in vulnerability to volcanic ash fall is considered to be minimal due to the influence of strong codes and code enforcement within the planning area.

All future development has the potential of being impacted by ash fall generated from a volcanic event. While this potential impact on the built environment is not considered to be significant, the economic impact on industries that rely on machinery and equipment such as agriculture or civil engineering projects could be significant. The extent of this hazard is difficult to gauge because it is dependent upon many variables, so the ability to institute land use recommendations based on potential impacts of this hazard is limited. While the impacts of volcanic hazards are sufficient to warrant risk assessment for emergency management purposes, the impacts are not considered to be sufficient to dictate land use decisions.

13.7 SCENARIO

The worst-case scenario for the Ada County planning area would be any volcanic activity associated with the Yellowstone hotspot. Geologic history has shown that volcanic activity associated with the hotspot could be catastrophic if it were to occur in today's environment. The probability of such an event occurring in the near term is up for geologic debate. A more likely scenario is volcanic activity in the Cascade Range producing a significant amount of ash fall within the planning area. No one would be injured or killed, but businesses and non-essential government would be closed until the cloud passes. People and animals without shelter would be affected. Structures would be safe, but private property left out in the open, such as farm equipment, might be damaged by the fine ash dust.

13.8 ISSUES

Since volcanic episodes have been fairly predictable in the recent past, there is not much concern about loss of life, or impact on property. However, economic and environmental impacts are something to consider in emergency management.

14. WILDFIRE

14.1 GENERAL BACKGROUND

> This risk assessment for the wildfire hazard has been developed so that it qualifies as a Community Wildfire Protection Plan for the Ada County Planning area, complying with the standards of the Healthy Forests Restoration Act.

A wildfire is defined as an uncontrolled fire on undeveloped or developed land that in most cases, but not all, requires fire suppression. Wildfires can be beneficial to the landscapes that they impact. They can be ignited by lightning or by human activity such as smoking, campfires, equipment use and arson. Wildfires occur when all of the necessary elements of a fire come together in a wooded or grassy area: an ignition source is brought into contact with a combustible material such as vegetation that is subjected to sufficient heat and has an adequate supply of oxygen from the ambient air.

A wildfire front is the portion of a wildfire sustaining continuous flaming combustion, where unburned material meets active flames. As the front approaches, the fire heats both the surrounding air and vegetative material through convection and thermal radiation. First, vegetative material is dried as water in it is vaporized at a temperature of 212ºF. Next, the wood releases flammable gases at 450ºF. Finally, wood can smolder at 720ºF, and ignite at 1,000ºF. Before the flames of a wildfire arrive at a particular location, heat transfer from the wildfire front can warm the air to 1,470ºF, which pre-heats and dries flammable materials, causing them to ignite faster and allowing the fire to spread faster. High temperature and long-duration surface wildfires may encourage flashover or *torching*: the drying of tree canopies and their subsequent ignition from below.

Large wildfires may affect air currents by the stack effect: air rises as it is heated, so large wildfires create powerful updrafts that draw in new, cooler air from surrounding areas in thermal columns. Great vertical differences in temperature and humidity encourage fire-created clouds, strong winds, and fire whirls with the force of tornadoes at speeds of more than 50 mph. Rapid rates of spread, prolific crowning or spotting, the presence of fire whirls, and strong convection columns signify extreme conditions.

14.1.1 Wildfire Types

Fire types can be generally characterized by their fuels as follows:

- Ground fires are fed by subterranean roots, duff and other buried organic matter. This fuel type is especially susceptible to ignition due to spotting. Ground fires typically burn by smoldering, and can burn slowly for days to months.
- Crawling or surface fires are fueled by low-lying vegetation such as leaf and timber litter, debris, grass, and low-lying shrubbery.
- Ladder fires consume material between low-level vegetation and tree canopies, such as small trees, downed logs and vines. Invasive plants that scale trees may encourage ladder fires.
- Crown, canopy or aerial fires burn suspended material at the canopy level, such as tall trees, vines and mosses. The ignition of a crown fire, called *crowning*, depends on the density of the suspended material, canopy height, canopy continuity, and the presence of surface and ladder fires to reach the tree crowns.

14.1.2 Factors Affecting Wildfire Risk

Three principal factors have a direct impact on the behavior of wildfires: topography, fuel, and weather.

Topography

Topography can have a powerful influence on wildfire behavior. The movement of air over the terrain tends to direct a fire's course. Gulches and canyons can funnel air and act as a chimney, intensifying fire behavior and inducing faster rates of spread. Saddles on ridge tops offer lower resistance to the passage of air and will draw fires. Solar heating of drier, south-facing slopes produces upslope thermal winds that can complicate behavior.

Slope is an important factor. If the percentage of uphill slope doubles, the rate of spread of wildfire will likely double. On steep slopes, fuels on the uphill side of the fire are closer physically to the source of heat. Radiation preheats and dries the fuel, thus intensifying fire behavior. Fire travels downslope much more slowly than it does upslope, and ridge tops often mark the end of wildfire's rapid spread.

Fuels

Fuels are classified by weight or volume (fuel loading) and by type. Fuel loading, often expressed in tons per acre, can be used to describe the amount of vegetative material available. If fuel loading doubles, the energy released also can be expected to double. Each fuel type is given a burn index, which is an estimate of the amount of potential energy that may be released, the effort required to contain a fire in a given fuel, and the expected flame length. Different fuels have different burn qualities. Some fuels burn more easily or release more energy than others. Grass, for instance, releases relatively little energy, but can sustain very high rates of spread.

Continuity of fuels is expressed in terms of horizontal and vertical dimensions. Horizontal continuity is what can be seen from an aerial photograph and represents the distribution of fuels over the landscape. Vertical continuity links fuels at the ground surface with tree crowns via ladder fuels.

Another essential factor is fuel moisture. Fuel moisture is expressed as a percentage of total saturation and varies with antecedent weather. Low fuel moistures indicate the probability of severe fires. Given the same weather conditions, moisture in fuels of different diameters changes at different rates. A 1,000-hour fuel, which has a 3- to 8-inch diameter, changes more slowly than a 1- or 10-hour fuel.

Weather

Of all the factors influencing wildfire behavior, weather is the most variable. Extreme weather leads to extreme events, and it is often a moderation of the weather that marks the end of a wildfire's growth and the beginning of successful containment. High temperatures and low humidity can produce vigorous fire activity. The cooling and higher humidity brought by sunset can dramatically quiet fire behavior.

Fronts and thunderstorms can produce winds that are capable of radical and sudden changes in speed and direction, causing similar changes in fire activity. The rate of spread of a fire varies directly with wind velocity. Winds may play a dominant role in directing the course of a fire. The radical and devastating effect that wind can have on fire behavior is a primary safety concern for firefighters. In July 1994, a sudden change in wind speed and direction on Storm King Mountain led to a blowup that claimed the lives of 14 firefighters. The most damaging firestorms are usually marked by high winds.

14.1.3 Historical Fire Regime and Current Condition Classification

Land managers need to understand historical fire regimes (that is, fire frequency and fire severity prior to significant human settlement) to be able to define ecologically appropriate goals and objectives for an area. This understanding must include knowledge of how historical fire regimes vary across the landscape. Five historical fire regimes are classified based on average number of years between fires (fire frequency) and the severity of the fire (amount of replacement) on the dominant overstory vegetation:

I. 0- to 35-year frequency and low (surface fires most common) to mixed severity (less than 75 percent of the dominant overstory vegetation replaced)
II. 0- to 35-year frequency and high (stand replacement) severity (greater than 75 percent of the dominant overstory vegetation replaced)
III. 35- to 100-year frequency and mixed severity (less than 75 percent of the dominant overstory vegetation replaced)
IV. 35- to 100-year frequency and high (stand replacement) severity (greater than 75 percent of the dominant overstory vegetation replaced)
V. >200-year frequency and high (stand replacement) severity.

Understanding ecosystem departures—how ecosystem processes and functions have changed—provides a context for managing sustainable ecosystems. The fire regime condition class (FRCC) is a classification of the amount of departure from the historical fire regime. There are three condition classes for each historical fire regime. All wildland vegetation and fuel conditions fit within one of the three classes. The classification is based on a relative measure describing the degree of departure from the historical fire regime. This departure results in changes to one or more of the following ecological components:

- Vegetation characteristics (species composition, structural stages, stand age, canopy closure and mosaic pattern)
- Fuel composition
- Fire frequency, severity, and pattern
- Associated disturbances (e.g. insect and disease mortality, grazing, and drought).

The three classes indicate low (FRCC 1), moderate (FRCC 2) and high (FRCC 3) departure from the historical fire regime. Low departure is considered to be within the historical range of variability, while moderate and high departures are outside.

Characteristic vegetation and fuel conditions are those that occurred within the historical fire regime. Uncharacteristic conditions are those that did not occur within the historical fire regime, such as invasive species (e.g. weeds, insects, and diseases), "high graded" forest composition and structure (e.g. large trees removed in a frequent surface fire regime), or repeated annual grazing that reduces grassy fuels across relatively large areas to levels that will not carry a surface fire.

Determination of the amount of departure is based on comparison of a composite measure of fire regime attributes to the central tendency of the historical fire regime. The amount of departure is then classified to determine the fire regime condition class. Table 14-1 presents a simplified description of the fire regime condition classes and associated potential risks.

The U.S. Forest Service has provided an assessment of fire regime condition class for the planning area, as summarized in Table 14-2. The analysis shows that 3 percent of the County is in FRCC 1 (low departure), 71 percent is in FRCC 2 (moderate departure), and a negligible area is in FRCC 3 (high departure). Areas defined as agriculture, rock, urban or water are not assigned a condition class. Communities with these cover classes are assumed to not be at risk from wildfires.

Table 14-1. Fire Regime Condition Class Definitions

Description	Potential Risks
Fire Regime Condition Class 1	
Within the historical range of variability.	• Fire behavior, effects, and other associated disturbances are similar to those that occurred prior to fire exclusion (suppression) and other types of management that do not mimic the natural fire regime and associated vegetation and fuel characteristics. • Composition and structure of vegetation and fuels are similar to the natural (historical) regime. • Risk of loss of key ecosystem components (e.g. native species, large trees and soil) is low.
Fire Regime Condition Class 2	
Moderate departure from the historical regime of variability.	• Fire behavior, effects, and other associated disturbances are moderately departed (more or less severe). • Composition and structure of vegetation and fuel are moderately altered. • Uncharacteristic conditions range from low to moderate. • Risk of loss of key ecosystem components is moderate.
Fire Regime Condition Class 3	
High departure from the historical regime of variability.	• Fire behavior, effects, and other associated disturbances are highly departed (more or less severe). • Composition and structure of vegetation and fuel are highly altered. • Uncharacteristic conditions range from moderate to high. • Risk of loss of key ecosystem components is high.

Table 14-2. Fire Regime Condition Classes by Area in Ada County

Condition Class	Acres	% Area
Low departure	21,341	3
Moderate departure	478,874	71
High departure	2,308	0
Agriculture	114,277	17
Rock/barren	1,369	0
Urban	57,653	9
Water	2,292	0

14.2 HAZARD PROFILE

Wildfire presents a considerable risk to vegetation and wildlife habitats. Short-term loss caused by a wildfire can include the destruction of timber, wildlife habitat, scenic vistas, and watersheds. Long-term effects include smaller timber harvests, reduced access to affected recreational areas, destruction of cultural and economic resources, and potential impacts on water supply and community infrastructure. Vulnerability to flooding increases due to the destruction of watersheds. The potential for significant damage to life and property exists in areas designated as wildland urban interface (WUI) areas, where development is adjacent to densely vegetated areas. For the Ada County Planning area, a WUI has been identified and mapped based on the following definition:

> *The geographical area where structures and other human development meet or intermingle with wildland or vegetative fuels.*

This definition comes from the 2012 *International Wildland Urban Interface Code* and it is defined geographically in the planning layers. Ada County and its planning partners use this definition to implement land use regulations in the identified WUI. All references to the WUI in this hazard mitigation plan are for areas identified and mapped under this definition.

14.2.1 Past Events

In the fire-adapted ecosystems of Idaho, fire is the dominant process constraining terrestrial vegetation patterns, habitat, and species composition. Fire was once an integral function of the majority of ecosystems in Idaho, including the Ada County planning area. The seasonal cycling of fire across the landscape was as regular as the July, August and September lightning storms plying across the canyons and mountains. Depending on the plant community composition, structural configuration, and buildup of plant biomass, fire resulted from ignitions with varying intensities and extent across the landscape. Shorter return intervals between fire events often resulted in less dramatic changes in plant composition. The fires burned with a varied return interval, but much of the county burned through a stand-replacing fire that occurred on a moderate return interval of 20 to 80 years.

Native plant communities in this region developed under the influence of fire, and adaptations to fire are evident at the species, community and ecosystem levels. Fire history data (from fire scars and charcoal deposits) suggest fire has played a role in shaping the vegetation in the region for thousands of years.

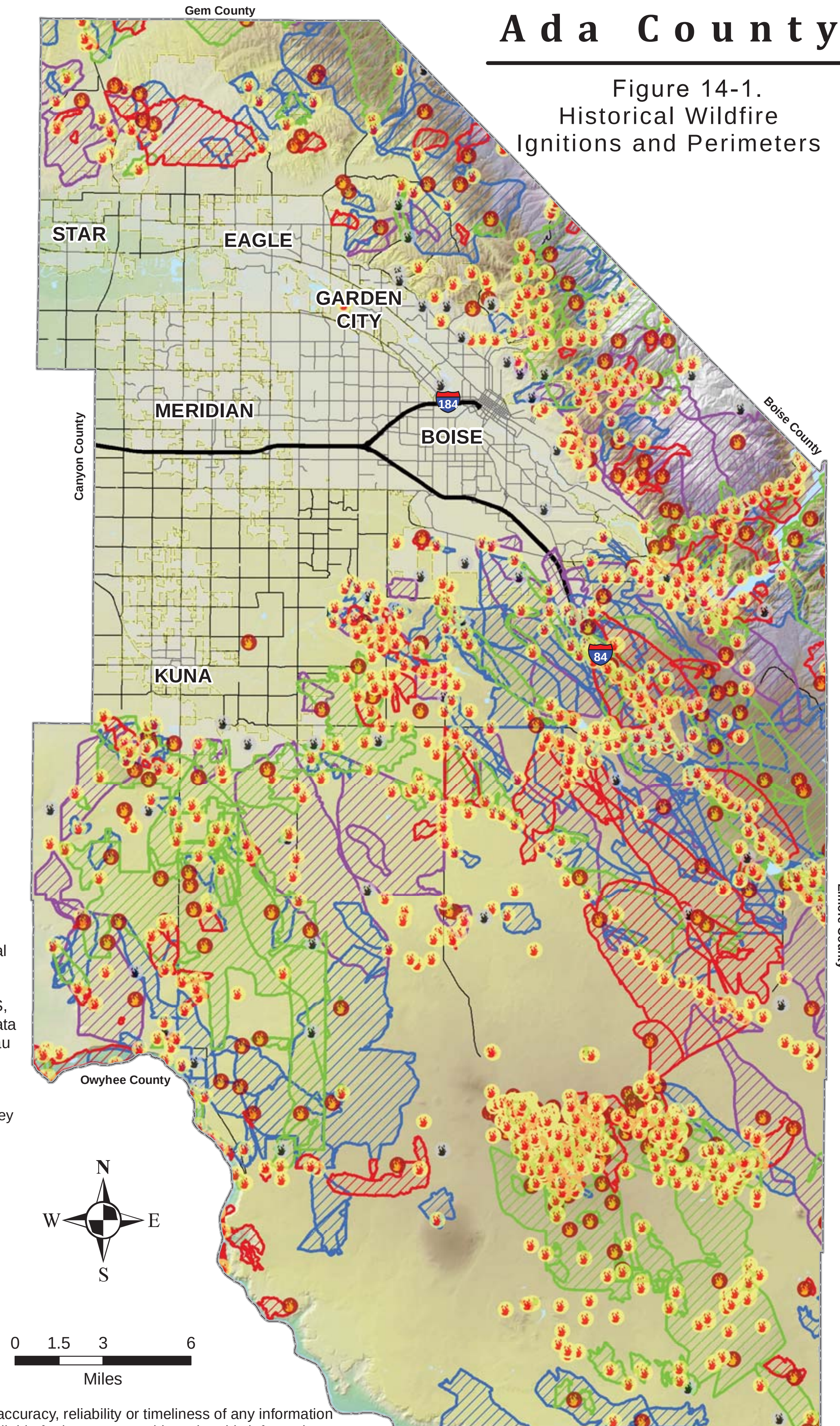
Detailed records of fire perimeter and ignition and extent have been obtained from the BLM for the Ada County planning area. Since 1957, there were 470 fire events over 10 acres on or near BLM lands within the Ada County planning area, burning 685,495 acres. These ignitions and perimeter points are shown in Figure 14-1. Table 14-3 is a summary of the number of fires per year from 2000 to 2015 on or near BLM lands in the Ada County planning area. There are over 589,000 acres of BLM-managed land in the Ada County planning area, representing over 86 percent of the planning area. Much of this land is in or adjacent to privately held lands within the WUI as well as the overall planning area.

Table 14-3. BLM Fire Statistics—Fires per Year in Ada County Planning Area, 2000-2015

Fire Year	# Fires	Total Acres	Causes
2015	6	178.10	6 Human
2014	6	1,540.88	2 natural, 6 human
2013	16	5,208.07	4 natural, 12 human
2012	24	10,804.70	2 natural, 22 human
2011	14	18,050.43	7 natural, 7 Human
2010	7	6,381.03	N/A
2009	6	629.17	N/A
2008	3	584.73	N/A
2007	32	6,685.70	N/A
2006	8	2,531.13	N/A
2005	13	10,286.88	N/A
2004	2	126.12	N/A
2003	3	1,295.72	N/A
2002	7	5,189.88	N/A
2001	26	1,1740.08	N/A
2000	9	5,789.50	N/A
Total	182	87,022.12	
Average	*11.38*	*5,438.88*	

Ada County

Figure 14-1.
Historical Wildfire Ignitions and Perimeters



Legend

Fire Ignition Causes

- Human
- Natural
- Unknown

Fire Perimeters

- 1957 - 1971
- 1972 - 1990
- 1991 - 2003
- 2004 - 2015

Wildfire ignition data from federal fire history reports by date and organization: 1980 - 2013 DOI (BIA, BLM, BOR, NPS), USFWS, and USFS. Wildfire perimeter data from Inside Idaho and the Bureau of Land Management.

Base Map Data Sources:
Ada County, U.S. Geological Survey

TETRA TECH

14.2.2 Location

Two sets of mapping were used to identify the extent and location of the wildfire hazard for this risk assessment:

- Wildfire Hazard Planning Area Map—The Ada County Department of Development Services developed this wildfire hazard mapping for land use purposes. It indicates wildfire hazard zones but includes no classification of risk within those zones.
- Mapping of Risk to Communities—The Idaho State Fire Plan Working Group produced the *Relative Risk to Communities from Wildland Fire* mapping. These maps characterize relative wildfire risk by integrating relative risk, relative hazard, and wildland urban interface. Within the WUI, risks are directly associated with the probability that an area will burn and the likely fire behavior if the area does burn. It was assumed that burn probability and likely fire behavior contribute equally to the risk to communities.

These two data sets and the modeling they were based on are the best data available to assess the wildfire risk for this plan. Figure 14-2 shows the combination of both data sets. The relative risk data was plotted within the identified WUI developed and administered the Ada county department of development services.

14.2.3 Frequency

Fire ecologists use natural fire rotation to establish recurrence intervals for a planning area. Fire rotation is a measure of relative expected intervals between fires at regional scales, where site-specific fire frequency estimates are not available. Natural fire rotation is defined as the number of years necessary for fires to burn over an area equal to that of the study area (Heinselman, 1981). It is calculated for large areas using past fire size records by dividing the length of the record period in years by the percentage of total area burned during that period. Modern-era fire rotation analysis summarizes areas into the following classes of expected fire frequency:

- High (fire rotation less than 100 years)
- Medium (fire rotation more than 100 years and less than 300 years)
- Low (fire rotation more than 300 years).

From 2000 to 2015, Ada County experienced an average of 11 fires per year, burning 5,439 acres per fire on or near BLM managed lands. This yields a natural fire rotation of 108.3 years, a medium rating, almost a high rating.

14.2.4 Severity

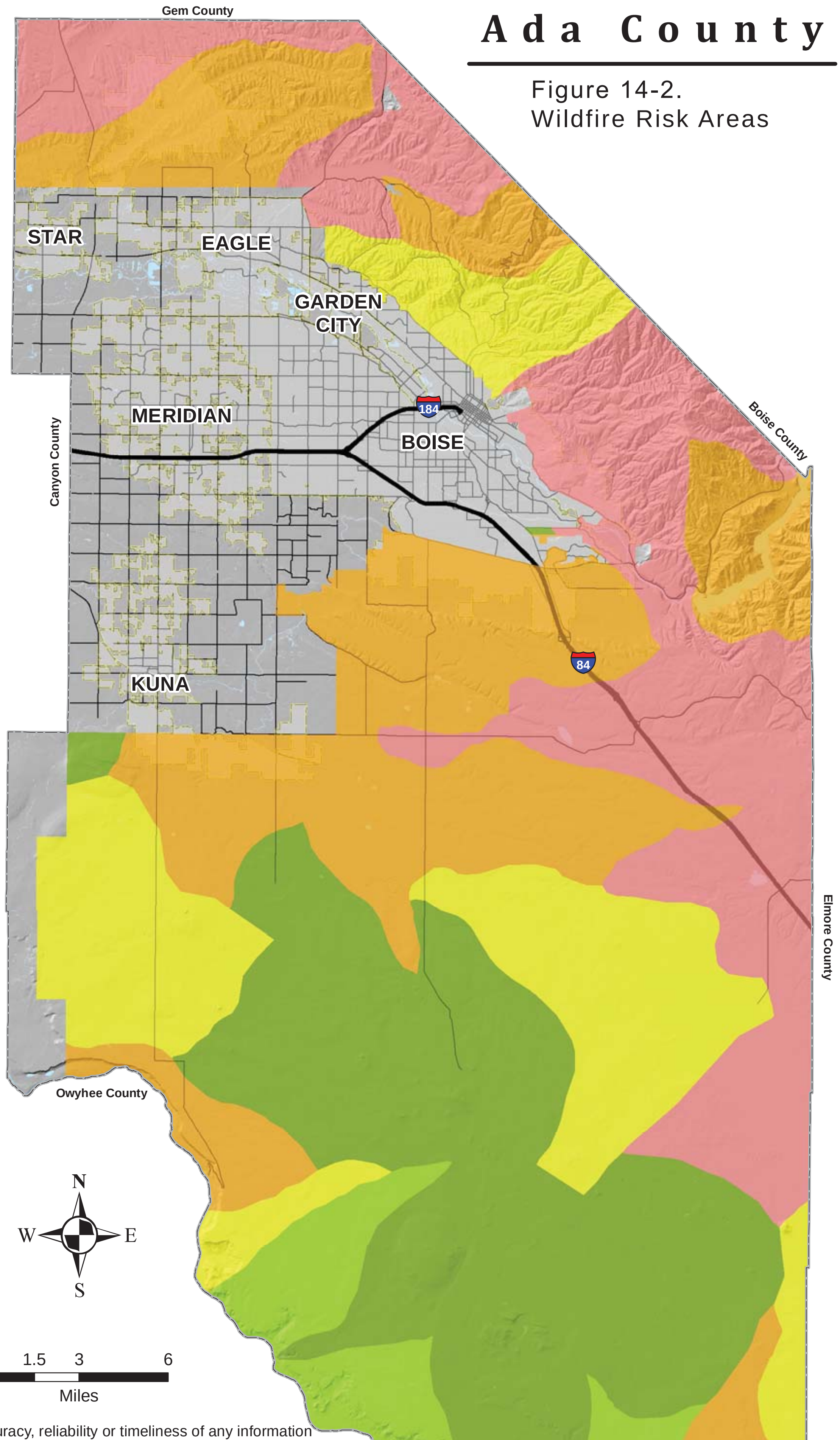
Fire severity has been defined as “the magnitude of significant negative fire impacts on wildland systems” (Simard, 1991). This definition has nothing to do directly with the fire itself—not the fire’s behavior, flame length, rate of spread, or any of the other measures of the fire. Rather, it is defined by the effects of a fire on wildland systems. This definition was born out of the need to provide a description of how fire intensity affects ecosystems, particularly wildfires for which direct information on fire intensity was absent and effects vary among different ecosystems (Keely, 2009).

Within the WUI, risks are associated with the probability that an area will burn, its severity, and the likely behavior of fire in the area. It was assumed that burn probability and fire behavior contribute equally to the risks to communities. Agriculture areas, rock, urban areas, and water are not assigned a burn probability or relative fire behavior. Communities with these cover classes are assume to not be at risk from wildfire.

Wildfire impacts beyond those on ecosystems include impacts on human life, structures and other improvements, and natural resources such as watersheds, grazing lands and recreational areas. Although fire suppression capabilities in the WUI areas are substantial, the volatile nature of wildfires makes fighting them a challenge. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke.

Ada County

Figure 14-2.
Wildfire Risk Areas



Legend

Relative Risk to Wildfire

- Low
- Low-Moderate
- Moderate
- Moderate-High
- High

The wildfire risk areas presented in this map are a combination of Idaho Bureau of Land Management Relative Risk to Communities from Wildland Fire and Ada County Wildland Urban Interface (WUI) maps.

Base Map Data Sources:
Ada County, U.S. Geological Survey

TETRA TECH

Ada County does not warrant the accuracy, reliability or timeliness of any information on this map, and shall not be held liable for losses caused by using this information.

Smoke and air pollution from wildfires can be a health hazard, especially for sensitive populations including children, the elderly and those with respiratory and cardiovascular diseases. In addition, wildfire can lead to ancillary impacts such as landslides in steep ravine areas and flooding due to the impacts of silt in local watersheds. There are two reported incidents of loss of life from wildfires in the planning area. One involved first responders and the other involved a resident who lived within a WUI.

14.2.5 Warning Time

Wildfires are often caused by humans, intentionally or accidentally. There is no way to predict when one might break out. The weather can provide an element of warning for local governments in that nicer weather heightens public activity in interface areas. Within Ada County the planning area, there is always a heightened state of readiness by fire response personnel during the spring, summer and fall as weather and the increased recreational uses within the WUI can trigger events.

Dry seasons and droughts are factors that greatly increase fire likelihood. Dry lightning may trigger wildfires. Severe weather can be predicted, so special attention can be paid during weather events that may include lightning. Reliable National Weather Service lightning warnings are available on average 24 to 48 hours prior to a significant electrical storm.

If a fire does break out and spread rapidly, residents may need to evacuate within days or hours. A fire's peak burning period generally is between 1 p.m. and 6 p.m. Once a fire has started, fire alerting is reasonably rapid in most cases. The spread of cellular and two-way radio communications in recent years has contributed to a significant improvement in warning time.

14.2.6 Firefighting Resources and Capabilities

Fire district personnel are often the first responders during emergencies. In addition to structure fire protection, they are called on during wildfires, floods, landslides, and other events. There are many in Ada County serving fire protection departments in various capacities. A complete inventory of resources and capabilities of fire districts in the Ada County planning area is provided in Appendix E of this volume.

14.3 CURRENT WILDFIRE MITIGATION ACTIVITIES

Several organizations in Ada County have been successful in developing, funding, and implementing wildfire mitigation projects. These projects have been well-supported by the community and are helping to lessen the impact of wildfires on Ada County residents, structures, ecosystems, and economy.

14.3.1 Idaho Power Transmission Line Corridor

Idaho Power's transmission line corridor in Ada County, owned in fee, is associated with the Boise Bench substation on Amity Road. Idaho Power actively manages fire breaks along Amity and Holcomb Roads and at the base of the hill slope below or adjacent to Homestead, Columbia Village, and Cove East. It also maintains a 200-foot-wide fuel break at the base of hill slope.

In undeveloped areas (rangeland), Idaho Power uses a sterilant to treat vegetation in a 20-foot radius around all wood pole structures, in order to reduce fuel and protect the wood structure during wildfires.

14.3.2 Boise Fire Wildfire Mitigation Team

The City of Boise has a dedicated interdepartmental wildfire mitigation team. Table 14-4 lists the team's wildfire mitigation projects completed over the past 5 years. Figure 14-3 shows the locations of these projects.

Table 14-4. City of Boise Wildfire Mitigation Projects Completed to Date

Project Name	Project Category	Activities	Project Partners	Total Project Area
2016 Projects				
Oregon Trails Reseeding	Restoration	Reseeding of native plants that have lower fire hazard than invasive grasses within the recurring project area of the Oregon Trails Reserve	Boise Department of Parks & Recreation, Boise Fire Department, Columbia Village Homeowners Association (HOA), Southwest Idaho Resource & Conservation District	110 acres
Citizen Fuel Reduction Policy	Policy, fuels reduction	Implementation of policy allowing mowing into city-owned reserve land by citizens whose property is adjacent to 4,200 acres of the reserve land	Boise Department of Parks & Recreation, Boise Fire Department, Boise Citizens, City of Boise Planning and Development Services	126 acres
Neighborhood Reinvestment Grant Chipping	Fuels reduction, education	Chipper services provided to four large HOAs in Boise: East End, Warm Springs Mesa, Highlands and Central Foothills	Boise Department of Parks & Recreation, Boise Fire Department, East End HOA, Warm Springs Mesa HOA, Highlands HOA and Central Foothills HOA	6,857 acres
Military Reserve Mowing	Fuels reduction	Mowing invasive, flammable grasses along Mountain Cove Road through Military Reserve. This section of road is highly traveled.	Boise Department of Parks & Recreation, Boise Fire Department, Southwest Idaho Resource & Conservation District	22 acres
Polecat Gulch Sagebrush Removal	Fuels reduction	Cutting and removal of dead sagebrush from site that experienced sage die-off from grasshopper invasion. Project also involved targeted spraying of herbicide onto skeleton weed to allow natives to outcompete the invasive weed.	Boise Department of Parks & Recreation, Boise Fire Department, Southwest Idaho Resource & Conservation District	3.8 acres
2015 Projects				
Oregon Trails	Fuels reduction, restoration	Sage brush thinning, goat grazing, plateau, and reseeding within the recurring project area of Oregon Trails Reserve.	Boise Department of Parks & Recreation, Boise Fire Department, Columbia Village HOA, Southwest Idaho Resource & Conservation District	110 acres
Station 12 Firewise Garden Maintenance	Maintenance	Soil erosion control within the recently built Firewise garden.	Boise Department of Parks & Recreation, Boise Fire Department, Southwest Idaho Resource & Conservation District, Firewise	0.3 acres
Oregon Trail Chipping Service	Fuels reduction, education	Homeowner-led fuel reduction within the listed HOAs. Homeowners cut and piled the vegetation they identified to be a fire hazard to their home. A roaming chipper then arrived to chip and haul the material away, lowering the fuel loads in the neighborhoods	Boise Department of Parks & Recreation, Boise Fire Department, Columbia Village HOA, Cove East HOA, Homestead Rim HOA, Oregon Trail Heights HOA, Surprise Valley HOA	990 acres 2500-2600 homes

Project Name	Project Category	Activities	Project Partners	Total Project Area
2014 Projects				
Hulls Gulch	Fuels reduction	Thinning trees in a riparian corridor to reduce the ability of fire to spread in a previously densely fueled understory, lowering the entire Hulls Gulch Reserve fire hazard	Boise Department of Parks & Recreation, Boise Fire Department, Southwest Idaho Resource & Conservation District	1.5 acres
Oregon Trails	Fuels reduction, restoration	Sage brush thinning, goat grazing, plateau, and reseeding within the recurring project area of Oregon Trails Reserve.	Boise Department of Parks & Recreation, Boise Fire Department, Southwest Idaho Resource & Conservation District, BLM, Columbia Village HOA	9 acres of thinning 36 acres of grazing 36 total acres
Project Signage	Education	Providing information about project sites to curious and concerned neighbors and passersby, thereby increasing awareness of fire mitigation techniques and efforts that the City of Boise and its partners are undertaking.	Boise Department of Parks & Recreation, Boise Fire Department, Boise Planning & Development Services, Southwest Idaho Resource & Conservation District	24 signs at 5 locations, 2 car magnets, outreach brochures
Station 12 Firewise	Education	Firewise garden installation: display of native plant species and layout/design of vegetation that lower fire hazards around homes.	Boise Fire Department, Boise Department of Parks & Recreation, Southwest Idaho Resource & Conservation District	0.3 acres
Remote Automatic Weather Station Pilot	Monitoring, education	Installation of fire weather station above Boise Hills Village that informs firefighters about important decision-making fire weather information. Also provides data for long-term fire weather studies throughout the Western United States	Boise Fire Department, Boise Department of Parks & Recreation, BLM, National Interagency Fire Center, Southwest Idaho Resource & Conservation District	1 site
2013 Projects				
Briarhill	Fuels reduction, restoration	Grazing, plateau, and reseeding of undeveloped land adjacent to steeply sloped residential areas in and around Briarhill neighborhood	Boise Fire Department, Boise Planning & Development Services, Boise Department of Parks & Recreation, BLM, We Rent Goats, Southwest Idaho Resource & Conservation District	10 acres
Castle Rock Reserve	Fuels reduction, restoration	Grazing, plateau, reseeding	Boise Planning & Development Services, Boise Fire Department, Boise Department of Parks & Recreation	47 acres
Military Reserve	Fuels reduction, restoration	Grazing, plateau and reseeding of native forbs and grasses to compete against flammable grasses along Mountain Cove Road through Military Reserve. This section of road is highly traveled.	Boise Department of Parks & Recreation, Boise Fire Department, Southwest Idaho Resource & Conservation District	25 acres
Neighborhood Chipper	Fuels reduction, education	Homeowner-led fuel reduction in neighborhoods north of Hill Road, from 36th Street to Seaman's Gulch. Homeowners cut and piled the vegetation they identified to be a fire hazard to their home. A roaming chipper then arrived to chip and haul the material away, lowering the fuel loads in the neighborhoods	Boise Planning & Development Services, Boise Fire Department, Boise Department of Parks & Recreation, BLM, Southwest Idaho Resource & Conservation District	272 homes

Project Name	Project Category	Activities	Project Partners	Total Project Area
Boise Heights Chipper	Fuels reduction, education	Homeowner-led fuel reduction within the Boise Heights HOA. Homeowners cut and piled the vegetation they identified to be a fire hazard to their home. A roaming chipper then arrived to chip and haul the material away, thereby lowering the fuel loads in the neighborhoods	Boise Planning & Development Services, Boise Fire Department, Boise Department of Parks & Recreation, BLM, Southwest Idaho Resource & Conservation District	39 homes
Oregon Trails/ Surprise Valley	Fuels reduction	Sage brush thinning of target areas identified as having high density sagebrush within the recurring project area of Oregon Trails Reserve.	Boise Planning & Development Services, Boise Fire Department, Boise Department of Parks & Recreation, Trinity Presbyterian Church, Surprise Valley HOA, Southwest Idaho Resource & Conservation District	11 acres
Quail Ridge	Fuels reduction, restoration	Grazing, plateau and reseeding of native grasses and forbs of area infested with whitetop, field bindweed, medusahead and bachelor button within the 48 acre property.	Boise Department of Parks & Recreation, Boise Fire Department, Southwest Idaho Resource & Conservation District	40 acres
2012 Projects				
Military Reserve	Fuels reduction, restoration	Grazing, plateau and reseeding of natives over the northwest corner of Military Reserve and 14-acre strip of land adjacent to Mountain Cove Road to lower the fuel load and restore some native species to the area.	City of Boise, BLM, FIRE-UP (Field Investigative Research Experience), Southwest Idaho Resource & Conservation District, We Rent Goats, Ridge to Rivers, The Veterans Administration, Idaho Department of Lands, homeowners adjacent to project area	35 acres
Neighborhood Chipper	Fuels reduction, education	Removal of hazardous fuel loads within listed HOAs. This included removal of built-up fuels from shrubs and trees around homes, reducing burnable biomass in event of fire.	Boise Fire Department, Boise Planning & Development Services, Boise Department of Parks & Recreation, BLM, Southwest Idaho Resource & Conservation District, Ada County, Central Foothills HOA, Boise Heights HOA, and Warm Springs Mesa HOA	352 homes
Oregon Trails	Fuels reduction	Sage brush thinning to reduce hazardous fuels adjacent to homes within the listed HOAs.	Boise Fire Department, Boise Department of Parks & Recreation, Boise Planning & Development Services, BLM, Southwest Idaho Resource & Conservation District, Ada County WILD, Cove East HOW, Columbia Village HOA, Homestead Rim HOA, and Oregon Trail Heights HOA	21 acres
Quail Ridge	Fuels reduction	Grazing of goats to reduce hazardous fuels within and around Quail Ridge HOA. Doubled as way of educating neighbors on how they can reduce fire hazards	Boise Fire Department, Boise Department of Parks & Recreation, Boise Planning & Development Services, Southwest Idaho Resource & Conservation District, BLM, We Rent Goats, Quail Ridge HOA, Briarhill HOA	75 acres

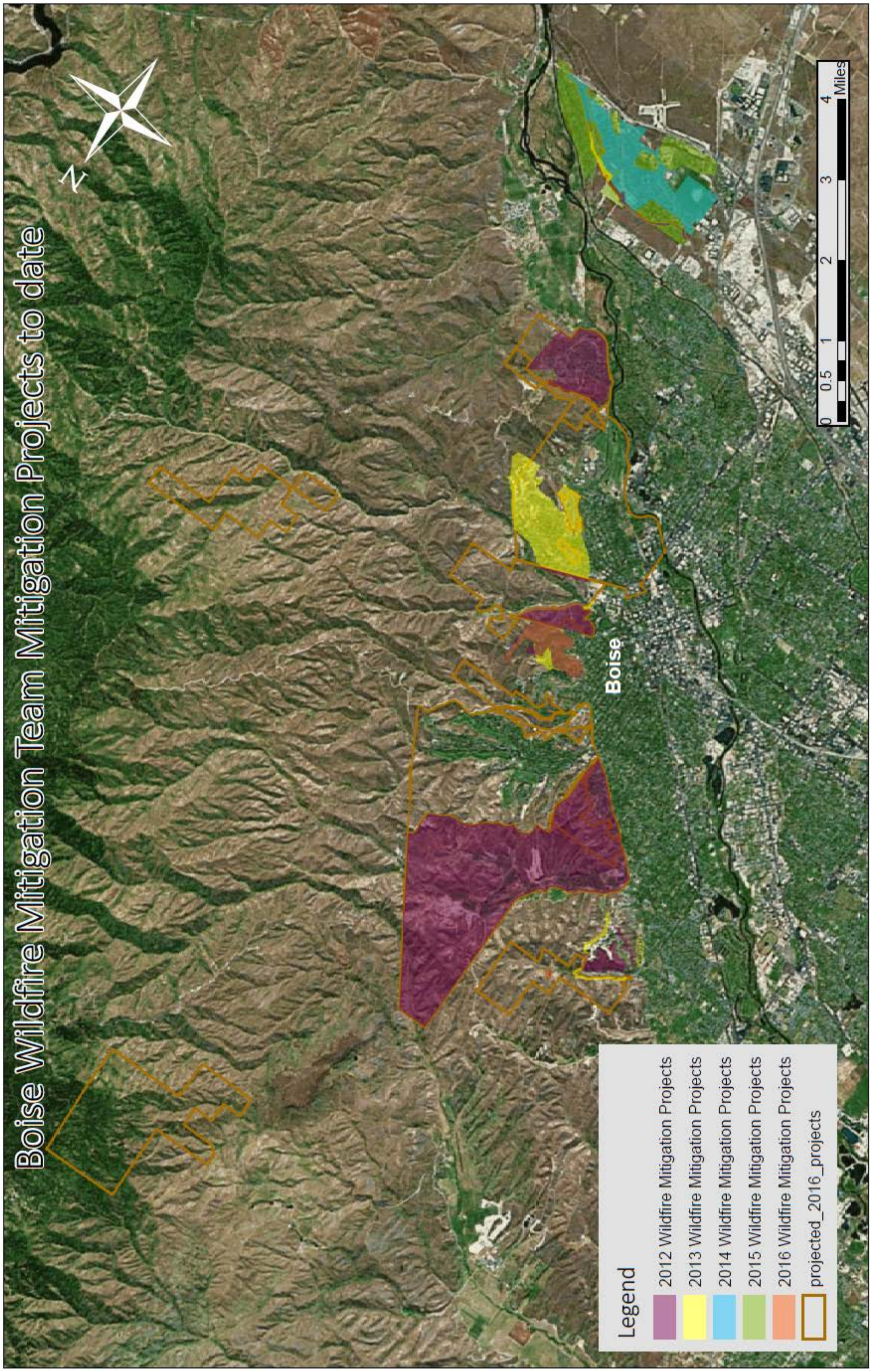


Figure 14-3. Boise Wildfire Mitigation Team Projects to Date

14.3.3 Avimor Fuel Break Project

Figure 14-4 shows the extent of a proactive mowing campaign in the Avimor development in northwestern Ada County, within the Eagle Fire Protection District. Over 6.5 acres were mowed in 2016. Blue lines in the figure indicate where a minimum 30-foot fuel strip was created. Orange areas are areas that were completely mowed. This program was also implemented in the Military Reserve area, covering almost 26 acres. These projects were deployed by the Conservation Branch of the Idaho Army National Guard Environmental Management Office.

Figure 14-4. Avimor Fuel Break Project-extent and location

14.3.4 The Healthy Hills Initiative

The Healthy Hills Initiative is working to provide science-based knowledge to protect and enhance Boise Foothills ecosystems through the collaboration of private, local, state and federal organizations:

- Ada Soil & Water Conservation District
- Southwest Idaho Resource Conservation and Development Council
- USDA Natural Resources Conservation Service
- City of Eagle
- Eagle Fire Department
- Ada County
- Bureau of Land Management
- U.S. Fish and Wildlife Service
- USDA Agricultural Research Service
- USDA Rocky Mountain Research Station
- Idaho Fish and Game.

When a fire started near Horseshoe Bend Road in August 2009, dry plants fueled the fire, and high winds pushed it into the foothills. Flames threatened several neighborhoods. Firefighters contained the fire, and no houses were damaged, but the fire burned more than 200 acres of Ada County wildlife habitat and recreational land. This fire showed the risk of wildfires in the foothills and started discussions on how to use proactive restoration and fuel management strategies to reduce wildfire hazard. A group of land managers and scientists partnered with the City of Eagle and Ada County to form the Healthy Hills Initiative. The Healthy Hills Initiative is working to restore this area. The Healthy Hills Initiative is implementing demonstration land and vegetation projects that have application to other burned or unhealthy foothills in the Treasure Valley. The group is focusing on the following:

- Reducing the potential for wildfires by managing vegetation, reducing fuels and combating invasive weeds
- Demonstrating restoration strategies to bring back native vegetation, which will benefit wildlife, the watershed and the citizens who use and enjoy this area
- Providing educational opportunities to students of all ages in the ecology, management, and scientific study of foothills ecosystems.

In 2010, over 200 volunteers planted over 8,000 native shrub seedlings in the burned area. This was the first of many future demonstration projects to be conducted on the 800 acres of Ada County and Bureau of Land Management lands.

14.3.5 Ada County Enhanced Wildfire Risk Mapping Project

In 2015 and 2016, ACEM funded a project to enhance wildfire mapping to support wildfire mitigation and risk assessment within the planning area. The objectives were to develop comprehensive maps and GIS data at the block level within the wildland urban interface and in a study region outside the WUI that displays the risk of wildfire and secondary hazards (based on characteristics such as interior urban environment, irrigated agriculture, etc.). This project was conducted simultaneously with this update to the hazard mitigation plan and was not completed in time to inform the update process. However, it will be completed in time to support the implementation, maintenance and future updates to the multi-hazard mitigation plan.

14.3.6 Southwest Idaho Wildfire Mitigation Forum

Every year, regional wildfire management stakeholders convene to identify and collaborate on wildfire mitigation strategies for southwest Idaho. The outreach and discussions that this event facilitate influence the direction and coordination of the wildfire mitigation actions identified in this plan. The annual forum helps build partnerships and community awareness, with a focus on networking, funding, prevention, resources, education and cooperation. The following mitigation planning partners and stakeholders are regular participants in this event:

- All Ada County fire organizations
- Ada County Emergency Management
- Idaho Office of Emergency Management
- The Healthy Hills Initiative
- Several Firewise communities.

The forum provides these organizations an opportunity to coordinate with other jurisdictions in the southwest Idaho region including federal, state and other local agencies. The 2016 event was held on May 16 in Boise and was hosted by Ada County Parks and Waterways (see Figure 14-5). Prior to 2016, the event was supported by Southwest Idaho Resource Conservation & Development and Idaho Firewise. In 2016 it was supported by the Fire Adapted Communities Learning Network, as it will be in 2017. The Fire Adapted Communities Learning Network is supported by an agreement between The Nature Conservancy, The U.S. Forest Service and agencies of the Department of the Interior through an award to the Watershed Research and Training Center.

Figure 14-5. Southwest Idaho Mitigation Forum Flyer

14.4 SECONDARY HAZARDS

Wildfires can generate a range of secondary effects, which in some cases may cause more widespread and prolonged damage than the fire itself. Fires can cause direct economic losses in the reduction of harvestable timber and indirect economic losses in reduced tourism. Wildfires cause the contamination of reservoirs, destroy transmission lines and contribute to flooding. They strip slopes of vegetation, exposing them to greater amounts of runoff. This in turn can weaken soils and cause failures on slopes. Major landslides can occur several years after a wildfire. Most wildfires burn hot and for long durations that can bake soils, especially those high in clay content, thus increasing the imperviousness of the ground. This increases the runoff generated by storm events, thus increasing the chance of flooding.

14.5 EXPOSURE

14.5.1 Population

The population living in individual wildfire risk areas was estimated by calculating the percentage of total planning area residential structures in each wildfire risk area and applying that percentage to the total planning area population. The results are shown in Table 14-5 for all but the low-moderate-risk area, which has a negligible population.

Table 14-5. Population Estimates Within Fire Hazard Risk Areas

	High Risk Area		Moderate/High Risk Area		Moderate Risk Area		Low Risk Area	
	Population	% of Total	Population	% of total	Population	% of Total	Population	% of Total
Boise	8,416	3.89%	1,277	0.59%	9,832	4.55%	94	0.04%
Eagle	0	0%	33	0.15%	0	0%	0	0%
Garden City	0	0%	0	0%	0	0%	0	0%
Kuna	0	0%	16	0.09%	0	0%	0	0%
Meridian	0	0%	0	0%	0	0%	0	0%
Star	0	0%	3	0.04%	0	0%	0	0%
Unincorporated	1,942	3.03%	6,012	9.40%	442	0.69%	3	0.01%
Total	10,358	2.43%	7,341	1.72%	10,274	2.41%	97	0.02%

Note: Population in the low-moderate risk area is negligible and therefore is not shown in this table.

14.5.2 Property

The number and value of homes in individual wildfire risk areas are listed in Table 14-6 through Table 14-9. Exposure in the low-moderate-risk area is negligible and therefore is not shown. Table 14-10 shows the general land use of parcels exposed to the individual wildfire risk areas in the unincorporated portions of the County.

14.5.3 Critical Facilities and Infrastructure

Table 14-11 summarizes critical facilities and infrastructure exposed to the wildfire hazard in the planning area. In the event of wildfire, there would likely be little damage to the majority of infrastructure. Most road and railroads would be without damage except in the worst scenarios. Power lines are the most at risk to wildfire because most are supported on poles made of wood and susceptible to burning. In the event of a wildfire, pipelines could provide a source of fuel and lead to a catastrophic explosion.

Table 14-6. Planning Area Structures Exposed to High Wildfire Risk

	Buildings Exposed	Assessed Value			% of Total Assessed Value
		Structure	Contents	Total	
Boise	2,806	$1,056,401,715	$553,575,561	$1,609,977,275	3.53
Eagle	0	$0	$0	$0	0
Garden City	0	$0	$0	$0	0
Kuna	0	$0	$0	$0	0
Meridian	0	$0	$0	$0	0
Star	0	$0	$0	$0	0
Unincorporated	591	$256,597,371	$142,207,537	$398,804,908	4.30
Total	3,397	$1,312,999,086	$695,783,098	$2,008,782,183	2.4

Table 14-7. Planning Area Structures Exposed to Moderate/High Wildfire Risk

	Buildings Exposed	Assessed Value			% of Total Assessed Value
		Structure	Contents	Total	
Boise	580	$820,484,062	$881,850,366	$1,702,334,428	3.73
Eagle	13	$5,485,940	$3,400,779	$8,886,719	0.15
Garden City	0	$0	$0	$0	0
Kuna	5	$4,244,908	$2,122,454	$6,367,362	0
Meridian	0	$0	$0	$0	0
Star	1	$236,810	$118,405	$355,215	0.03
Unincorporated	1,781	$764,093,170	$398,560,401	$1,162,653,571	12.54
Total	2,380	$1,594,544,890	$1,286,052,405	$2,880,597,295	3.44

Table 14-8. Planning Area Structures Exposed to Moderate Wildfire Risk

	Buildings Exposed	Assessed Value			% of Total Assessed Value
		Structure	Contents	Total	
Boise	3,294	$1,162,434,388	$607,867,013	$1,770,301,401	3.88
Eagle	0	$0	$0	$0	0
Garden City	0	$0	$0	$0	0
Kuna	0	$0	$0	$0	0
Meridian	0	$0	$0	$0	0
Star	0	$0	$0	$0	0
Unincorporated	135	$66,551,506	$40,765,592	$107,317,098	1.16%
Total	3,429	$1,228,985,894	$648,632,605	$1,877,618,499	2.24

Table 14-9. Planning Area Structures Exposed to Low Wildfire Risk

	Buildings Exposed	Assessed Value			% of Total Assessed Value
		Structure	Contents	Total	
Boise	34	$6,716,645	$4,183,729	$10,900,374	0.02
Eagle	0	$0	$0	$0	0
Garden City	0	$0	$0	$0	0
Kuna	0	$0	$0	$0	0
Meridian	0	$0	$0	$0	0
Star	0	$0	$0	$0	0
Unincorporated	1	$1,269,453	$634,726	$1,904,179	0.02
Total	35	$7,986,098	$4,818,455	$12,804,553	0.02

Table 14-10. Land Use Within the Wildfire Risk Areas in Unincorporated County

	Low		Low/Moderate		Moderate		Moderate/High		High	
Land Use	Area (acres)	% of Total	Area (acres)	% of Total	Area (acres)	% of Total	Area (acres)	% of Total	Area (acres)	% of Total
Agriculture	9630.17	5.07	27.17	0.11	8702.05	7.33	46509.42	23.50	39375.81	30.72
Agriculture Prime Farmland	14151.67	7.45	160.30	0.66	12377.87	10.43	33033.75	16.69	18447.03	14.39
Commercial Retail & Office	5260.08	2.77	0	0	2309.92	1.95	2619.47	1.32	706.99	0.55
Industrial	196.23	0.10	0	0	154.46	0.13	371.93	0.19	43.87	0.03
Open Space	1707.73	0.90	0	0	2243.79	1.89	1819.62	0.92	3024.05	2.36
Other	6264.23	3.30	0	0	5149.90	4.34	13591.57	6.87	8681.95	6.77
Public/ Government	130166.30	68.57	24152.27	99.23	75806.28	63.87	78074.57	39.46	50435.46	39.34
Residential	20495.16	10.80	0	0	10961.62	9.24	21231.22	10.73	7214.84	5.63
Residential TOD	1100.03	0.58	0	0	536.13	0.45	88.52	0.04	162.76	0.13
Schools	866.99	0.46	0	0	443.16	0.37	542.34	0.27	99.42	0.08
Total	189838.59	100%	24339.74	100	118685.18	100	197882.41	100	128192.18	100

Table 14-11. Critical Facilities Exposed to Wildfire Hazards

	Number of Critical Facilities in Risk area			
	Low Risk area	Moderate Risk area	Moderate/High Risk area	High Risk area
Medical and Health Services	0	0	0	0
Government Function	0	1	1	0
Protective Function	0	1	1	2
Schools	0	1	1	1
Hazmat	0	0	7	1
Other Critical Function	1	6	5	6
Transportation Systems	0	10	25	17
Electric Facilities	1	4	5	7
Water	1	6	33	22
Wastewater	0	1	2	0
Total	3	30	80	56

During a wildfire event, hazardous material containers at Tier II material containment sites could rupture due to excessive heat and act as fuel for the fire, causing rapid spreading and escalating the fire to unmanageable levels. In addition they could leak into surrounding areas, saturating soils and seeping into surface waters, and have a disastrous effect on the environment.

14.5.4 Environment

Many ecosystems are adapted to historical fire regimes. Ecosystem stability is threatened when any of the attributes for a given fire regime diverge from its range of natural variability. In such cases, wildfires can cause severe environmental impacts:

- Damaged Fisheries—Critical fisheries can suffer from increased water temperatures, sedimentation, and changes in water quality.
- Soil Erosion—The protective covering provided by foliage and dead organic matter is removed, leaving the soil fully exposed to wind and water erosion. Accelerated soil erosion occurs, causing landslides and threatening aquatic habitats.
- Spread of Invasive Plant Species—Non-native woody plant species frequently invade burned areas. When weeds become established, they can dominate the plant cover over broad landscapes, and become difficult and costly to control.
- Disease and Insect Infestations—Unless diseased or insect-infested trees are swiftly removed, infestations and disease can spread to healthy forests and private lands. Timely active management actions are needed to remove diseased or infested trees.
- Destroyed Endangered Species Habitat—Catastrophic fires can devastate endangered species.
- Soil Sterilization—Topsoil exposed to extreme heat can become water repellant, and soil nutrients may be lost. It can take decades or even centuries for ecosystems to recover from a fire. Some fires burn so hot that they can sterilize the soil.

14.6 VULNERABILITY

There are currently no recognized models that estimate the vulnerability of people, property or infrastructure in for wildfire. There are too many variables with wildfire behavior to establish damage curves for the various wildfire severity zones. The vulnerabilities to wildfires are many. This section quantifies vulnerabilities in a fashion consistent with FEMA-suggested best management practices for risk assessment for hazard mitigation planning. For vulnerabilities that are not quantifiable, a qualitative assessment is provided. Except as discussed in this section, vulnerable populations, property, infrastructure and environment are assumed to be the same as described in the section on exposure.

14.6.1 Population

Smoke and air pollution from wildfires can be a severe health hazard, especially for sensitive populations, including children, the elderly and those with respiratory and cardiovascular diseases. Smoke generated by wildfire consists of emissions that contain particulate matter (soot, tar, water vapor, and minerals), gases (carbon monoxide, carbon dioxide, nitrogen oxides), and toxics (formaldehyde, benzene). Public health impacts associated with wildfire include difficulty in breathing, odor, and reduction in visibility. Wildfire may also threaten the health and safety of those fighting the fires.

14.6.2 Property

Loss estimations for this assessment were developed representing 10 percent, 30 percent and 50 percent of the assessed value of exposed structures. This allows emergency managers to select a range of economic impact based on an estimate of the percent of damage to the general building stock. Damage in excess of 50 percent is considered to be substantial by most building codes and typically requires total reconstruction of the structure. Loss estimates for the general building stock for jurisdictions that have an exposure to the top three hazard risk areas are listed in Table 14-12 through Table 14-14.

Table 14-12. Potential Damage to Buildings in High Wildfire Risk Areas

	Building Count	Assessed Value	10% Damage	30% Damage	50% Damage
Boise	2,806	$1,609,977,275	$160,997,728	$482,993,183	$804,988,638
Eagle	0	$0	$0	$0	$0
Garden City	0	$0	$0	$0	$0
Kuna	0	$0	$0	$0	$0
Meridian	0	$0	$0	$0	$0
Star	0	$0	$0	$0	$0
Unincorporated	591	$398,804,908	$39,880,491	$119,641,472	$199,402,454
Total	3,397	$2,008,782,183	$200,878,219	$602,634,655	$1,004,391,092

Table 14-13. Potential Damage to Buildings in Moderate/High Wildfire Risk Areas

	Building Count	Assessed Value	10% Damage	30% Damage	50% Damage
Boise	13	$1,702,334,428	$170,233,443	$510,700,328.42	$851,167,214.03
Eagle	0	$8,886,719	$888,672	$2,666,015.80	$4,443,359.67
Garden City	5	$0	$0	$0	$0
Kuna	0	$6,367,362	$636,736	$1,910,208.70	$3,183,681.16
Meridian	1	$0	$0	$0	$0
Star	1,781	$355,215	$35,522	$106,564.56	$177,607.60
Unincorporated	580	$1,162,653,571	$116,265,357	$348,796,071.36	$581,326,785.61
Total	2,380	$2,880,597,295	$288,059,730	$864,179,189	$1,440,298,648

Table 14-14. Potential Damage to Buildings in Moderate Wildfire Risk Areas

	Building Count	Assessed Value	10% Damage	30% Damage	50% Damage
Boise	3,294	$1,770,301,401	$177,030,140.13	$531,090,420.38	$885,150,701
Eagle	0	$0	$0	$0	$0
Garden City	0	$0	$0	$0	$0
Kuna	0	$0	$0	$0	$0
Meridian	0	$0	$0	$0	$0
Star	0	$0	$0	$0	$0
Unincorporated	135	$107,317,098	$10,731,709.78	$32,195,129.33	$53,658,549
Total	3,429	$1,877,618,499	$187,761,850	$563,285,550	$938,809,250

14.6.3 Critical Facilities and Infrastructure

Critical facilities of wood frame construction are especially vulnerable during wildfire events. In the event of wildfire, there would likely be little damage to most infrastructure. Most roads and railroads would be without damage except in the worst scenarios. Power lines are the most at risk from wildfire because most poles are made of wood and susceptible to burning. Fires can create conditions that block or prevent access and can isolate residents and emergency service providers. Wildfire typically does not have a major direct impact on bridges, but it can create conditions in which bridges are obstructed. Many bridges in areas of high to moderate fire risk are important because they provide the only ingress and egress to large areas and in some cases to isolated neighborhoods.

Transportation infrastructure increases the wildfire vulnerability of adjacent lands because it provides access to the WUI. For example, a car towing a trailer through the WUI with a safety chain dragging on the ground that cause sparks can start a wildfire. Any access to a wildfire hazard area increases the vulnerability of that area. Figure 14-1 shows that a large percentage of fire starts and perimeters are adjacent to transportation corridors. Hazus-MH estimates that there are over 213 miles of major roads and Interstate within the WUI.

14.6.4 Ecosystem Impacts

Wildfire is a part of nature. It plays a key role in shaping ecosystems by serving as an agent of renewal and change. But fire can be deadly, destroying homes, wildlife habitat and timber, and polluting the air with emissions harmful to human health. Fire also releases carbon dioxide—a key greenhouse gas—into the atmosphere. Fire's effect on the landscape may be long-lasting. Fire effects are influenced by forest conditions before the fire and management action taken or not taken after the fire. Fire can shape ecosystem composition, structure and functions in multiple ways:

- By selecting fire-adapted species and removing other, susceptible species
- By releasing nutrients from the biomass and improving nutrient cycling
- By affecting soil properties through changing soil microbial activities and water relations
- By creating heterogeneous mosaics, which in turn, can further influence fire behavior and ecological processes
- By damaging watersheds that serve as water supplies for urban areas
- By eliminating natural grazing areas.

Fire as a destructive force can rapidly consume large amount of biomass and cause negative impacts such as post-fire soil erosion and water runoff, and air pollution; however, as a constructive force, fire is also responsible for maintaining the health and perpetuity of fire-dependent ecosystems. Considering the unique ecological roles of fire in mediating and regulating ecosystems, fire should be incorporated as an integral component of ecosystems and management.

14.7 DEVELOPMENT TRENDS

In response to input received on the 2011 hazard mitigation plan update, the wildfire risk assessment for the 2017 update was limited to the designated WUI area rather than the entire planning area. The reasoning for this was that the risk assessment should focus on areas where there is risk, without diluting the overall risk by including areas where best available data indicates that there is no risk. The Ada County planning partnership understands that hazard risk mapping is not exact and that wildfires can occur in areas that have been mapped as having no risk. However, for this planning effort, it is reasonable to focus the wildfire risk assessment where the best available data identifies high risk. Because of this difference in assessment areas for the 2011 and 2017 plans, a comparative analysis of risk assessment results for the wildfire hazard was not performed. Future updates to this plan should apply the 2017 methodology for consistency and ease of comparing risk assessment results.

The planning area appears to be well equipped to deal with the wildfire hazard to future development. The key will be the availability of good hazard identification mapping that accurately reflects risks. As new science, data and technology become available, wildfire mapping should be updated.

Another key element to dealing with future development trends will be the ability of fire districts to maintain their levels of service. In a weak economy with decreasing tax revenues, fire districts struggle to maintain their resources at existing levels. Maintaining and or improving service will be a key element to dealing with future growth in the WUI.

County-wide adoption of stricter building codes for structures in the WUI is the first step to reducing risk in new construction. Increased public outreach will be the tool used to educate and assist property owners already in the WUI on how to comply with new codes and reduce the risk to their property. This combination of public education and code enforcement will be critical to reducing the risk of wildfire countywide.

Boise City Foothills Policy Plan

The purpose of the *Boise City Foothills Plan* of 1997 is to preserve multiple qualities and values of the Foothills while allowing for controlled development. The plan recognizes the constraints to Foothills development, including the wildfire hazard and the need for appropriate subdivision design, street layout, building materials and design, and landscaping. As an amendment of the Boise City Comprehensive Plan, the Foothills Plan has adopted zoning and building codes with specific wildfire prevention provisions.

Wildland-Urban Interface Overlay District

Ada County has delineated its high hazard area as a Wildland-Urban Fire Interface overlay district, with specific requirements for building construction and defensible space. The building requirements, are listed in Section 419.3 – 419.12.3 of the County's Uniform Building Code of 1997. The zoning code regulations apply to the area within the overlay district. Any new construction, alteration, moving, or change of use of a habitable structure is required to establish and maintain a minimum 50-foot defensible space around its perimeter. Within this defensible space buffer zone, there can be only single specimens of trees or ornamental vegetation, and cultivated ground cover or grasses up to a maximum height of 4 inches. All deadwood must be removed from trees, and clusters of trees must be thinned so that the crowns do not overlap. Trees must be pruned up to 6 feet. Areas adjacent to private roads and driveways must be cleared of vegetation. Areas within 5 feet on either side of driveways must be cleared, and the entire width of the easement of private roads must be cleared. Other regulations in the code address the location of liquefied petroleum gas, firewood, and other combustible materials near structures, road access to subdivisions, length of cul-de-sacs and water supply needs for fire flow.

14.8 SCENARIO

A major conflagration in Ada County might begin with a wet spring, adding to fuels already present on the forest floor. Flashy fuels would build throughout the spring. The summer could see the onset of insect infestation. A dry summer could follow the wet spring, exacerbated by dry hot winds. Carelessness with combustible materials or a tossed lit cigarette, or a sudden lighting storm could trigger a multitude of small isolated fires.

The embers from these smaller fires could be carried miles by hot, dry winds. The deposition zone for these embers would be deep in the forests and interface zones. Fires that start in flat areas move slower, but wind still pushes them. It is not unusual for a wildfire pushed by wind to burn the ground fuel and later climb into the crown and reverse its track. This is one of many ways that fires can escape containment, typically during periods when response capabilities are overwhelmed. These new small fires would most likely merge. Suppression resources would be redirected from protecting the natural resources to saving more remote subdivisions.

The worst-case scenario would include an active fire season throughout the American west, spreading resources thin. Firefighting teams would be exhausted or unavailable. Many federal assets would be responding to other fires that started earlier in the season. While local fire districts would be useful in the WUI areas, they have limited wildfire response capabilities and would have a difficult time responding to the ignition zones due to topography and other access limitations. Even though the existence and spread of the fire is known, it may not be possible to respond to it adequately. An initially manageable fire can become out of control before resources can reach the area.

Heavy rains could follow, causing flooding and landslides and releasing sediment into rivers, permanently changing floodplains and damaging sensitive habitat. With the forests removed from the watershed, stream flows could easily double. High-magnitude floods could increase in frequency.

14.9 ISSUES

The major issues for wildfire are the following:

- Public education and outreach to people living in or near the fire hazard zones should include information about and assistance with mitigation activities such as defensible space and advance identification of evacuation routes and safe zones.
- Wildfires could cause landslides as a secondary natural hazard.
- Climate change could affect the wildfire hazard.
- Future growth into interface areas should continue to be managed.
- Area fire districts need to continue to train on wildland-urban interface events.
- Vegetation management activities would include enhancement through expansion of the target areas as well as additional resources.
- Regional consistency is needed for higher building code standards such as residential sprinkler requirements and prohibitive combustible roof standards.
- Additional fire department water supply is needed in high risk wildfire areas.
- A buildable-lands analysis that looks at vacant lands and their designated land use would be a valuable tool in helping decision-makers make wise decisions about future development.

15. PLANNING AREA RISK RANKING

A risk ranking was performed for the hazards of concern described in this plan. This risk ranking assesses the probability of each hazard's occurrence as well as its likely impact on the people, property, and economy of the planning area. The risk ranking was conducted via facilitated brainstorming sessions with the Steering Committee. Estimates of risk were generated with data from Hazus-MH using methodologies promoted by FEMA. The results are used in establishing mitigation priorities.

15.1 PROBABILITY OF OCCURRENCE

The probability of occurrence of a hazard is indicated by a probability factor based on likelihood of annual occurrence:

- High—Hazard event is likely to occur within 25 years (Probability Factor = 3)
- Medium—Hazard event is likely to occur within 100 years (Probability Factor =2)
- Low—Hazard event is not likely to occur within 100 years (Probability Factor =1)
- No exposure—There is no probability of occurrence (Probability Factor = 0)

The assessment of hazard frequency is generally based on past hazard events in the area. Table 15-1 summarizes the probability assessment for each hazard of concern for this plan.

Table 15-1. Probability of Hazards

Hazard Event	Probability (high, medium, low)	Probability Factor
Dam/Canal Failure	Low	1
Drought	High	3
Earthquake	Low (based on 500-year probability)	1
Flood	High	3
Landslide	Medium	2
Severe Weather	High	3
Volcano	Low	1
Wildfire	High	3

15.2 IMPACT

Hazard impacts were assessed in three categories: impacts on people, impacts on property and impacts on the local economy. Numerical impact factors were assigned as follows:

- **People**—Values were assigned based on the percentage of the total ***population exposed*** to the hazard event. The degree of impact on individuals will vary and is not measurable, so the calculation assumes for simplicity and consistency that all people exposed to a hazard because they live in a hazard zone will be equally impacted when a hazard event occurs. It should be noted that planners can use an element of subjectivity when assigning values for impacts on people. Impact factors were assigned as follows:
    - High—50 percent or more of the population is exposed to a hazard (Impact Factor = 3)
    - Medium—25 percent to 49 percent of the population is exposed to a hazard (Impact Factor = 2)

- Low—25 percent or less of the population is exposed to the hazard (Impact Factor = 1)
- No impact—None of the population is exposed to a hazard (Impact Factor = 0)

- **Property**—Values were assigned based on the percentage of the total ***property value exposed*** to the hazard event:
  - High—30 percent or more of the total assessed property value is exposed to a hazard (Impact Factor = 3)
  - Medium—15 percent to 29 percent of the total assessed property value is exposed to a hazard (Impact Factor = 2)
  - Low—14 percent or less of the total assessed property value is exposed to the hazard (Impact Factor = 1)
  - No impact—None of the total assessed property value is exposed to a hazard (Impact Factor = 0)

- **Economy**—Values were assigned based on the percentage of the total ***property value vulnerable*** to the hazard event. Values represent estimates of the loss from a major event of each hazard in comparison to the total assessed value of the property exposed to the hazard. For some hazards, such as wildfire, landslide and severe weather, vulnerability was considered to be the same as exposure due to the lack of loss estimation tools specific to those hazards. Loss estimates separate from the exposure estimates were generated for the earthquake and flood hazards using Hazus-MH.
  - High—Estimated loss from the hazard is 20 percent or more of the total assessed property value (Impact Factor = 3)
  - Medium—Estimated loss from the hazard is 10 percent to 19 percent of the total assessed property value (Impact Factor = 2)
  - Low—Estimated loss from the hazard is 9 percent or less of the total assessed property value (Impact Factor = 1)
  - No impact—No loss is estimated from the hazard (Impact Factor = 0)

The impacts of each hazard category were assigned a weighting factor to reflect the significance of the impact. These weighting factors are consistent with those typically used for measuring the benefits of hazard mitigation actions: impact on people was given a weighting factor of 3; impact on property was given a weighting factor of 2; and impact on the operations was given a weighting factor of 1.

Table 15-2, Table 15-3 and Table 15-4 summarize the impacts for each hazard.

15.3 RISK RATING AND RANKING

The risk rating for each hazard was determined by multiplying the probability factor by the sum of the weighted impact factors for people, property and operations, as summarized in Table 15-5.

Based on these ratings, a priority of high, medium or low was assigned to each hazard. The hazards ranked as being of highest concern are earthquake and severe weather. Hazards ranked as being of medium concern are landslide, flood and wildfire. The hazards ranked as being of lowest concern are drought and dam failure. Table 15-6 shows the hazard risk ranking.

Table 15-2. Impact on People from Hazards

Hazard Event	Impact (high, medium, low)	Impact Factor	Multiplied by Weighting Factor (3)
Dam/Canal Failure	Medium	2	3
Drought	None	0	0
Earthquake	High	3	9
Flooding	Low	1	3
Landslide	Low	1	3
Severe Weather	Low	1	3
Volcano	Low	1	3
Wildfire	Low	1	3

Table 15-3. Impact on Property from Hazards

Hazard Event	Impact (high, medium, low)	Impact Factor	Multiplied by Weighting Factor (3)
Dam/Canal Failure	High	3	6
Drought	None	0	0
Earthquake	High	3	6
Flooding	Low	1	2
Landslide	Low	1	2
Severe Weather	High	3	6
Volcano	Low	1	2
Wildfire	Low	1	2

Table 15-4. Impact on Economy from Hazards

Hazard Event	Impact (high, medium, low)	Impact Factor	Multiplied by Weighting Factor (3)
Dam/Canal Failure	High	3	1
Drought	High	3	1
Earthquake	Low	1	1
Flooding	Low	1	1
Landslide	Low	1	1
Severe Weather	Medium	2	2
Volcano	Low	1	1
Wildfire	Medium	2	2

Table 15-5. Hazard Risk Rating

Hazard Event	Probability Factor	Sum of Weighted Impact Factors	Total (Probability x Impact)
Dam/Canal Failure	1	(6+6+3)	15
Drought	3	(0+0+3)	9
Earthquake	1	(9+6+1)	16
Flooding	3	(3+2+1)	18
Landslide	2	(3+2+1)	12
Severe Weather	3	(3+6+2)	33
Volcano	1	(3+2+1)	6
Wildfire	3	(3+2+2)	21

Table 15-6. Hazard Risk Ranking

Hazard Ranking	Hazard Event	Category
1	Severe Weather	High
2	Earthquake	Medium
3	Wildfire	Medium
4	Flood	Medium
5	Dam/Canal Failure	Medium
6	Landslide	Low
7	Drought	Low
8	Volcano	Low

16. CLIMATE CHANGE CONSIDERATIONS

16.1 WHAT IS CLIMATE CHANGE?

Climate, consisting of patterns of temperature, precipitation, humidity, wind and seasons, plays a fundamental role in shaping natural ecosystems and the human economies and cultures that depend on them. “Climate change” refers to changes over a long period of time. Worldwide, average temperatures have increased 1.4ºF since 1880 (NASA, 2016a). Although this change may seem small, it can lead to large changes in climate and weather.

The warming trend and its related impacts over the past 60 years have proliferated due to increasing concentrations of carbon dioxide and other greenhouse gases in the earth’s atmosphere. Greenhouse gases are gases that trap heat in the atmosphere, resulting in a warming effect. Carbon dioxide is the most commonly known greenhouse gas; however, methane, nitrous oxide and fluorinated gases also contribute to warming. Scientists are able to place this rise in carbon dioxide in a longer historical context through the measurement of carbon dioxide in ice cores. According to these records, carbon dioxide concentrations in the atmosphere are the highest that they have been in 650,000 years, as shown in Figure 16-1 (NASA, 2016b).

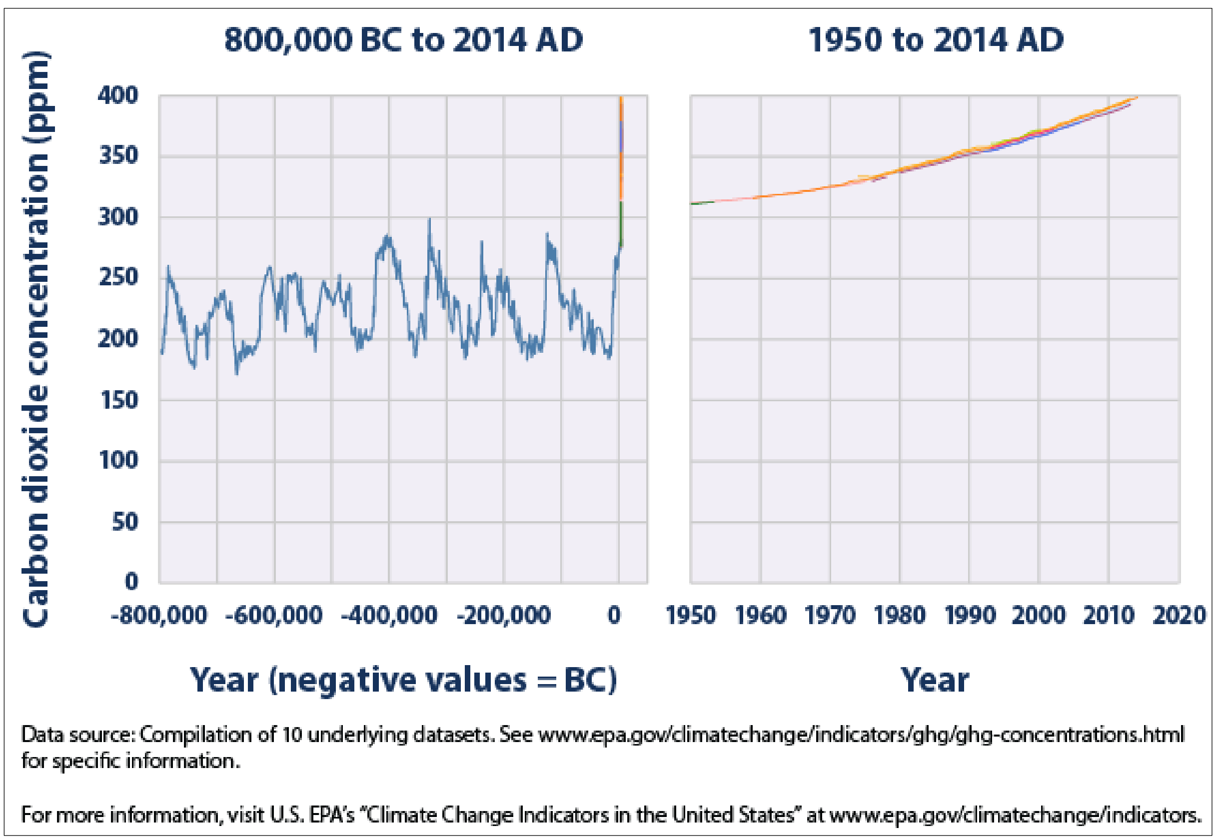


Figure 16-1. Global Carbon Dioxide Concentrations Over Time

Climate change will affect the people, property, economy and ecosystems of Ada County in a variety of ways. Climate change impacts are most frequently associated with negative consequences, such as increased flood vulnerability or increased heat-related illnesses/public health concerns; however, other changes may present opportunities. The most important effect for the development of this plan is that climate change will have a measurable impact on the occurrence and severity of natural hazards.

16.2 HOW CLIMATE CHANGE AFFECTS HAZARD MITIGATION

An essential aspect of hazard mitigation is predicting the likelihood of hazard events in a planning area. Typically, predictions are based on statistical projections from records of past events. This approach assumes that the likelihood of hazard events remains essentially unchanged over time. Thus, averages based on the past frequencies of, for example, floods are used to estimate future frequencies: if a river has flooded an average of once every 5 years for the past 100 years, then it can be expected to continue to flood an average of once every 5 years.

For hazards that are affected by climate conditions, the assumption that future behavior will be equivalent to past behavior is not valid if climate conditions are changing. As flooding is generally associated with precipitation frequency and quantity, for example, the frequency of flooding will not remain constant if broad precipitation patterns change over time. Specifically, as hydrology changes, storms currently considered to be a 1-percent-annual-chance event (100-year flood) might strike more often, leaving many communities at greater risk. The risks of landslide, severe storms, extreme heat and wildfire are all affected by climate patterns as well. For this reason, an understanding of climate change is pertinent to efforts to mitigate natural hazards. Information about how climate patterns are changing provides insight on the reliability of future hazard projections used in mitigation analysis. This chapter summarizes current understandings about climate change in order to provide a context for the recommendation and implementation of hazard mitigation measures.

16.3 CURRENT INDICATIONS OF CLIMATE CHANGE

The major scientific agencies of the United States and the world—including the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA) and the Intergovernmental Panel on Climate Change (IPCC)—agree that climate change is occurring. Multiple temperature records from all over the world have shown a warming trend, and the IPCC has stated that the warming of the climate system is unequivocal (IPCC, 2014). Of the 10 warmest years in the 134-year record, all but one (1998) occurred since 2000, and 2015 was the warmest year on record (NASA, 2016). Worldwide, average temperatures have increased 1.4ºF since 1880 (NASA, 2016).

Rising global temperatures have been accompanied by other changes in weather and climate. Many places have experienced changes in rainfall resulting in more intense rain, as well as more frequent and severe heat waves (IPCC, 2014). The planet's oceans and glaciers have also experienced changes: oceans are warming and becoming more acidic, ice caps are melting, and sea levels are rising (NASA, 2016). Global sea level has risen 6.7 inches, on average, in the last 100 years (NASA, 2016). This has already put some coastal homes, beaches, roads, bridges, and wildlife at risk (USGCRP, 2009).

NASA currently maintains information on the vital signs of the planet. At the time of the development of this plan, the following trends and status of these signs are as follows (NASA, 2016):

- Carbon Dioxide—Increasing trend, currently at 403.28 parts per million
- Global Temperature—Increasing trend, increase of 1.4ºF since 1880
- Arctic Ice Minimum—Decreasing trend, 13.4 percent per decade

- Land Ice—Decreasing trend, 287.0 billion metric tons per year
- Sea Level—Increasing trend, 3.4 mm per year.

16.4 PROJECTED FUTURE IMPACTS

The Third National Climate Assessment Report for the United States indicates that impacts resulting from climate change will continue through the 21st century and beyond. Although not all changes are understood at this time, the following impacts are expected in the United States (NASA, 2016):

- Temperatures will continue to rise.
- Growing seasons will lengthen.
- Precipitation patterns will change.
- Droughts and heat waves will increase.
- Hurricanes will become stronger and more intense.
- Sea level will rise 1 to 4 feet by 2100.
- The Arctic may become ice free.

A research project at the University of Idaho (http://idahoclimatescience.weebly.com/streamflow.html) sought to identify and develop indicators of climate change in the State of Idaho. Indicators provide useful information about what is occurring in complex systems. The following information is extracted and summarized from the website providing information on their findings:

- **Temperature and Growing Season**—Through the analysis of climate data throughout Idaho, scientists have found that the growing season in Idaho has increased by an average of 13 days since early in the 20th century. On average, the last spring frost occurs eight days earlier and the first fall frost is five days later.
- **Rainfall**—Rainfall intensity is believed to be related to climate change due to the increased capacity of warmer temperatures to hold water, potentially leading to heavier rainfall events. Scientists analyzed extreme rainfall events—the largest daily precipitation accumulation during March 15 through May 15—at 28 climate stations across Idaho. The results suggest that the intensity of big rainfall events has increased. Most large events have occurred since 1990.
- **Snowpack**—Scientists in Idaho have been measuring snowpack levels in the state since 1937. These annual measurements provide clear evidence that snowpack has been declining in the state over the past 50 years.
- **Streamflow**—Measurements of stream flow across the state indicate that spring runoff is occurring earlier and that the total annual volume of flow has decreased. These observations are based on records from 1950 to 2005.
- **Stream Temperature**—Average stream temperatures in the state may be increasing. Annual average temperatures in the North Clearwater River have increased by just over 1ºF over a 36-year period.
- **Wildfire**—In the western United States there have been four times as many major wildfires and six times as much area of forest burned when comparing totals from 1970 to 1986 and 1986 to the present. Scientists are monitoring the severity of fire burns to see if any trends are able to be established.
- **Plants and Forests**—Through observations of plant life cycle events and temperature data, scientists have determined that indicator plant species are blooming earlier on average.
- **Salmon Migration**—Sockeye salmon migration has been occurring earlier in the spring. Thirty years' worth of data suggests that salmon are returning to freshwater streams about one day earlier per decade.

- **Wildlife**—Changes in temperature impact plant and animal life cycle events. Tracking by citizen scientists has provided data that indicates that Mountain Bluebirds in Idaho lay eggs earlier when spring temperatures are warmer.

16.5 RESPONSES TO CLIMATE CHANGE

Communities and governments worldwide are working to address, evaluate and prepare for climate changes that are likely to impact communities in coming decades. Adaptation is defined by the IPCC as the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects (IPCC, 2014 http://www.ipcc.ch/report/ar5/wg2/).

Societies across the world are facing the need to adapt to changing conditions associated with natural disasters and climate change such as those indicated above. Farmers are altering crops and agricultural methods to deal with changing rainfall and rising temperature; architects and engineers are redesigning buildings; planners are looking at managing water supplies to deal with droughts or flooding.

Most ecosystems show a remarkable ability to adapt to change and to buffer surrounding areas from the impacts of change. Forests can bind soils and hold large volumes of water during times of plenty, releasing it through the year; floodplains can absorb vast volumes of water during peak flows; coastal ecosystems can hold out against storms, attenuating waves and reducing erosion. Other ecosystem services—such as food provision, timber, materials, medicines and recreation—can provide a buffer to societies in the face of changing conditions.

Ecosystem-based adaptation is the use of biodiversity and ecosystem services as part of an overall strategy to help people adapt to the adverse effects of climate change. This includes the sustainable management, conservation and restoration of specific ecosystems that provide key services.

16.6 CLIMATE CHANGE IMPACTS ON HAZARDS

The following sections provide information on how each identified hazard of concern for this planning process may be impacted by climate change and how these impacts may alter current exposure and vulnerability for the people, property, critical facilities and the environment in Ada County to these hazards.

16.7 DAM FAILURE

16.7.1 Impacts on the Hazard

Small changes in rainfall, runoff, and snowpack conditions may have significant impacts for water resource systems, including dams. Dams are designed partly based on assumptions about a river’s flow behavior, expressed as hydrographs. Changes in weather patterns can have significant effects on the hydrograph used for the design of a dam. If the hygrograph changes, it is conceivable that the dam can lose some or all of its designed margin of safety, also known as freeboard. If freeboard is reduced, dam operators may be forced to release increased volumes earlier in a storm cycle in order to maintain the required margins of safety. Such early releases of increased volumes can increase flood potential downstream.

Dams are constructed with safety features known as “spillways.” Spillways are put in place on dams as a safety measure in the event of the reservoir filling too quickly. Spillway overflow events, often referred to as “design failures,” result in increased discharges downstream and increased flooding potential. Although climate change will not increase the probability of catastrophic dam failure, it may increase the probability of design failures.

16.7.2 Population

Population exposure and vulnerability to the dam failure hazard are unlikely to change as a result of climate change.

16.7.3 Property

Property exposure and vulnerability to the dam failure hazard are unlikely to change as a result of climate change.

16.7.4 Critical Facilities

The exposure and vulnerability of critical facilities are unlikely to change as result of climate change. Dam owners and operators may need to alter maintenance and operations to account for changes in the hydrograph and increased sedimentation.

16.7.5 Environment

The exposure and vulnerability of the environment to dam failure are unlikely to change as a result of climate change. Ecosystem services may be used to mitigate some of the factors that may increase the risk of design failures, such as increasing the natural water storage capacity in watersheds above dams.

16.8 DROUGHT

16.8.1 Impacts on the Hazard

The long-term effects of climate change on regional water resources are unknown, but global water resources are already experiencing the following stresses without climate change:

- Growing populations
- Increased competition for available water
- Poor water quality
- Environmental claims
- Uncertain reserved water rights
- Groundwater overdraft
- Aging urban water infrastructure.

With a warmer climate, droughts could become more frequent, more severe, and longer-lasting. According to the National Climate Assessment, “higher surface temperatures brought about by global warming increase the potential for drought. Evaporation and the higher rate at which plants lose moisture through their leaves both increase with temperature. Unless higher evapotranspiration rates are matched by increases in precipitation, environments will tend to dry, promoting drought conditions” (Globalchange.gov, 2014). Because expected changes in precipitation patterns are still uncertain, the potential impacts and likelihood of drought are uncertain.

By addressing current stresses on water supplies and by building a flexible, robust program, Ada County will be able to more adeptly respond to changing conditions and to survive dry years.

16.8.2 Population

Population exposure and vulnerability to drought are unlikely to increase as a result of climate change. While greater numbers of people may need to engage in behavior change, such as water saving efforts, significant life or health impacts are unlikely.

16.8.3 Property

Property exposure and vulnerability may increase as a result of increased drought resulting from climate change, although this would most likely occur in non-structural property such as crops and landscaping. It is unlikely that structure exposure and vulnerability would increase as a direct result of drought, although secondary impacts of drought, such as wildfire, may increase and threaten structures.

16.8.4 Critical Facilities

Critical facility exposure and vulnerability are unlikely to increase as a result of increased drought resulting from climate change; however, critical facility operators may need to alter standard management practices and actively manage resources, particularly in water-related service sectors.

16.8.5 Environment

The vulnerability of the environment may increase as a result of increased drought resulting from climate change. The ecosystems and biodiversity in Ada County are already under stress from development and water diversion activities. Prolonged or more frequent drought resulting from climate change may further stress the ecosystems in the region.

16.9 EARTHQUAKE

16.9.1 Impacts on the Hazard

The impacts of global climate change on earthquake probability are unknown. Some scientists say that melting glaciers could induce tectonic activity. As ice melts and water runs off, tremendous amounts of weight are shifted on the earth's crust. As newly freed crust returns to its original, pre-glacier shape, it could cause seismic plates to slip and stimulate volcanic activity, according to research into prehistoric earthquakes and volcanic activity. NASA and USGS scientists found that retreating glaciers in southern Alaska may be opening the way for future earthquakes (NASA, 2004).

Secondary impacts of earthquakes could be magnified by climate change. Soils saturated by repetitive storms or heavy precipitation could experience liquefaction or an increased propensity for slides during seismic activity due to the increased saturation. Dams storing increased volumes of water due to changes in the hydrograph could fail during seismic events.

16.9.2 Population, Property, Critical Facilities and the Environment

Because impacts on the earthquake hazard are not well understood, increases in exposure and vulnerability of the local resources are not able to be determined.

16.10 FLOOD

16.10.1 Impacts on the Hazard

Use of historical hydrologic data has long been the standard of practice for designing and operating water supply and flood protection projects. For example, historical data are used for flood forecasting models and to forecast snowmelt runoff for water supply. This method of forecasting assumes that the climate of the future will be similar to that of the period of historical record. However, the hydrologic record cannot be used to predict changes in frequency and severity of extreme climate events such as floods. Going forward, model calibration or statistical relation development must happen more frequently, new forecast-based tools must be developed, and a standard of practice that explicitly considers climate change must be adopted. Climate change is already impacting water resources, and resource managers have observed the following:

- Historical hydrologic patterns can no longer be solely relied upon to forecast the water future.
- Precipitation and runoff patterns are changing, increasing the uncertainty for water supply and quality, flood management and ecosystem functions.
- Extreme climatic events will become more frequent, necessitating improvement in flood protection, drought preparedness and emergency response.

The amount of snow is critical for water supply and environmental needs, but so is the timing of snowmelt runoff into rivers and streams. Rising snowlines caused by climate change will allow more mountain areas to contribute to peak storm runoff. High frequency flood events (e.g. 10-year floods) in particular will likely increase with a changing climate. Along with reductions in the amount of the snowpack and accelerated snowmelt, scientists project greater storm intensity, resulting in more direct runoff and flooding. Changes in watershed vegetation and soil moisture conditions will likewise change runoff and recharge patterns. As stream flows and velocities change, erosion patterns will also change, altering channel shapes and depths, possibly increasing sedimentation behind dams, and affecting habitat and water quality. With potential increases in the frequency and intensity of wildfires due to climate change, there is potential for more floods following fire, which increase sediment loads and water quality impacts.

As hydrology changes, what is currently considered a 1-percent-annual-chance (100-year flood) may strike more often, leaving many communities at greater risk. Planners will need to factor a new level of safety into the design, operation, and regulation of flood protection facilities such as dams, bypass channels and levees, as well as the design of local sewers and storm drains.

16.10.2 Population and Property

Population and property exposure and vulnerability may increase as a result of climate change impacts on the flood hazard. Runoff patterns may change resulting in flooding in areas where it has not previously occurred.

16.10.3 Critical Facilities

Critical facility exposure and vulnerability may increase as a result of climate change impacts on the flood hazard. Runoff patterns may change resulting in risk to facilities that have not historically been at risk from flooding. Additionally, changes in the management and design of flood protection critical facilities may be needed as additional stress is placed on these systems.

16.10.4 Environment

The exposure and vulnerability of the environment may increase as a result of climate change impacts on the flood hazard. Changes in the timing and frequency of flood events may have broader ecosystem impacts that alter the ability of already stressed species to survive.

16.11 LANDSLIDE

16.11.1 Impacts on the Hazard

Climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration. Increase in global temperature is likely to affect the snowpack and its ability to hold and store water. Warming temperatures also could increase the occurrence and duration of droughts, which would increase the probability of wildfire, reducing the vegetation that helps to support steep slopes. All of these factors would increase the probability for landslide occurrences.

16.11.2 Population and Property

Population and property exposure and vulnerability would be unlikely to increase as a result of climate change impacts on the landslide hazard. Landslide events may occur more frequently, but the extent and location should be contained within mapped hazard areas and recently burned areas.

16.11.3 Critical Facilities

Critical facility exposure and vulnerability would be unlikely to increase as a result of climate change impacts on the landslide hazard; however, critical facility owners and operators may experience more frequent disruption to service provision as a result of landslide hazards. For example, transportation systems may experience more frequent delays if slides blocking these systems occur more frequently.

16.11.4 Environment

Exposure and vulnerability of the environment would be unlikely to increase as a result of climate change, but more frequent slides in riverine systems may impact water quality and have negative impacts on already stressed species.

16.12 SEVERE WEATHER

16.12.1 Impacts on the Hazard

Climate change presents a challenge for risk management associated with severe weather. The frequency of severe weather events has increased steadily over the last century. The number of weather-related disasters during the 1990s was four times that of the 1950s, and cost 14 times as much in economic losses. Historical data shows that the probability for severe weather events increases in a warmer climate.

This increase in average surface temperatures can also lead to more intense heat waves that can be exacerbated in urbanized areas by what is known as urban heat island effect. The evidence suggests that heat waves are already increasing, especially in western states.

16.12.2 Population and Property

Population and property exposure and vulnerability would be unlikely to increase as a direct result of climate change impacts on the severe weather hazard. Severe weather events may occur more frequently, but exposure and vulnerability will remain the same. Secondary impacts, such as the extent of localized flooding, may increase, thus impacting greater numbers of people and structures.

16.12.3 Critical Facilities

Critical facility exposure and vulnerability would be unlikely to increase as a result of climate change impacts on the severe weather hazard; however, critical facility owners and operators may experience more frequent disruptions. For example, more frequent and intense storms may cause more frequent disruptions in power service.

16.12.4 Environment

Exposure and vulnerability of the environment would be unlikely to increase; however, more frequent storms and heat events and more intense rainfall may place additional stressors on already stressed systems.

16.13 VOLCANO

16.13.1 Impacts on the Hazard

Climate change is not likely to affect the risk associated with volcanoes; however, volcanic activity can affect climate change. Volcanic clouds absorb terrestrial radiation and scatter a significant amount of incoming solar radiation. By reducing the amount of solar radiation reaching the Earth's surface, large-scale volcanic eruptions can lower temperatures in the lower atmosphere and change atmospheric circulation patterns. The massive outpouring of gases and ash can influence climate patterns for years following a volcanic eruption. Additionally, while climate change is not likely to increase the frequency of eruptions, changes in precipitation amounts could increase the potential for lahars or debris avalanches in volcanic areas.

16.13.2 Population, Property, Critical Facilities and the Environment

Exposure and vulnerability to the volcano hazard are unlikely to change as a direct result of climate change.

16.14 WILDFIRE

16.14.1 Impacts on the Hazard

Wildfire is determined by climate variability, local topography, and human intervention. Climate change has the potential to affect multiple elements of the wildfire system: fire behavior, ignitions, fire management, and vegetation fuels. Hot dry spells create the highest fire risk. Increased temperatures may intensify wildfire danger by warming and drying out vegetation. Additionally, changes in climate patterns may impact the distribution and perseverance of insect outbreaks that create dead trees (increase fuel). When climate alters fuel loads and fuel moisture, forest susceptibility to wildfires changes. Climate change also may increase winds that spread fires. Faster fires are harder to contain, and thus are more likely to expand into residential neighborhoods.

16.14.2 Population, Property and Critical Facilities

Larger, more severe, and more frequent fires may impact the people, property and critical facilities by increasing the risk of ignition from nearby fire sources. Additionally, secondary impacts such as air quality issues may increase.

16.14.3 Environment

It is possible that the exposure and vulnerability of the environment will be impacted by impacts on wildfire risk from climate change, as natural fire regimes may change, resulting in more frequent or higher intensity burns. These impacts may alter the composition of the ecosystems in the areas in and surrounding Ada County.

17. NON-NATURAL HAZARDS OF CONCERN

Hazard mitigation plans are required to include a risk assessment of natural hazards that can or have impacted a planning area (Section 201.6(c)(2)(i) 44 CFR). Plans have the option, but are not required, to include an assessment on non-natural hazards as well. The Steering Committee decided that for this update, the *Ada County Multi-Hazard Mitigation Plan* would include a profile of potential non-natural hazards that could impact the planning area. This creates an opportunity for plan integration and linkage between planning processes.

The non-natural hazards addressed in this chapter are profiled but not fully assessed like the natural hazards addressed elsewhere in this plan. These hazards are not included in the risk ranking. Planning partners have the option of identifying mitigation actions for the non-natural hazards of concern, as long as they have fully addressed their natural hazard risk as required under Section 201.6 44 CFR. The following profiles are consistent with the non-natural hazards addressed in the 2013 Idaho State Hazard Mitigation Plan.

17.1 HAZARDOUS MATERIALS

Hazardous materials are substances that are considered severely harmful to human health and the environment, as defined by the U.S. EPA's Comprehensive Environmental Response, Compensation, and Liability Act (commonly known as Superfund). Many hazardous materials are commonly used substances that are harmless in their normal uses but dangerous if released. The EPA designates more than 800 substances as hazardous and identifies many more as potentially hazardous due to their characteristics and the circumstances of their release (EPA, 2013). If released or misused, hazardous substances can cause death, serious injury, long-lasting health effects, and damage to structures, other properties, and the environment. Many products containing hazardous substances are used and stored in homes and these products are shipped daily on highways, railroads, waterways, and pipelines. The following are the most common types of hazardous material incidents:

- **Fixed-Facility Hazardous Materials Incident**—This is the uncontrolled release of materials from a fixed site capable of posing a risk to health, safety, and property as determined by the Resource and Conservation and Recovery Act. It is possible to identify and prepare for a fixed-facility incident because federal and state laws require those facilities to notify state and local authorities about what is being used or produced at the site.
- **Hazardous Materials Transportation Incident**—A hazardous materials transportation incident is any event resulting in uncontrolled release of materials during transport that can pose a risk to health, safety, and property as defined by Department of Transportation Materials Transport regulations. Transportation incidents are difficult to prepare for because there is little if any notice about what materials could be involved should an accident happen. Hazardous materials transportation incidents can occur at any place within the country, although most occur on the interstate highways or major federal or state highways, or on major rail lines.

17.1.1 Location, Extent and Magnitude

Because hazardous materials are so widely used, stored and transported, a hazardous material event could take place almost anywhere. Moreover, many hazardous materials are used, stored and transported in very large quantities, so the impacts of an event may be widespread and powerful. Hazardous material incidents usually occur on major highways and railways. According to the 2013 Idaho State Hazard Mitigation Plan, there are 152 Tier II facilities in Ada County. There is no magnitude rating for hazardous material incidents at present.

17.1.2 Planning Capability for Hazardous Materials

Ada County Emergency Management maintains the following planning capabilities for hazardous materials:

- A Threat Hazard Inventory and Risk Assessment that addresses the risk and vulnerability of the planning area to hazardous materials (in compliance with FEMA's Civil Planning Guidance #201)
- A National Incident Management System and emergency operations/response plans for the entire Ada County operational area (in compliance with FEMA's Civil Planning Guidance #101)
- A Hazardous Materials Response Plan in 2013 (in compliance with the Superfund Amendment and Reauthorization Act (SARA) Title III).

Not all plans are available for public access due to security concerns. Plans that are available for public access can be viewed at: https://adacounty.id.gov/accem/Emergency-Plans/Local-State-Federal-Plans.

17.2 CIVIL DISTURBANCES

(*The following are excerpts from the 2013 Idaho State Hazard Mitigation Plan*)

Civil unrest spans a variety of actions including labor unrest, strikes, civil disobedience, demonstrations, riots, and rebellion. Civil disturbances arise from acts of civil disobedience, often spontaneous, involving large numbers of persons, generally caused by political grievances and urban economic conflicts or a decrease in the supply of essential goods and services. Civil disturbance is often a form of protest, arising from highly emotional social and economic issues.

Civil disturbance severity depends on the nature of the disturbance. The high-profile World Trade Organization conference in Seattle in 2000 resulted in mass arrests, civilian curfews, and over $20 million in property damage. The Rodney King beating unleashed seven days of violence and $1 billion in property damage, and left 50 people dead. It is not possible to predict the potential severity of civil disturbance; however, it is necessary to think about the potential of such a disturbance. Incidents like these are less likely to occur in a smaller city, due to the noncontiguous nature of suburban development patterns.

Mob violence is segregated into three forms: riots, lynching, and vigilante groups. Mobs are typically associated with disorder and lack of respect for the law. Uncontrolled, unorganized, angry, and emotional, these commons masses, otherwise known as mobs, share a common purpose.

There is a low, medium, and high range that can be associated with the severity of the hazard of civil disturbance. Such disturbances may originate from a political rally or university football game celebration getting out of control or demonstrations by environmental protestors. Dispatching police to control traffic corridors or intrusion on private property is considered a low severity civil disturbance. Disruption of businesses and potential property damage are assessed as a moderate civil disturbance. In these cases, police intervention would be required to restore order without employing chemical agents or physical force. A severe civil disturbance would involve rioting, arson, looting, and assault, where aggressive police action (tear gas, curfews, and mass arrests) may be required.

In general, a high hazard severity rating is assigned to an event where emotionally charged and highly contentious business or police action engender the outrage of a segment of the population. While the hazard severity would be high, there would be a moderate vulnerability in such an event and low probability, and as such, a low risk rating is assigned to a high severity civil disturbance. A moderate hazard severity rating would be assigned to a localized event that resulted in damage to property, police action, or some physical harm to the people involved, either protesters or police. In that the vulnerability to such an event is moderate, the severity is moderate, and the probability is moderate, a moderate risk rating is assigned to the potential moderate civil disturbance event.

A low hazard rating would be assigned to a localized event that resulted in minimal to no property damage, no police action (though potential police presence), and no physical harm to the participants, bystanders, or police. As such, while there may a high probability rating for such forms of low severity civil disturbance, and while the vulnerability rating may be moderate, a low severity hazard would be given a low hazard rating.

17.2.1 Location, Extent and Magnitude

Because of their often spontaneous nature, it is difficult to identify specifics; however, information gathered in advance may warn officials and provide locations of future civil disturbances.

17.2.2 Planning Capability for Civil Disturbances

Ada County Emergency Management maintains the following planning capabilities for civil disturbances:

- A Threat Hazard Inventory and Risk Assessment that addresses the risk and vulnerability of the planning area to hazardous materials (in compliance with FEMA's Civil Planning Guidance #201)
- A National Incident Management System and emergency operations/response plans for the entire Ada County operational area (in compliance with FEMA's Civil Planning Guidance #101)
- The Ada County Mass Casualty Incident Plan and a Terrorism Plan.

Not all plans are available for public access due to security concerns. Plans that are available for public access can be viewed at: https://adacounty.id.gov/accem/Emergency-Plans/Local-State-Federal-Plans.

17.3 PANDEMIC

An outbreak is defined by the U.S. Centers for Disease Control and Prevention (CDC) as the occurrence of more cases of disease than normally expected within a specific place or group of people over a given period of time. State and local regulations require immediate reporting of any known or suspected outbreaks by health care providers, health care facilities, laboratories, veterinarians, schools, child day care facilities, and food service establishments. An epidemic is a localized outbreak that spreads rapidly and affects a large number of people or animals in a community. A pandemic is an epidemic that occurs worldwide or over a very large area and affects a large number of people or animals.

The Idaho Office of Emergency Management has identified the following as human diseases that could contribute to a serious epidemic in the area:

- **Cholera**—A bacterial infection in the small intestine that may cause diarrhea, dehydration, and death. It spreads by ingesting food or water contaminated with feces from infected persons. Cholera outbreaks no longer exist in the United States due to water treatment and sanitation systems.
- **Diphtheria**—A contagious infection caused by bacteria affecting the upper respiratory tract and less often the skin. Coughing, sneezing, or even laughing easily transmits the disease. Complications are breathing problems, heart failure, and nervous system damage. Diphtheria is rare in the United States due to immunizations.
- **HIV/AIDS**—An abbreviation for human immunodeficiency virus /acquired immunodeficiency syndrome. A viral infection transmitted by sexual intercourse, contaminated blood transfusions, or from infected mother to child during pregnancy or breastfeeding compromises the immune system. This

disease is recent compared to other pandemics, first recognized by the CDC in 1981. No current cure exists although breakthroughs in research are promising.

- **Influenza**—An infectious viral disease of birds and mammals commonly transmitted through airborne aerosols such as coughing or sneezing. Symptoms are chills, headache, fever, nausea, muscle pain and occasionally pneumonia. New flu strains caused pandemics in the late 19th and 20th centuries: Russian flu, 1918 Spanish flu, Asian flu, Hong Kong flu, and A/H1N1 or the swine flu. According to the CDC, avian influenza occurs naturally among wild aquatic birds worldwide and can infect domestic poultry and other bird and animal species. Avian flu viruses do not normally infect humans. The recent avian flu strains H5N1 and H7N9 have caused human deaths but have not escalated to pandemic proportions.
- **Measles**—A serious respiratory disease caused by a virus. It spreads easily through coughing and sneezing. In rare cases, it can be deadly. The measles, mumps, rubella vaccine protects against measles.
- **Pertussis (also known as whooping cough)—**A serious respiratory (in the lungs and breathing tubes) infection caused by the pertussis bacteria. It causes violent persistent coughing. Whooping cough is most harmful for young babies and can be deadly. The DTaP vaccine protects against whooping cough.
- **Plague**—A disease that affects humans and other mammals, caused by the bacterium *Yersinia pestis*. Humans usually get plague after rodent fleabite carrying the bacterium or by handling an infected animal. Plague killed millions of people in Europe during the middle ages. Today, modern antibiotics are effective in treating plague. Without prompt treatment, the disease can cause serious illness or death. Human plague infections continue to occur in the western United States, but significantly more cases occur in parts of Africa and Asia
- **Polio (or poliomyelitis)—**A disease caused by poliovirus. It can cause lifelong paralysis and can be deadly. The polio vaccine can protect against polio.
- **Q-fever**—A worldwide disease with acute and chronic stages caused by the bacterium *Coxiella burnetii*. Cattle, sheep, and goats are the primary reservoirs although a variety of species may be infected. During birthing, the organisms are shed in high numbers within amniotic fluids and the placenta. The organism is extremely hardy and resistant to heat, drying, and many common disinfectants. Infection of humans usually occurs by inhalation of these organisms from air that contains barnyard dust contaminated by dried placental material, birth fluids, and excreta of infected animals. Other modes of transmission to humans, including tick bites, ingestion of unpasteurized milk or dairy products, and human-to-human transmission, are rare. Humans are often very susceptible to the disease, and very few organisms may be required to cause infection.
- **Severe acute respiratory syndrome (SARS)**—A viral respiratory illness caused by a coronavirus, called SARS-associated coronavirus (SARS-CoV). SARS was first reported in Asia in 2003. The illness spread to more than two dozen countries in North America, South America, Europe, and Asia before the global outbreak was contained.
- **Small Pox**—A serious, contagious, and sometimes fatal infectious disease. There is no specific treatment for smallpox disease, and the only prevention is vaccination. Smallpox outbreaks occurred from time to time for thousands of years, but the disease is now eradicated after a successful worldwide vaccination program. The last case of smallpox in the United States was in 1949. The last naturally occurring case in the world was in Somalia in 1977. After the disease was eliminated from the world, routine vaccination against smallpox among the public was stopped because it was no longer necessary for prevention.
- **Tuberculosis (TB)**—A disease caused by a bacterium called *Mycobacterium tuberculosis*. The bacteria usually attack the lungs, but can attack any part of the body such as the kidney, spine, and brain. If not treated properly, TB can be fatal. TB is spread through the air from one person to another. The bacteria are put into the air when a person with TB coughs, sneezes, speaks, or sings.
- **Typhoid**—A bacterial infection of the intestinal tract and bloodstream. Most of the cases are acquired during foreign travel to underdeveloped countries. The germ that causes typhoid is a unique human strain of salmonella called *salmonella typhi*.

- **West Nile virus**—A potentially serious illness established as a seasonal epidemic in North America that flares up in the summer and continues into the fall.

According to the 2013 Idaho State's Hazard Mitigation Plan, factors in Idaho that heighten the probability of occurrences of such events include large numbers of travelers arriving via the region's air and sea ports, the transportation of infected animals into the area, contaminated garbage or other waste washing ashore, or disease transmission through individuals transporting or coming into contact with hospitalized or nursing-home-bound patients (IOEM, 2013).

17.3.1 Location, Extent and Magnitude

Health hazards that affect the residents of Ada County may arise in a variety of situations, such as during a communicable disease outbreak, after a natural disaster, or as the result of a bioterrorism incident. All populations in Ada County are susceptible to bioterrorism or pandemic events. Populations who are young or elderly or have compromised immune systems are likely to be more vulnerable. The relative ease of world-wide travel in addition to the world's expanding global food industry ensures that all countries are vulnerable to pandemic events at any time.

17.3.2 Planning Capability for Pandemic

The Central District Health Department has developed and maintains a regional preparedness and response plan for pandemic that covers the Ada County planning area.

17.4 RADIOLOGICAL

(The following are excerpts from the 2013 Idaho State Hazard Mitigation Plan)

Radiation is the release of energy from unstable atoms. When atoms are unstable, the nuclei have too much energy and release the energy called radiation in the form of electromagnetic (EM) waves or small particles at various speeds (DOE, 1992). Examples of relatively low-energy EM radiation are visible light from the sun, or radio, television, and microwaves from transmission antennae. These interact with materials in various ways, but they do not carry enough energy to directly alter the chemical properties of atoms or molecules.

More energetic EM radiation can ionize atoms or molecules, altering their chemical properties. Ionizing EM radiation is generally hazardous to health because it can disrupt the biochemical bonds. Some non-ionizing EM radiation can be seen or felt (such as light or heat), but ionizing EM radiation (such as X-rays and gamma rays) can only be measured with instrumentation that senses the amount of ionization in its detector. Ionization can also occur when energetic particles such as neutrons, electrons (beta particles), or helium nuclei (alpha particles) pass at high speed through a material. Particulate radiation is usually measured by the same means as ionizing EM radiation (http://www.physics.isu.edu/radinf/).

17.4.1 Location, Extent and Magnitude

Natural sources of radioactive elements are found in air, water, soil, and human bodies. Ionizing particulate and EM radiation are generated in the environment by naturally occurring radioactive material in the earth's crust (terrestrial radioactivity, radon) or through the effects of cosmic radiation originating outside the earth's atmosphere. Thorium and uranium are naturally occurring radioactive elements that are used as nuclear fuels. Idaho has one of the largest concentrations of uranium nationally. A variety of industries (e.g., oil/gas extraction industries and community drinking water treatment) that process natural material create an unintended concentration of natural radioactivity; this is referred to as technologically enhanced naturally occurring radioactivity. Technologically produced radioactive material is generated by nuclear reactors or high energy particle accelerators, and relatively high levels of ionizing EM radiation are produced using X-ray machines. Radioactive materials are often encapsulated so that the ionizing EM radiation they produce may be used without the hazard posed by uncontained radioactive contamination. Technologically produced radioactivity and radiation are used extensively in medical and industrial applications. Everyone receives varying amounts of radiation exposure from natural and technological sources.

17.4.2 Planning Capability for Radiological

Ada County Emergency Management has prepared and maintains a hazardous materials response plan that addresses radiological hazards.