4.9 EARTHQUAKES

4.9.1 Description

An earthquake occurs when two blocks of the earth suddenly slip past one another, releasing built up energy from plate tectonics, regional stress regimes, and induced from fluid injection or underground mining activities. The surface between these two blocks is called a fault or fault plane. When these blocks move, they produce seismic waves that are transmitted outward through the rock in all directions, producing ground shaking and secondary effects. Utah is situated away from the primary tectonic plate boundaries where a significant portion of the world's earthquakes typically occur. Instead, it lies within the western portion of the North American plate. Nevertheless, seismic activity in Utah is ultimately influenced by its connection with the Pacific plate, primarily along the plate's edge along the west coast of the United States.

Earthquakes are unique multi-hazard events with the potential to cause excessive damage and loss of life. Earthquake secondary effects often include surface fault rupture (generally≥ magnitude [M] 6.5), liquefaction and lateral spreading can be triggered as low as approximately 0.1 g.4 Landslides, rock fall (generally ≥ M 4), tectonic subsidence, seiches and tsunamis. Effects from ground shaking may include building and infrastructure damage, fires, building, dam and canal failure, hazardous material releases, and non-structural building damage such as toppled cabinets, bookcases, and other furniture or equipment that was not restrained, falling ceiling tiles, lights, and other ceiling mounted items, and movement of unrestrained furniture, equipment, and other building interior items.

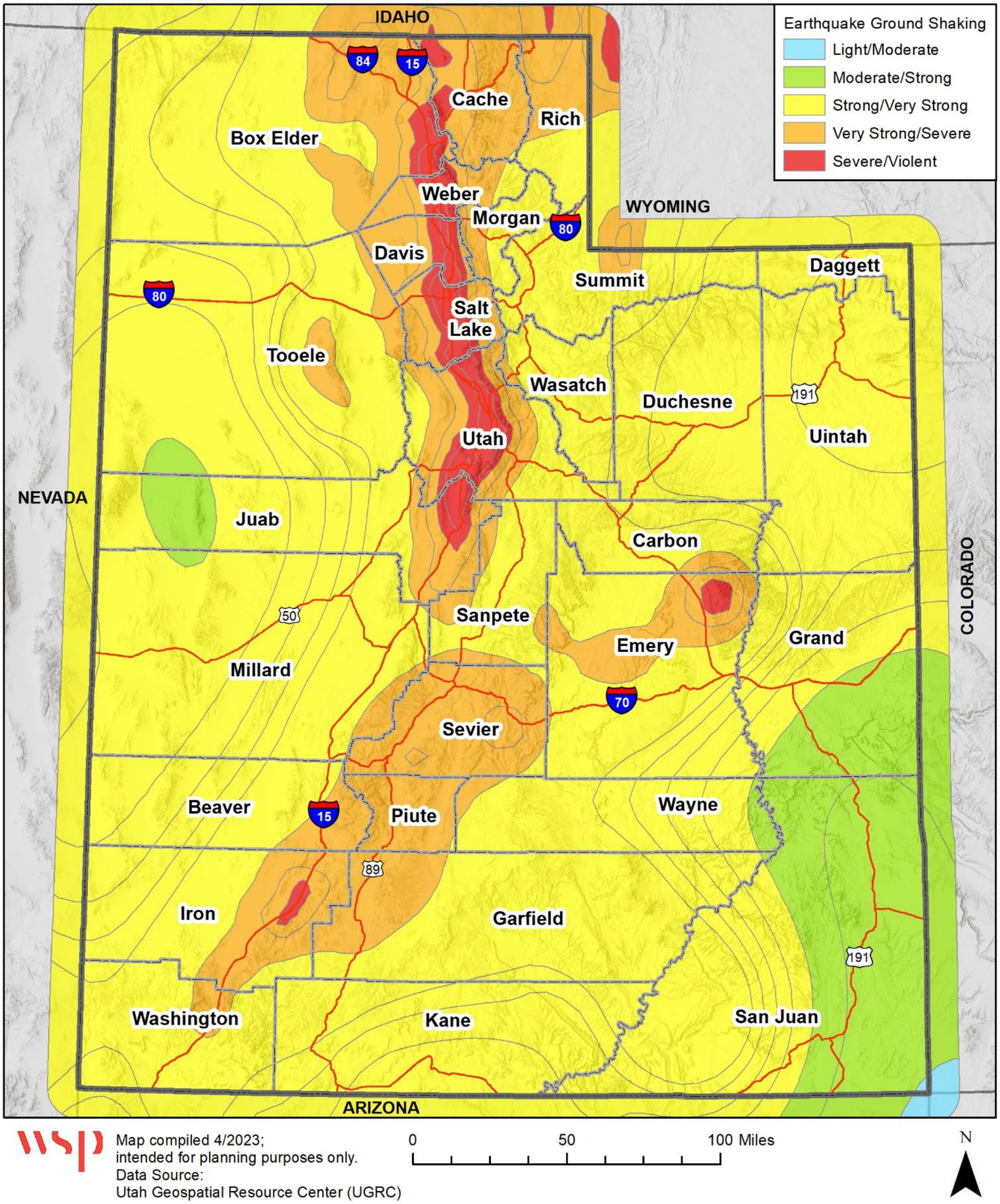
Utah straddles the physiographic region boundary between the extending Basin and Range Province to the west and the relatively stable Rocky Mountains and the Colorado Plateau to the east. This boundary coincides with an area of earthquake activity called the Intermountain Seismic Belt (ISB). The ISB is a zone of significant earthquake activity up to 120 miles wide extending in north-south direction 800 miles from Canada to northern Arizona and eastern Nevada. Large, damage-causing earthquakes in Utah are likely to occur in the ISB that generally extends through the center of the state, essentially following Interstate 15, where there are many active faults capable of producing earthquakes. Unfortunately, this location is also where over 85% of Utah's population lives along the Wasatch Front, and also includes the rapidly urbanizing St. George and Cedar City areas.

Moderate-to-large earthquakes, generally M 6 and greater, can cause substantial damage to buildings, roads, bridges, and utilities often leading to injuries and fatalities. Background earthquakes are defined as those events less than M 6.75 ± 0.25 that cannot be associated with a known fault. A classic example of a background earthquake within the Wasatch Front region is the 1975 M 6.0 Pocatello Valley, Idaho, earthquake. Utah's only historical surface fault rupturing earthquake is the 1934 M 6.6 Hansel Valley earthquake that also caused two fatalities.

Ground Shaking

Ground shaking is a sudden motion or trembling of the Earth as stored elastic energy is released by fracture and movement of rocks along a fault. Anticipated ground shaking at a particular site is part of the structure design process detailed in the 2021 International Building Code (IBC) and International Residential Code (IRC) adopted statewide in Utah. The anticipated ground shaking is determined from USGS National Seismic Hazard Maps that are part of the IBC and IRC codes (see Figure 4-66).

Figure 4-66 Utah Ground Shaking Potential

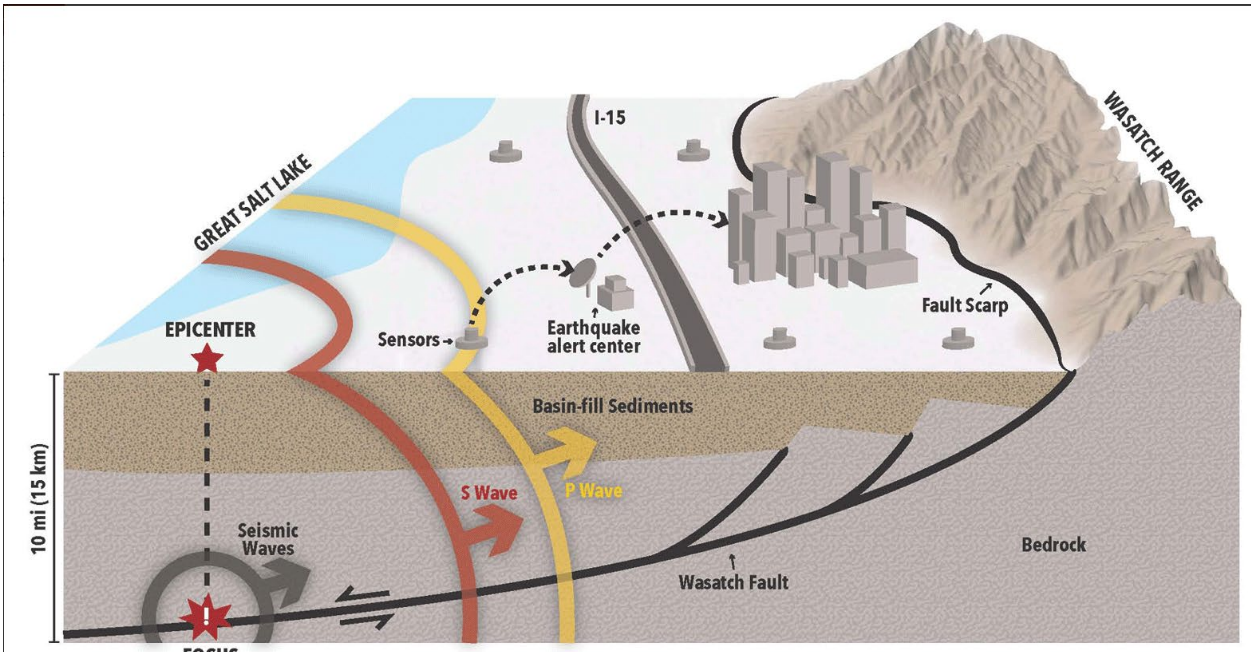


Map compiled 4/2023; intended for planning purposes only.
Data Source: Utah Geospatial Resource Center (UGRC)

Surface Fault Rupture

Surface Fault Rupture is a displacement of the ground surface along a fault during an earthquake that often results in a steep scarp. In the Intermountain West, this geological process typically requires earthquakes greater than about M 6.5 to occur. The figure below displays how a subsurface fault can lead to a surface fault rupture along the fault scarp, commonly along the base of mountains such as the Wasatch Front.

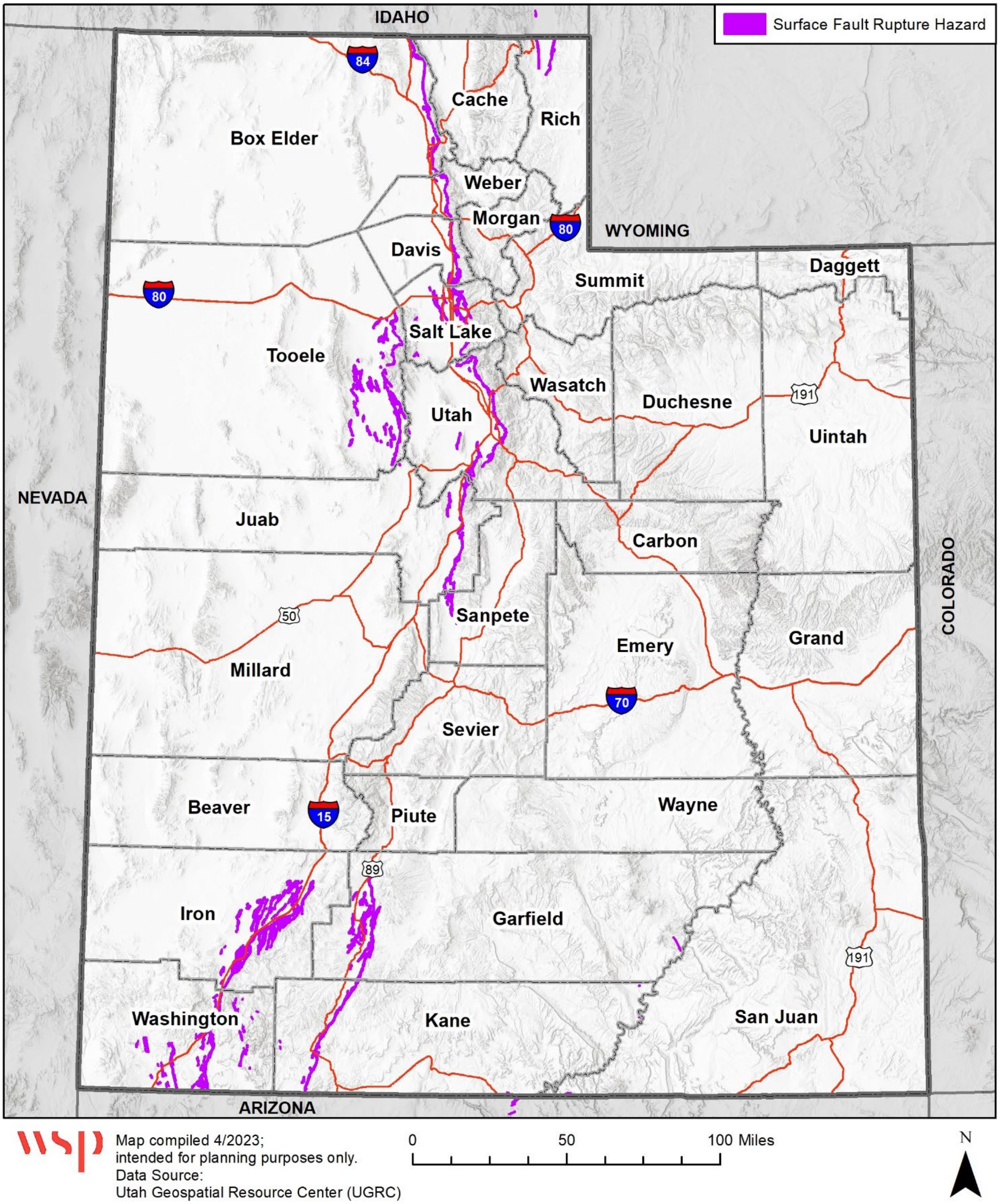
Figure 4-67 Subsurface and Surface Fault Illustration



Source: https://geology.utah.gov/hazards/earthquakes/utah-faults/

Fault displacements can easily exceed infrastructure design, resulting in structural failure and collapse. The UGS publishes surface fault rupture hazard maps (https://geology.utah. gov/map-pub/maps/geologic-hazard-maps) that show the location of fault traces at the surface and appropriate special study zones, where the UGS recommends a surface fault rupture investigation be performed before development. Hazard ordinances adopted by the cities of Cottonwood Heights, Draper, Holladay, and Salt Lake, and the counties of Salt Lake, Morgan, Utah, and Wasatch incorporate these UGS hazard maps. See Figure 4-68 below for mapping of surface fault rupture hazards statewide.

Figure 4-68 Utah Surface Fault Rupture Hazard



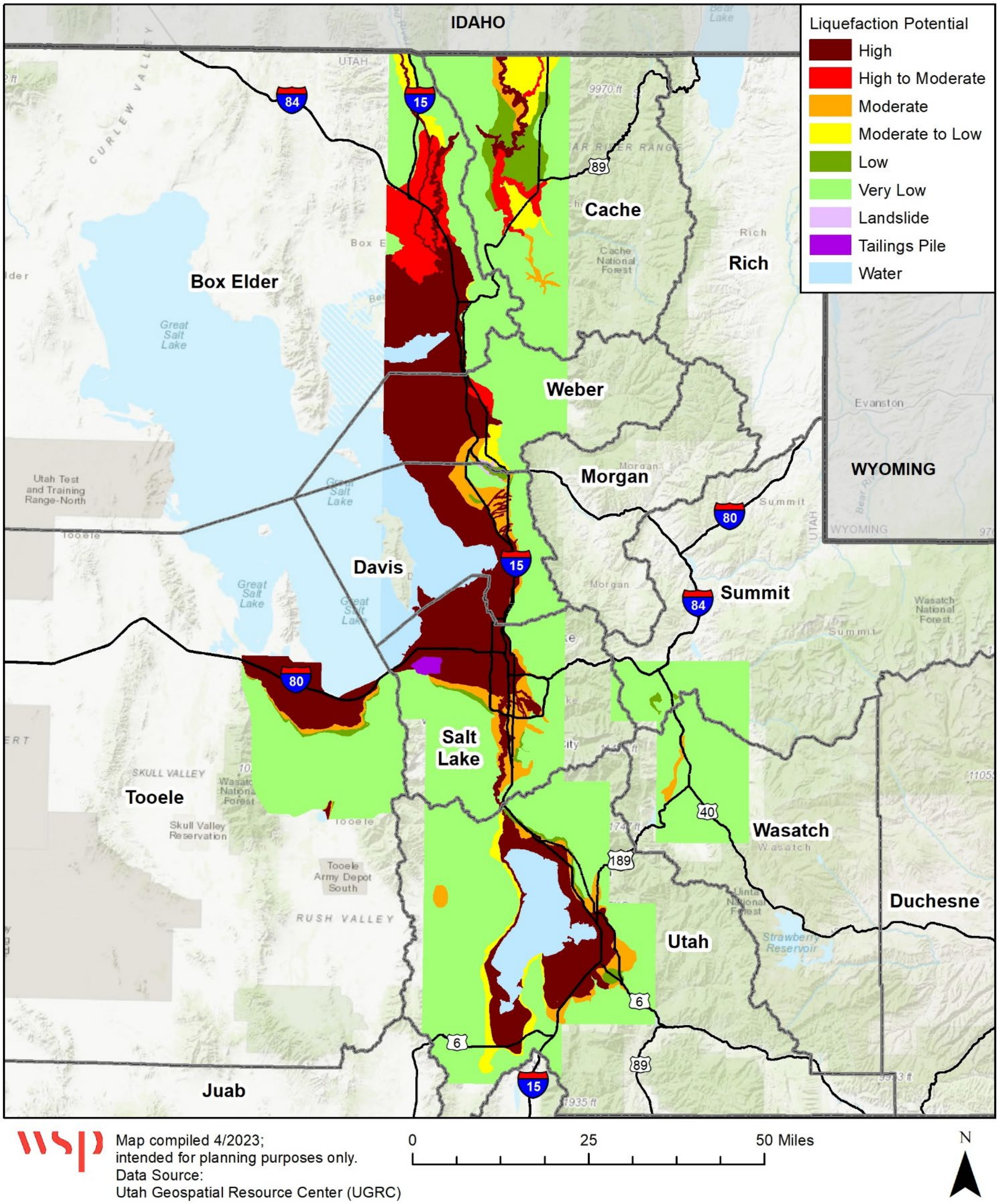
Surface fault rupture investigations are critical for determining the hazard. However, performing a surface-faulting investigation and adherence to ordinances and guidelines does not guarantee safety. Significant uncertainty is often present due to limited paleo seismic data related to the practical limitations of conducting such investigations (epistemic uncertainty), and natural variability in the location, recurrence, and displacement of successive surface-faulting earthquakes. Aleatory variability in fault behavior cannot be reduced; therefore, predicting exactly when, where, and how much ground rupture will occur during future surface-faulting earthquakes is not possible. New faults may form, existing faults may propagate beyond their present lengths, and elapsed time between individual surface-faulting earthquakes can vary by hundreds or thousands of years and be affected by clustering, triggering, and multi- or partial-segment ruptures. For those reasons, developing property near hazardous faults will always involve a level of irreducible, inherent risk.

Liquefaction

Liquefaction is a sudden, large decrease in shear strength of a saturated sandy soil caused by a temporary increase in soil pore water pressure during an earthquake and subsequent collapse of soil structure, resulting in sand boils, differential foundation settlement, lateral spread landslides, and localized shallow flooding.

Liquefaction can cause buildings to tip and settle, roads to crack, deform and flood, buried storage tanks and other underground infrastructure to rise towards the surface, and other types of damage to buildings and infrastructure. Significantly large areas along the densely populated Wasatch Front are subject to liquefaction and lateral spreading, among other areas in Utah. The 1934 M 6.6 Hansel Valley and 1962 M 5.7 Cache Valley earthquakes caused liquefaction and property damage in Utah. In addition, the 1992 M 5.5 St. George earthquake (Christenson, 1995) caused liquefaction and the 2010 M4.5 Randolph earthquake is one of the smallest magnitude earthquakes known worldwide to have caused liquefaction. Figure 4-69 illustrates mapped liquefaction potential statewide.

Figure 4-69 Utah Liquefaction Potential



Seiches

A seiche is a standing (oscillating) wave in a body of water that is at least partially enclosed and can be induced by earthquakes and other energy sources. These waves can damage near-shore infrastructure, such as docks, buildings, utilities, dams, etc. and cause localized flooding of low-lying areas. Bear Lake, Great Salt Lake, and Utah Lake are all near Quaternary faults capable of producing a seiche during an earthquake. Quaternary faults capable of producing tsunamis are also present beneath these lakes.

Tectonic Deformation

Tectonic deformation is the lowering and tilting of a valley floor on the down-dropped side of a fault during an earthquake and commonly causes localized flooding and gravity flow utility failure. The location of the northern end of the Jordan River in Salt Lake Valley has moved significantly several times in the geologic past, likely the result of tectonic deformation.

Earthquake-Triggered Landslides and Rock fall

Landslides and rockfall are often triggered by earthquake ground shaking. The 1988 M 5.3 San Rafael Swell earthquake produced significant rockfall in the region. See the landslides section for more information.

4.9.2 Geographic Area

Figure 4-70 and Figure 4-71 show the locations of known quaternary faults in Utah.

Figure 4-70 Utah Quaternary Faults

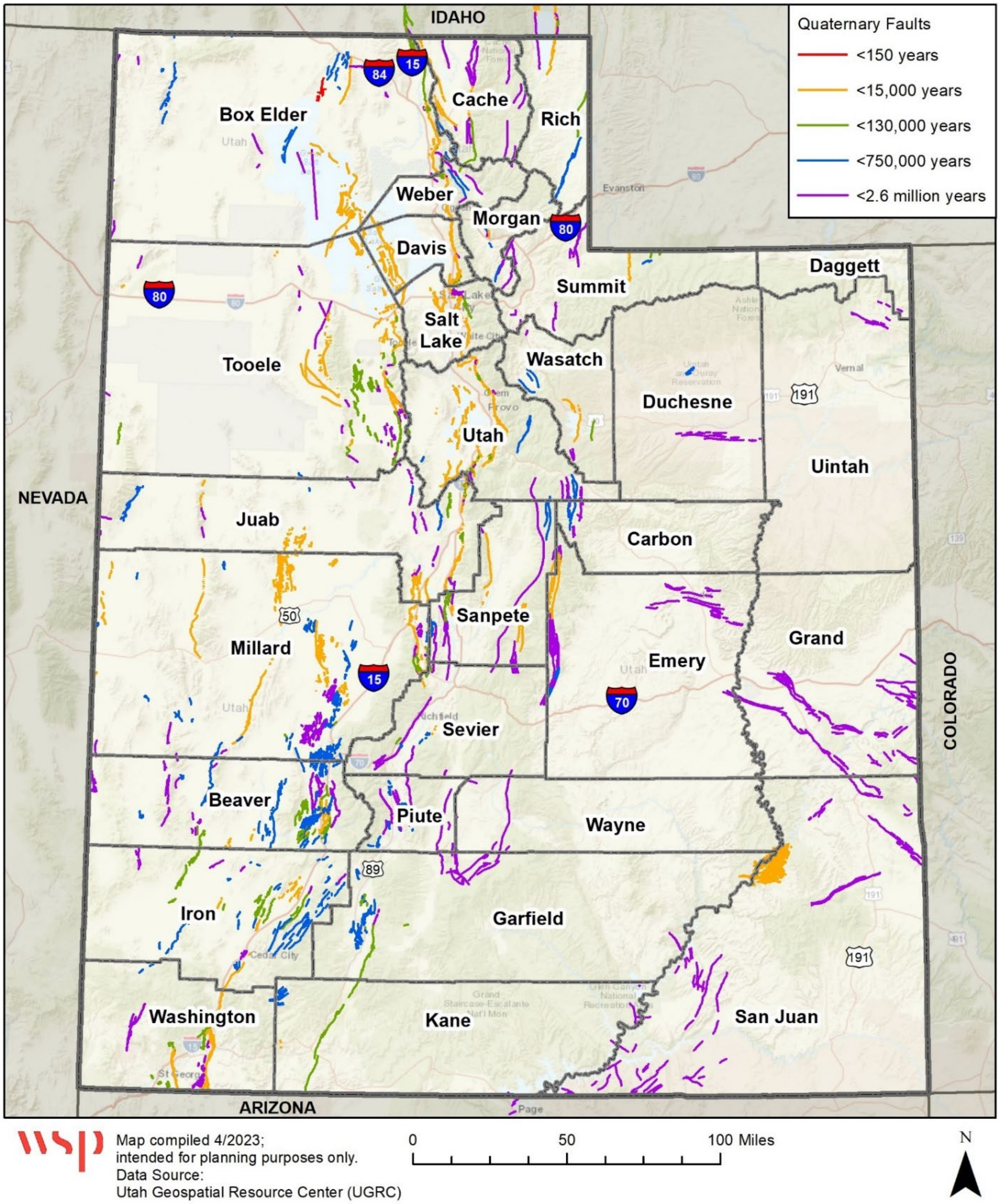
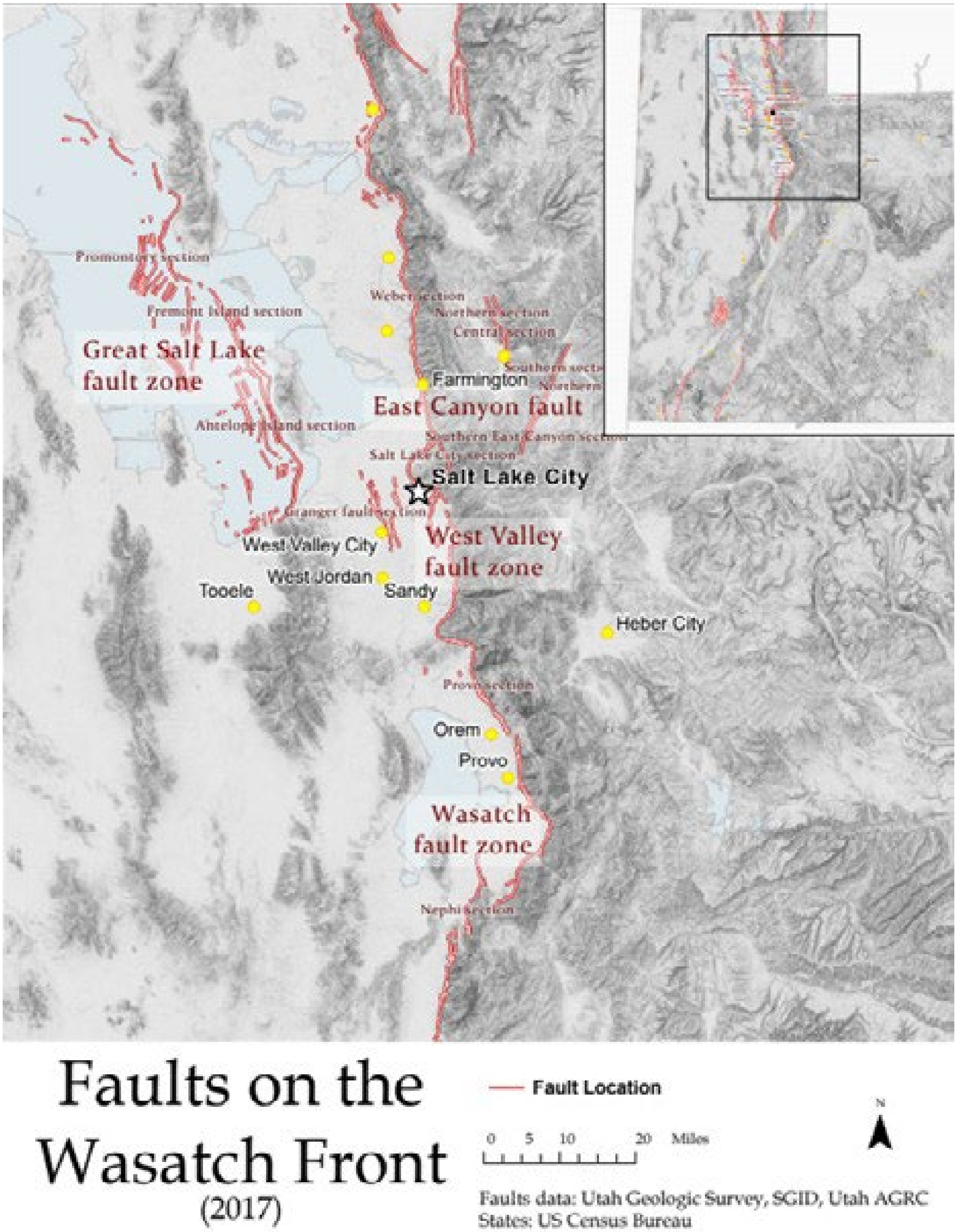


Figure 4-71 Faults in Northern Utah



The 350-km-long Wasatch fault zone (WFZ) consists of 10 segments that are thought to have ruptured repeatedly and independently in large magnitude (M ≥ 6.75) earthquakes. The five central segments from north to south are the Brigham City, Weber, Salt Lake City, Provo, and Nephi segments. These central segments are thought to be the most hazardous, because each segment has had multiple large Holocene (past 11,700 yrs.) earthquakes that have produced surface rupture. Detailed geologic investigations at 23 paleo seismic sites on these segments have yielded data on the timing of past earthquakes and measured single-event fault displacements. The resulting data show that at least four to five earthquakes have occurred on each central segment in the past 6000 years large enough to cause surface rupture. At least 22 surface-faulting earthquakes have ruptured the central segments of the WFZ since approximately 6000 years ago.

Many other Quaternary faults capable of producing significant earthquakes exist in Utah besides the WFZ. Other notable faults include the East and West Bear Lake, East and West Cache, Hurricane, Oquirrh-Great Salt Lake, Sevier-Toroweap, Washington, and West Valley fault zones. However, earthquakes on other faults or background earthquakes that are the result of tectonic loading may also occur within and surround the state of Utah.

4.9.3 Extent/Magnitude

The amount of energy released during an earthquake is usually expressed as a magnitude and is measured directly from the earthquake as recorded on seismographs. Seismologists have developed several magnitude scales; one of the first was the Richter Scale, developed in 1932 by the late Dr. Charles F. Richter of the California Institute of Technology (Table 4-38). The Richter Magnitude Scale is used to quantify the magnitude or strength of the seismic energy released by an earthquake.

Table 4-38 Richter Scale Magnitude

MAGNITUDE	EFFECTS	FREQUENCY WORLDWIDE
Less than 2.0	Microearthquakes, not felt or rarely felt; recorded by seismographs.	Continual
2.0-2.9	Felt slightly by some people; no damage to buildings.	Over 1M per year
3.0-3.9	Often felt by people; rarely causes damage; shaking of indoor objects noticeable.	Over 100,000 per year
4.0-4.9	Noticeable shaking of indoor objects and rattling noises; felt by most people in the affected area; slightly felt outside; generally, no to minimal damage.	10K to 15K per year
5.0-5.9	Can cause damage of varying severity to poorly constructed buildings; at most, none to slight damage to all other buildings. Felt by everyone.	1K to 1,500 per year
6.0-6.9	Damage to a moderate number of well-built structures in populated areas; earthquake-resistant structures survive with slight to moderate damage; poorly designed structures receive moderate to severe damage; felt in wider areas; up to hundreds of miles/kilometers from the epicenter; strong to violent shaking in epicentral area.	100 to 150 per year

MAGNITUDE	EFFECTS	FREQUENCY WORLDWIDE
7.0-7.9	Causes damage to most buildings, some to partially or completely collapse or receive severe damage; well-designed structures are likely to receive damage; felt across great distances with major damage mostly limited to 250 km from epicenter.	10 to 20 per year
8.0-8.9	Major damage to buildings, structures likely to be destroyed; will cause moderate to heavy damage to sturdy or earthquake-resistant buildings; damaging in large areas; felt in extremely large regions.	One per year
9.0 and Greater	At or near total destruction - severe damage or collapse to all buildings; heavy damage and shaking extends to distant locations; permanent changes in ground topography.	One per 10-50 years

Another measure of earthquake severity is Intensity. Intensity is an expression of the amount of shaking at any given location on the ground surface based on felt or observed effects. Seismic shaking is typically the greatest cause of losses to structures during earthquakes. Intensity is measured with the Modified Mercalli Intensity Scale (Table 4-39).

Table 4-39 Modified Mercalli Intensity (MMI) Scale

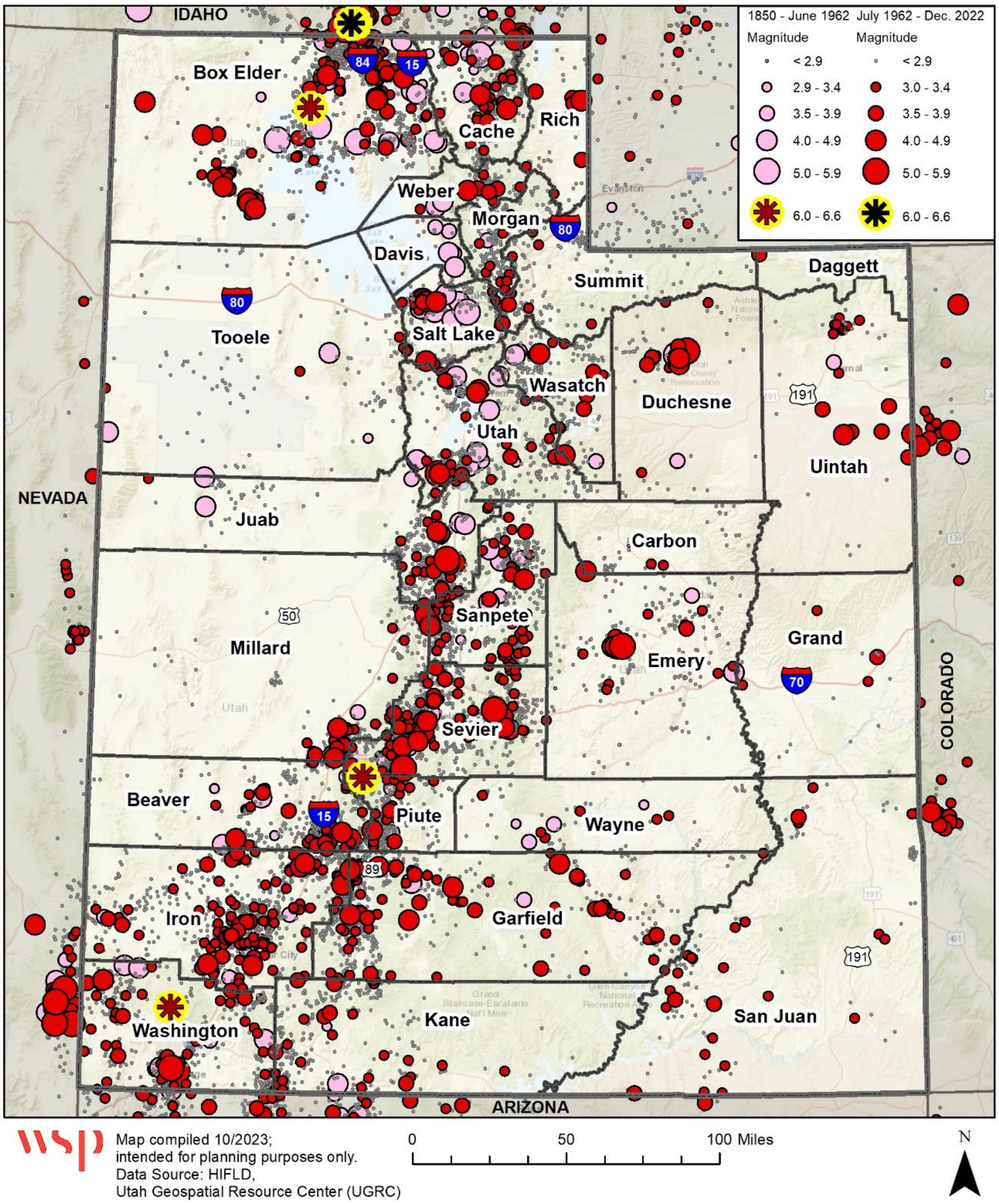
MMI	FELT INTENSITY
I	Not felt except by a very few people under special conditions. Detected mostly by instruments.
II	Felt by a few people, especially those on upper floors of buildings. Suspended objects may swing.
III	Felt noticeably indoors. Standing automobiles may rock slightly.
IV	Felt by many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

4.9.4 Past Occurrences

As previously mentioned, geologic investigations of Utah's faults indicate a long geologic history of repeated large earthquakes of M 6.5 and greater prior to settlement. There have been over 1,400 earthquakes with a magnitude of 3.0 or greater in Utah since 1850, and 61 earthquakes with a magnitude of 5.0 or greater throughout the same time period. The following sections summarize two significant recent events which impacted populated areas in Utah.

Utah has experienced seventeen earthquakes greater than M 5.5 since pioneer settlement in 1847 (Figure 4-72) and geologic investigations of Utah's faults indicate a long geologic history of repeated large earthquakes of M 6.5 and greater prior to settlement. Utah is not on a boundary between tectonic plates where most of the world's earthquakes occur, but rather is in the western part of the North America plate. However, earthquakes in Utah are indirectly caused by interactions with the Pacific plate along the plate margin on the west coast of the United States. Also, many small earthquakes in east-central Utah are induced by underground coal mining.

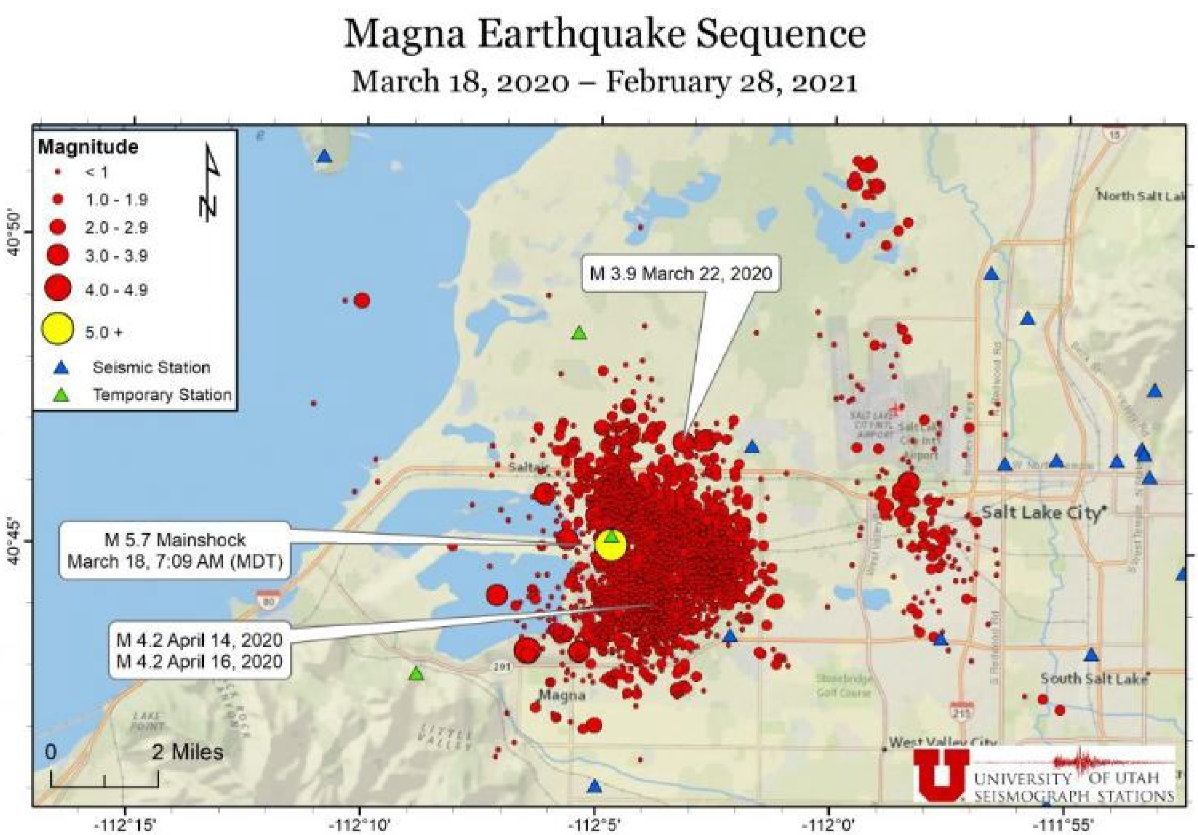
Figure 4-72 Past Earthquake Events (1950-2022)



2020 M 5.7 Salt Lake City Earthquake

On March 18, 2020, a magnitude 5.7 earthquake struck the Wasatch Front area, with an epicenter just north of Magna, Utah at a depth of 6.6 miles. According to the USGS, this was the strongest earthquake in the state in almost 20 years, and the first large magnitude earthquake in the Salt Lake Valley since 1962. According to the University of Utah Seismograph Stations (UUSS), the earthquake sequence generated 2,589 aftershocks between March 18, 2020 and February 28, 2021. The two largest of these were M 4.6 events that occurred later the same day of the main shock. Figure 4-73 below illustrates the locations and magnitudes of the earthquakes associated with the 2020 Magna event as measured by UUSS.

Figure 4-73 2020 Magna Earthquake Sequence



Significant shaking was felt in downtown Salt Lake City and reported as far away as Wyoming and Southern Idaho. Over 30,000 felt reports were received by the USGS and UUSS during this earthquake sequence, and the main earthquake had a Modified Mercalli Intensity rating of VIII (Severe). This MMI rating is associated with light damage in specially designed structures and more significant damage in older construction or buildings with less stringent seismic design.

Impacts along the Wasatch Front were significant. There were no deaths resulting from the event and only some minor injuries reported. However, reports of minor damage throughout the area were widespread. Total economic losses were estimated at $629 million. Approximately 50,000 power outages were reported across Northern Utah in the immediate aftermath, however this was mostly resolved by that same evening. Salt Lake City International Airport was shut down and evacuated and most flights that day were diverted. The airport was already operating a much lower capacity than normal due to the COVID-19 pandemic.

Table 4-40 below contains detailed information from Utah Risk Management concerning damage claims made involving state owned assets following the Magna Earthquake. These damages alone totaled more than $39 million. This event served as a highlight of the potential for damaging earthquakes in the Salt Lake City Metropolitan Area.

Table 4-40 State Asset Insured Losses in Magna Earthquake Sequence

ACCOUNT: ACCOUNT NAME	GROSS TOTAL	REPORTED LOSS
Department of Cultural & Community Engagement – Admin	$330,860.44	State of Utah Alice Merrill Horne Collection stored at the ArtHaus at 310 S 500 W appears to have suffered severe damage in the earthquake
Facilities Construction & Management (DFCM) – Maint.	$179,550.00	Earthquake damage, DNR Bldg. on 1524 W North Temple. Damage to walls, etc.
Facilities Construction & Management (DFCM) – Maint.	$20,349.00	Earthquake damage
University of Utah	$4,075.86	Earthquake Damage
Alcoholic Beverage Services	$976.98	Earthquake damage 205 West 400 South, SLC. Breakage and cleanup
Alcoholic Beverage Services	$774.83	Earthquake damage 3381 South Redwood Road, WVC. Breakage and cleanup
Alcoholic Beverage Services	$437.38	Earthquake damage, 1255 West North Temple. Breakage and cleanup.
Alcoholic Beverage Services	$266.39	Earthquake damage, 63 East Miller Ave. Breakage and cleanup.
Alcoholic Beverage Services	$28.36	Earthquake Damage, 3905 West 5400 South, Taylorsville. Breakage and cleanup
Alcoholic Beverage Services	$640.21	Earthquake damage 1675 South 900 West. Breakage and cleanup
Alcoholic Beverage Services	$22.21	Earthquake damage, 255 South 300 West. Breakage and cleanup
Alcoholic Beverage Services	$623.22	St. George did not feel the quake, but received earthquake-damaged product from the warehouse. $623.22
Alcoholic Beverage Services	$489.04	Earthquake damage 280 West Harris Ave
Alcoholic Beverage Services	$27.77	Earthquake damage 6262 South 5600 West, WVC. Breakage and cleanup
University of Utah	$5,139.44	Minor damages due to earthquake
Utah Board of Higher Education	$15,456.00	Earthquake knocked out power and cracking interior walls in building
University of Utah	$5,916.66	Minor damages due to earthquake
University of Utah	$5,455.88	Minor damages due to earthquake
University of Utah	$2,276.15	Minor damages due to earthquake
University of Utah	$7,998.51	Minor damages due to earthquake
Natural Resources – Wildlife Resources	$133,290.59	Damaged to Lee Kay Shooting range caused by Earthquakes
Facilities Construction & Management (DFCM) – Maint.	$3,240.00	"Agency loss of some personal items such as picture frames and small knickknacks. No furniture loss that I could see from it falling over. Building loss, which is more my concern, we have some superficial cracking in sheetrock joints in the stairwells

ACCOUNT: ACCOUNT NAME	GROSS TOTAL	REPORTED LOSS
Facilities Construction & Management (DFCM) – Maint	$92,965.00	We have significant sheet rock cracking in the stairwells along joints and directional change tie in points. There are other damages to the property as well. Earthquake
Facilities Construction & Management (DFCM) – Maint	$35,800,000.00	We have significant damage to this building and some of it may be structural, this is being assessed. We also have significant damage to the plaster in the building and this will require substantial repairs to bring back to its original condition.
Utah State Fair Park	$63,881.00	Unfortunately, the recent earthquake damaged several of the historic buildings located on the property
University of Utah	$15,031.15	Earthquake caused some damage to parking structure at Bldg.
Facilities Construction & Management (DFCM) – Maint	$4,213.00	White Memorial Chapel Steeple: Possible Seismic Damage from Earthquake
Facilities Construction & Management (DFCM) – Maint	$720,181.56	Damage to sheetrock throughout the building, some settling at door frames cause doors to stick or not close correctly. Earthquake damage.
Alcoholic Beverage Services	$600,000.00	Earthquake damage DABC warehouse stock of liquor. secondary ensuing loss 4/10/20
Agriculture	$8,246.00	Earthquake damage to UDAF building
Facilities Construction & Management (DFCM) – Maint	$179,948.69	Earthquake damage
Facilities Construction & Management (DFCM) – Maint	$27,900.00	Earthquake damage
Facilities Construction & Management (DFCM) – Maint	$43,225.00	Earthquake damage
Facilities Construction & Management (DFCM) – Maint	$99,750.00	Earthquake damage
Facilities Construction & Management (DFCM) – Maint	$115,545.00	Earthquake damage
Facilities Construction & Management (DFCM) – Maint	$38,792.26	Earthquake damage to DNR boat shop
Facilities Construction & Management (DFCM) – Maint	$50,465.50	Earthquake damage to DNR warehouse
Facilities Construction & Management (DFCM) – Maint	$36,651.00	Rampton Wall damage from earthquake
Utah Division of Archives and Records Service	$11,840.00	State archives building on a unit we replace last year or the year before. This is the cooling system and as near as we can tell the motor bracket broke during the initial earthquake.
Weber State University	$5,366.38	Earthquake damage
Weber State University	$5,953.14	Earthquake damage

ACCOUNT: ACCOUNT NAME	GROSS TOTAL	REPORTED LOSS
Weber State University	$27,966.87	Earthquake damage
Weber State University	$4,967.89	Earthquake damage
Weber State University	$1,439.96	Earthquake damage
University of Utah	$7,431.72	Minor damages due to earthquake. Significant crack in the north structural wall of this garage.
University of Utah	$28,212.00	Earthquake damage
Facilities Construction & Management (DFCM) – Maint	$91,359.03	Earthquake damage DABC warehouse. Property #07581 1625 South 900 West, Salt Lake City, Utah 84104. Significant damage to racking and fire piping, water cleanup"
University of Utah	$56,594.24	Earthquake damage
Salt Lake Community College	$390.50	Earthquake damage
Salt Lake Community College	$519.20	Earthquake damage
Salt Lake Community College	$2,012.45	Earthquake damage
Salt Lake Community College	$1,045.00	Earthquake damage
Salt Lake Community College	$15,549.76	Earthquake damage
Salt Lake Community College	$82,979.37	Earthquake damage
Salt Lake Community College	$770.00	Earthquake damage
Salt Lake Community College	$77.00	Earthquake damage
Facilities Construction & Management (DFCM) – Maint	$10,942.72	Structural damage at the Art Haus
Alcoholic Beverage Services	$399.82	Earthquake damage Magna DABC. Breakage and cleanup
Facilities Construction & Management (DFCM) – Maint	$23,660.00	Governor's Mansion earthquake damage
Transportation (UDOT)	$14,717.28	UDOT West Jordan Maintenance Shed Earthquake Claim
Transportation (UDOT)	$31,120.60	UDOT Murray Maintenance Shed Earthquake Claim. Brickwork and concrete floor. Cracks in floor were some preexisting
Transportation (UDOT)	$5,326.78	UDOT Salt Lake Metro Maintenance Shed Earthquake Claim
Transportation (UDOT)	$30,120.57	UDOT Parleys Maintenance Shed Earthquake Claim
Total Damages:	$39,075,452.36	

Source: Utah Division of Risk Management

The 2008 M 6.0 Wells, Nevada Earthquake – Lessons for Utah

The February 21, 2008, M 6.0 Wells, Nevada earthquake occurred at 6:16 a.m. in a rural town in northeastern Nevada with a population of 1,657 people. The earthquake was felt throughout eastern Nevada, southern Idaho, and northwestern Utah, including the Wasatch Front region of Utah. There were 1883 responses from the earthquake in six states on the USGS Did You Feel It? Website. The earthquake caused minor damage to over 40, and major damage to 17 commercial and government buildings, along with damage to over 60 chimneys and widespread non-structural damage, such as windows, drywall, furniture, and building contents for a total estimated damage of $10.5 million.

The event initiated the quick response of both state and federal scientific and emergency management agencies. Within hours of the event, Nevada and Utah state emergency operations centers were activated and coordinating. Seismic details of the main shock and aftershocks were available through the Nevada Seismological Laboratory (NSL) and USGS National Earthquake Information Center. Geologists from Nevada Bureau of Mines and Geology (NBMG), the UGS, and the University of Nevada Reno Center for Neotectonics Studies were field checking known Quaternary faults near the earthquake's epicenter. Within days of the event, a UGS technical clearinghouse website organized early earthquake information. Shortly thereafter, an NBMG earthquake portal provided a comprehensive central location for maps, photographs, preliminary damage reports, and reconnaissance field reports and seismologists from the University of Utah, NSL, and the USGS had deployed temporary seismic instrument arrays.

The predominately unreinforced brick construction of many of the residential, commercial, and governmental buildings and the fragile economic conditions in Wells are very similar to those found in many rural Utah communities. Building and infrastructure damage from a similar event in rural Utah will likely be very similar to Wells, along with disruptions to employment, schools, supplies, utilities, and other essential amenities. Learning from the experiences of Wells can help Utah communities better prepare for, respond to, and recover from a damaging earthquake or other geologic-hazard event. In addition, the Wells earthquake also demonstrated the effectiveness of how multiple agencies responded to an event far from their normal base of operations in a relatively remote area in winter conditions.

4.9.5 Probability

Since the late 1960s, abundant paleoseismic data on the timing and size of prehistoric surface-rupturing earthquakes have been collected on the WFZ and other faults in Utah's Wasatch Front region, which extends into southeastern Idaho and southwestern Wyoming. Motivated in part by the recent development of improved methods to analyze paleoseismic data, the Working Group on Utah Earthquake Probabilities (WGUEP) was formed in January 2010, under the auspices of the UGS and the USGS, to evaluate the probabilities of future occurrence of moderate-to-large earthquakes in the Wasatch Front region. The working group consisted of 14 geologists, seismologists, and engineers affiliated with diverse federal, state, academic, and consulting organizations.

The WGUEP's goal was to develop probabilistic earthquake forecasts for the Wasatch Front region that include: (1) combined time-dependent and time-independent probabilities of large earthquakes for the five central segments of the WFZ and two segments of the Great Salt Lake fault zone, (2) time-independent probabilities for less well-studied faults, and (3) estimates of the time-independent probabilities of background earthquakes not associated with known or mapped faults in the M 5.0 to 6.75 range.

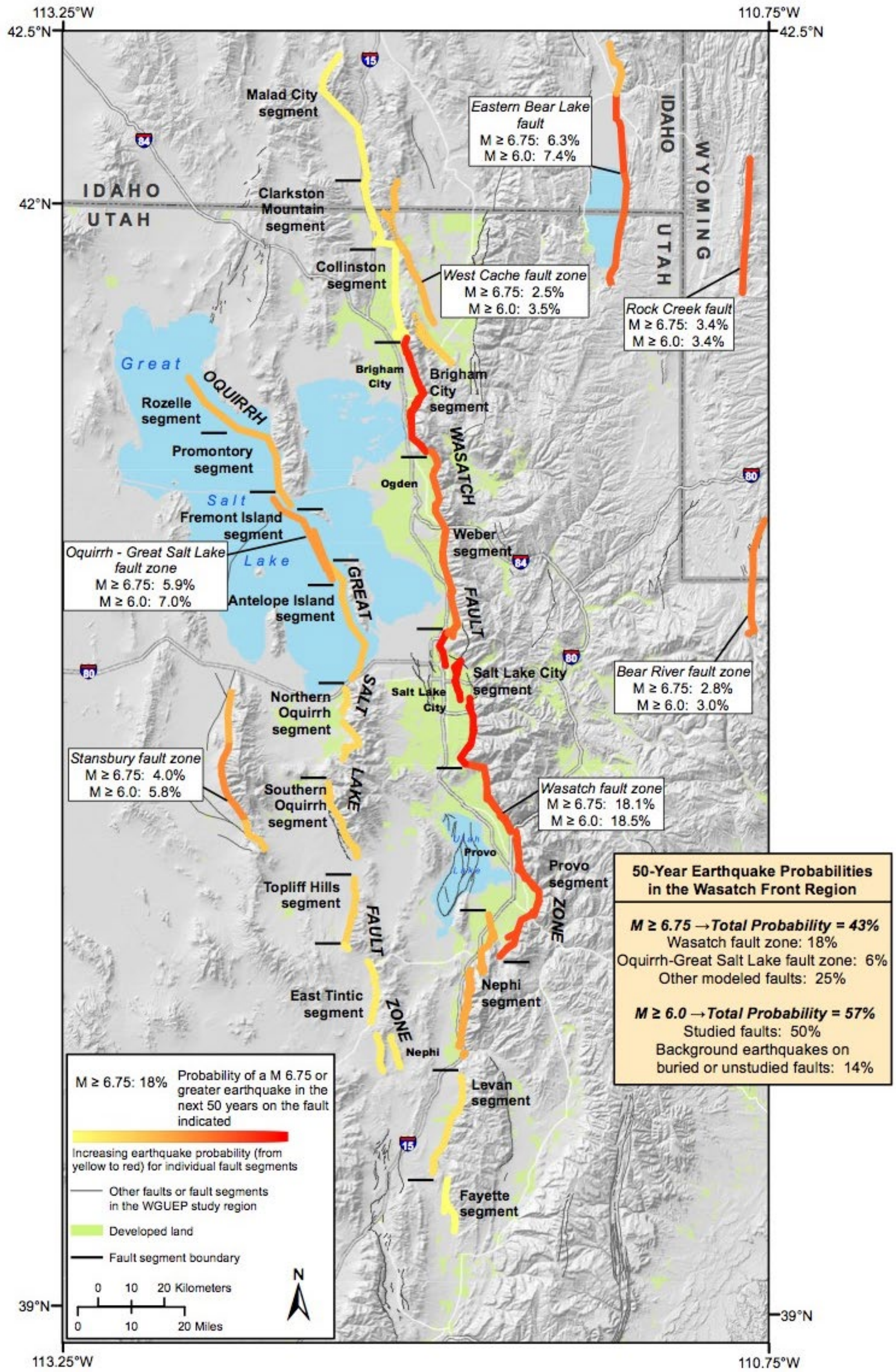
The WGUEP provided the forecasts with the hope that they will help heighten the public's awareness and understanding of the region's seismic hazards, just as the forecasts of the Working Groups on California Earthquake Probabilities (WGCEP) have successfully done. The consensus-based time-dependent and time-independent earthquake probabilities in the Wasatch Front region are not only useful for regional hazard analyses, but they also give a robust basis for site-specific probabilistic seismic hazard analyses (PSHAs) for the safe design and evaluation of critical structures and facilities. In addition, the time-dependent probabilities for fault ruptures can be incorporated into the PSHAs that will support urban seismic hazard maps planned by the USGS for the Wasatch Front region. Additionally, earthquake forecasts can aid in developing public policies leading to more effective and sustained earthquake mitigation efforts for the Wasatch Front region.

Based on the inputs summarized above, the probability of one or more large (M ≥ 6.75) earthquakes occurring in the Wasatch Front region in the 50-year time period of 2014 to 2063 is 43%. This regional probability is for earthquakes on all the characterized faults. The probability of one or more earthquakes of M 6.0 or larger in the Wasatch Front region in that time period is 57%. In addition, the probability of one or more earthquakes of M 5.0 or larger in the Wasatch Front region in that time period is 93%.

A significant contribution to these total probabilities comes from the WFZ and Oquirrh-Great Salt Lake fault zone. The total probability of at least one earthquake of M 6.75 or larger on either of these two fault zones is 23% in the 2014 to 2063 time period.

The total probability from the other modeled faults is 25%, due in part to some significant contributions from faults with higher slip rates, such as the Eastern Bear Lake and Stansbury fault zones. The Eastern Bear Lake fault has a probability of 6.3% for one or more earthquakes of M 6.75 or larger in that time period. The 50-year probability is 34% for one or more earthquakes of M 6.0 or larger on the other faults. For background, earthquakes of M 6.0 or larger on buried or unknown faults, the 50-year probability is 14%. Figure 4-74 shows the 50-year probabilities for earthquakes of M 6.75 or larger on selected fault segments. For example, the probabilities on the Salt Lake City, Brigham City, Provo, and Weber segments are 5.8%, 5.6%, 3.9%, and 3.2%, respectively. The 50-year probability on the Nephi segment is relatively low at only 1.8% because its most recent rupture occurred only about 300 years ago. Although these individual probabilities might seem small, the total probability for an earthquake of M 6.75 or larger somewhere on the WFZ in the next 50 years is 18%. In the next 100 years, the probability increases to 33%. Such a large earthquake occurring anywhere along the WFZ will result in considerable damage to communities in the Wasatch Front region and their economies.

Figure 4-74 50-year (2014-63) probabilities M 6.0 and 6.75 earthquake



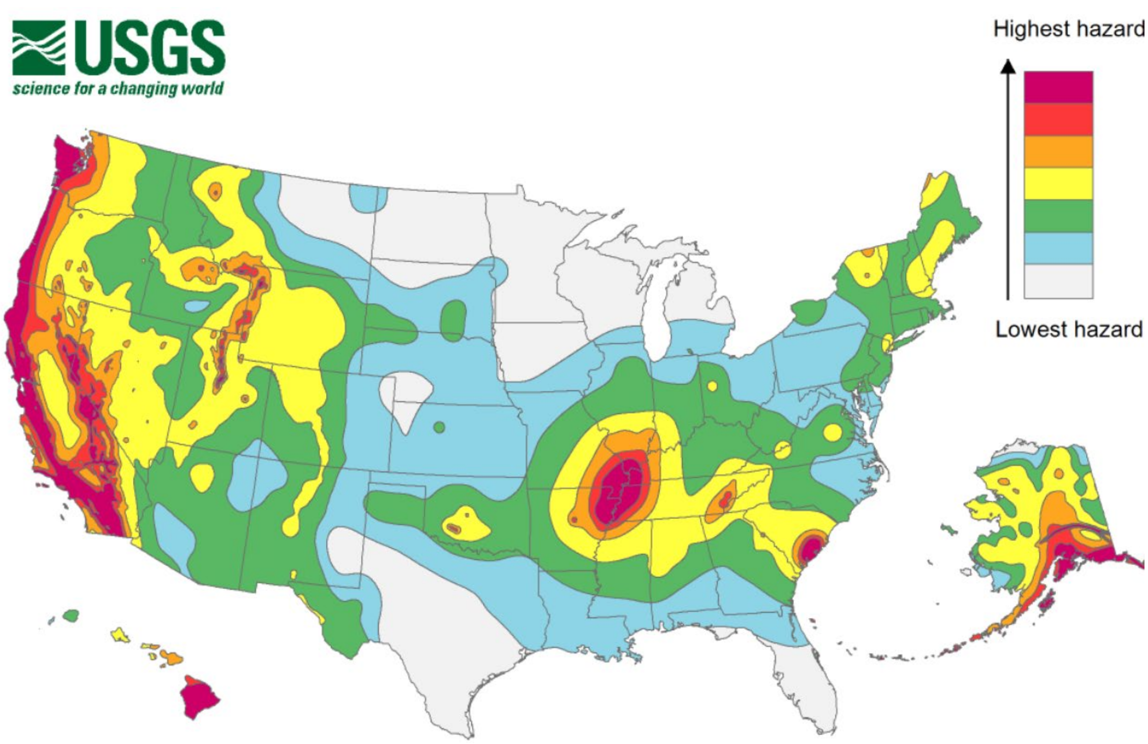
Source: DuRoss, Christopher B. *Earthquake forecast for the Wasatch Front region of the Intermountain West*. No. 2016-3019. US Geological Survey, 2016.

Considering that the average age of Utah's citizens is the youngest in the nation with a median age of 29.2 years, there is a realistic chance that many current residents of the Wasatch Front region will experience a large earthquake in their lifetimes. Preparing for earthquakes requires an awareness that even earthquakes in the M 5 range can cause significant localized damage in urbanized areas and the probability of earthquakes of this size occurring in the coming decades in Utah is very high.

To assist with assessing earthquake probability, the USGS also conducted a 2018 update of the U.S. National Seismic Hazard Model. It is crucial to emphasize that while we can provide estimated probabilities for earthquakes, we cannot predict when or where they occur. The most effective approach to earthquake preparedness is to ensure that building codes are met and comprehensive preparedness efforts are in place. According to the USGS, the model defines the potential for earthquake ground shaking for various probability levels across the 48 contiguous United States. The model, last updated in 2014, represents an assessment of the best available science in earthquake hazards and incorporates new findings on earthquake ground shaking, seismicity, and long-period amplification over deep sedimentary basins. The model is also applied in seismic provisions of building codes, insurance rate structures, risk assessments, and other public policy. Figure 4-75 below illustrates the results of the 2018 model. As shown, the Wasatch Front is part of a belt of heightened seismic risk in the intermountain west, stretching north through Wyoming, Montana, and Idaho. This region of Utah is also where more than 85% of the state population resides.

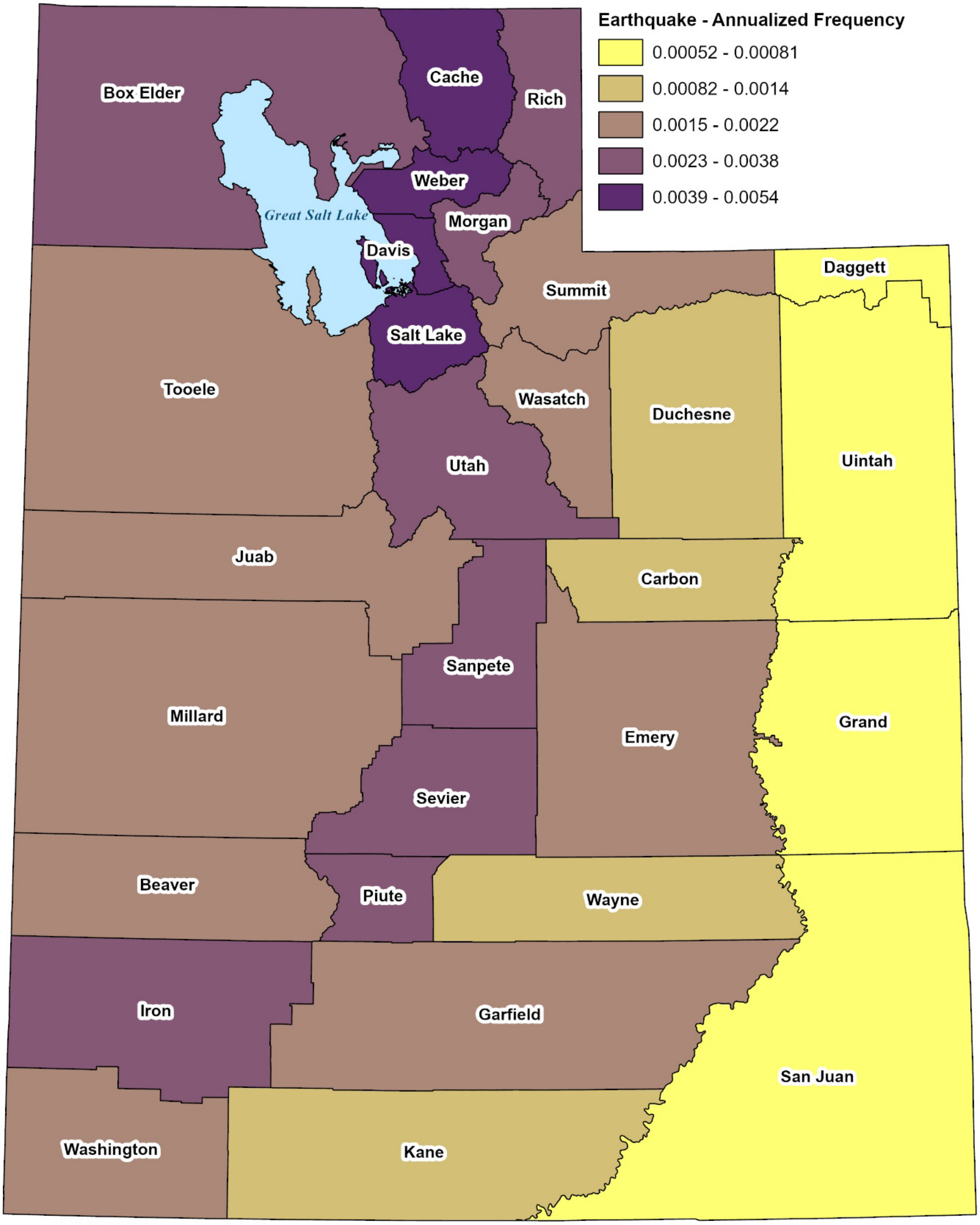
The effect of climate change on the probability of earthquake is discussed in Section 4.9.6, *Climate Change Considerations*. Discussion of the populations likely to be most severely impacted by earthquake is provided in Section 4.9.8, *Vulnerability of Jurisdictions*, specifically in the subsection titled *Population Impacts*.

Figure 4-75 USGS Long Term Probabilistic Seismic Hazard Map 2018



The FEMA National Risk Index (NRI) was used for the basis of probability of an earthquake occurrence in any one year by county. The trend shows that northern Utah Wasatch Front counties have the highest probability of a damaging earthquake.

Figure 4-76 National Risk Inventory (NRI) Annualized Frequency for Earthquake



Source: FEMA NRI November 2021

4.9.6 Climate Change Considerations

The impacts of climate change on earthquake intensity and probability are largely unknown, but there is not expected to be a correlation.

4.9.7 Vulnerability of State Assets

In the drafting of the 2023 State HMP, updated state facilities data was provided by the Utah Division of Risk Management. The data presented in this plan was compiled with the help of several state agencies and entities. An analysis of state-owned facilities was performed on potential for earthquake ground shaking and the results are discussed here.

An analysis of state-owned facilities shows that 1,640 state assets are exposed to severe/violent ground shaking potential (the highest level of risk in the state) throughout Utah, totaling approximately $10.4 billion in total value. Across all areas exposed to strong ground shaking potential or higher, this total exposed value of state assets rises to approximately $14.1 billion. The counties with the greatest concentration of at-risk assets and value are Salt Lake, Cache, Utah, and Weber Counties. This is summarized below by County in Table 4-41, Table 4-42, and Table 4-43 by risk. The analysis was also categorized by Agency and found in Table 4-44. The University of Utah has the highest dollar exposure across ground shaking hazards with 388 total facilities totaling $5.05 billion. Utah State University is the second highest with 390 facilities totaling $1.36 billion and Administrative Services - Facilities (DFCM) at a close third with 144 facilities totaling $1.33 billion. The Department of Natural Resources - Parks & Recreation Division has the greatest number assets exposed with 661, totaling $145 million.

The consequences of these losses to basic services in the aftermath of an earthquake could affect most or all state assets, potentially affecting continuity of government services. In addition, cascading failures are possible, especially from loss of generation or distribution of electrical power that could further impact ability of state government to operate. Analysis presented in Section 4.9.8 *Vulnerability of Jurisdictions* provides additional insight related to the resilience of basic services, particularly in the section titled *Community Lifelines and Infrastructure*.

Table 4-41 State Facilities at Risk to Severe/Violent Ground Shaking Hazards by County and FEMA Lifeline

COUNTY	COMMUNICATIONS	ENERGY	FOOD, WATER, SHELTER	HAZARDOUS MATERIAL	HEALTH AND MEDICAL	SAFETY AND SECURITY	TRANSPORTATION	TOTAL COUNT	TOTAL VALUE
Box Elder	-	-	-	-	-	54	-	**54**	**$59,062,450**
Cache	-	-	-	-	-	8	-	**8**	**$3,182,000**
Davis	-	-	-	-	-	62	-	**62**	**$371,445,189**
Iron	-	-	-	-	-	12	-	**12**	**$13,058,153**
Juab	-	-	-	-	-	4	-	**4**	**$1,438,000**
Salt Lake	-	3	1	-	9	950	2	**965**	**$7,687,267,140**
Utah	-	-	-	-	34	313	-	**347**	**$1,320,272,517**
Weber	1	-	-	-	1	186	-	**188**	**$949,724,175**
Total	**1**	**3**	**1**	**0**	**44**	**1,589**	**2**	**1,640**	**$10,405,449,625**

Source: Utah Division of Risk Management, Utah Geological Survey, WSP Analysis

Table 4-42 State Facilities at Risk to Very Strong/Severe Ground Shaking Hazards by County and FEMA Lifeline

COUNTY	COMMUNICATIONS	ENERGY	FOOD, WATER, SHELTER	HAZARDOUS MATERIAL	HEALTH AND MEDICAL	SAFETY AND SECURITY	TRANSPORTATION	TOTAL COUNT	TOTAL VALUE
Beaver	-	-	-	-	-	10	-	**10**	**$5,073,714**
Box Elder	1	-	-	-	-	28	-	**29**	**$8,659,740**
Cache	-	-	-	-	-	389	-	**389**	**$1,394,846,955**
Davis	-	-	-	-	-	38	-	**38**	**$5,888,042**
Emery	-	-	-	-	-	16	-	**16**	**$1,135,260**
Garfield	-	-	-	-	-	11	-	**11**	**$2,700,628**
Iron	1	-	-	-	-	159	-	**160**	**$472,544,917**
Juab	1	-	-	-	-	24	-	**25**	**$3,404,232**
Morgan	-	-	-	-	-	8	-	**8**	**$647,688**
Piute	-	-	-	-	-	16	-	**16**	**$2,719,178**
Rich	-	-	-	-	-	65	-	**65**	**$15,487,139**
Salt Lake	-	-	-	-	-	42	-	**42**	**$206,602,145**
Sanpete	-	-	-	-	-	14	-	**14**	**$6,322,000**
Sevier	1	-	-	-	-	75	-	**76**	**$149,299,993**
Tooele	-	-	-	-	-	5	-	**5**	**$17,058,384**
Utah	-	-	-	-	-	12	-	**12**	**$7,363,595**
Wasatch	-	-	-	-	-	8	-	**8**	**$744,360**
Washington	-	-	-	-	-	3	-	**3**	**$667,568**
Weber	-	-	-	-	-	16	-	**16**	**$7,633,660**
Total	**4**	**0**	**0**	**0**	**0**	**939**	**0**	**943**	**$2,308,799,198**

Source: Utah Division of Risk Management, Utah Geological Survey, WSP Analysis

Table 4-43 State Facilities at Risk to Strong/Very Strong Ground Shaking Hazards by County and FEMA Lifeline

COUNTY	COMMUNICATIONS	ENERGY	FOOD, WATER, SHELTER	HAZARDOUS MATERIAL	HEALTH AND MEDICAL	SAFETY AND SECURITY	TRANSPORTATION	TOTAL COUNT	TOTAL VALUE
Beaver	-	-	-	-	-	5	-	5	$841,908
Box Elder	-	-	-	-	-	4	-	4	$1,186,240
Carbon	-	-	-	-	-	57	-	57	$153,280,406
Daggett	1	-	-	-	-	15	-	16	$4,712,624
Duchesne	-	-	-	-	-	49	-	49	$20,065,479
Emery	-	-	-	-	-	64	-	64	$11,355,950
Garfield	-	-	-	-	-	30	-	30	$8,756,190
Grand	-	-	-	-	-	12	-	12	$3,118,440
Iron	-	-	-	-	-	8	-	8	$2,647,599
Juab	-	-	-	-	-	1	-	1	$232,000
Kane	3	-	-	-	-	48	-	51	$11,541,015
Millard	-	-	-	-	-	39	-	39	$18,765,970
Morgan	-	-	-	-	-	30	-	30	$4,052,832
San Juan	-	-	-	-	-	4	-	4	$429,138
Sanpete	-	-	-	-	-	129	-	129	$397,646,016
Summit	-	-	-	-	-	91	-	91	$30,689,796
Tooele	1	-	-	-	-	44	-	45	$48,307,954
Uintah	-	-	-	-	-	69	-	69	$126,903,944
Utah	1	-	-	-	-	16	-	17	$3,407,762
Wasatch	-	-	-	-	-	128	3	131	$56,412,924
Washington	1	-	-	-	1	129	-	131	$490,313,001
Wayne	-	-	-	-	-	27	-	27	$9,571,476
Total	7	0	0	0	1	999	3	1,010	$1,404,238,664

Source: Utah Division of Risk Management, Utah Geological Survey, WSP Analysis

Table 4-44 State Assets at Risk to Ground Shaking Hazards by Agency

	SEVERE/VIOLENT		VERY STRONG/SEVERE		STRONG/VERY STRONG	
Administrative Services - Archives	1	$14,960,000	-	-	-	-
Administrative Services - Facilities (DFCM)	107	$1,207,580,834	17	$68,058,112	20	$57,598,735
Administrative Services - Fleet	5	$54,360	-	-	-	-
Agriculture	1	$98,700	-	-	-	-

	SEVERE/VIOLENT		VERY STRONG/SEVERE		STRONG/VERY STRONG	
Alcoholic Beverage Control	2	$33,905,000	-	-	-	-
Bridgerland Technical College	-	-	4	$67,150,000	-	-
Capitol Preservation Board	10	$637,668,000	-	-	-	-
Corrections - CUCF					43	$154,886,208
Corrections - Utah State Prison	94	$293,262,220	-	-	-	-
Corrections AP & P	9	$46,775,548	-	-	-	-
Courts	1	$9,916,000	-	-	3	$342,000
Davis Technical College	5	$112,238,000	-	-	1	$553,000
Dixie State University	-	-	-	-	59	$341,568,359
Dixie Technical College	-	-	-	-	3	$49,447,316
Environmental Quality Department	9	$5,580,500	4	$212,000	11	$589,002
Health Department	2	$1,542,556	-	-	-	-
Heber Valley Railroad	-	-	-	-	3	$1,396,700
Human Services - Juvenile Justice Services	29	$123,846,415	5	$19,538,720	5	$24,359,521
Human Services - State Hospital	32	$108,807,758	-	-	-	-
Human Services Department	8	$9,098,430	2	$1,398,000	1	$647,640
Human Services Department-Developmental Center	46	$73,845,536	-	-	-	-
Mountainland Technical College	6	$42,754,791	-	-	-	-
National Guard	206	$333,146,908	34	$52,464,428	20	$23,560,225
Natural Resources - Forestry, Fire & State Lands	9	$3,964,000	4	$292,014		
Natural Resources - Parks & Recreation	115	$31,469,519	168	$34,095,409	378	$79,785,144
Natural Resources - Utah Geological Survey	1	$1,848,672	-	-	-	-
Natural Resources - Water Resources Division	-	-	-	-	1	$400,000
Natural Resources - Wildlife Resources	50	$19,360,000	75	$20,426,492	103	$33,083,786
Natural Resources Department	3	$2,050,000	1	$2,685,000	-	-
Ogden/Weber Technical College	22	$112,018,193	-	-	-	-
Public Safety Department	5	$5,280,520	-	-	4	$399,000
Salt Lake Community College	52	$509,202,228	10	$80,715,000	-	-
School For The Deaf And Blind	17	$52,427,648	-	-	-	-
Snow College	-	-	4	$76,126,000	37	$224,961,293
Southern Utah University	1	$176,256	98	$404,422,346	4	$1,271,270
Southwest Technical College	-	-	2	$30,215,362	-	-
Tooele Technical College	-	-	-	-	2	$21,302,300
Transportation (UDOT)	123	$68,722,659	158	$89,466,421	235	$80,965,243
Transportation (UDOT) - Aeronautical Operations	1	$2,253,000	-	-	-	-
Uintah Basin Technical College	-	-	-	-	7	$54,868,000

	SEVERE/VIOLENT		VERY STRONG/SEVERE		STRONG/VERY STRONG	
University Of Utah	365	$4,960,537,592	11	$81,374,476	12	$8,513,858
USU Eastern	-	-	-	-	20	$130,092,488
Utah Communications Authority	1	$112,000	4	$323,670	7	$338,432
Utah State Fairpark	43	$50,194,067	-	-	-	-
Utah State University	21	$30,950,929	342	$1,279,835,748	27	$54,085,696
Utah System Of Higher Education	1	$24,983,000	-	-	-	-
Utah Valley University	119	$749,490,424	-	-	3	$20,134,000
Veterans Affairs	12	$78,638,000	-	-	1	$39,089,448
Weber State University	106	$646,689,362	-	-	-	-
Total	**1,640**	**$10,405,449,625**	**943**	**$2,308,799,198**	**1,010**	**$1,404,238,664**

Source: Utah Division of Risk Management and WSP analysis

Table 4-45 contains a summary of information from Utah Risk Management concerning damage claims made involving state-owned assets following the Magna Earthquake. These damages alone totaled more than $39 million for 76 claims. This event served as a highlight of the potential for damaging earthquakes to affect state assets in the Salt Lake City Metropolitan Area.

No direct impacts of climate change on the vulnerability of state assets to earthquake hazards are anticipated. Any impact of climate change on the vulnerability of state assets to earthquake hazards will likely be indirect. For example, if new infrastructure such as dams, levees, or canals constructed to cope with drought hazards, that would increase the exposure of assets to earthquake hazards. As of this ESHMP update no formal study of climate change impacts on earthquake hazards has been conducted.

Table 4-45 State Asset Insured Losses in 2020 Magna Earthquake Sequence Summary

STATE AGENCY	TOTAL LOSS CLAIMS
Agriculture	$8,246
Alcoholic Beverage Services	$604,686
Department of Cultural & Community Engagement - Admin	$330,860
Facilities Construction & Management (DFCM) - Maint	$37,538,738
Natural Resources - Wildlife Resources	$133,291
Salt Lake Community College	$103,343
Southern Utah University	$0
Transportation (UDOT)	$81,285
University of Utah	$138,132
Utah Board of Higher Education	$15,456
Utah Division of Archives and Records Service	$11,840
Utah State Fairpark	$63,881
Weber State University	$45,694
Total	**$39,075,452**

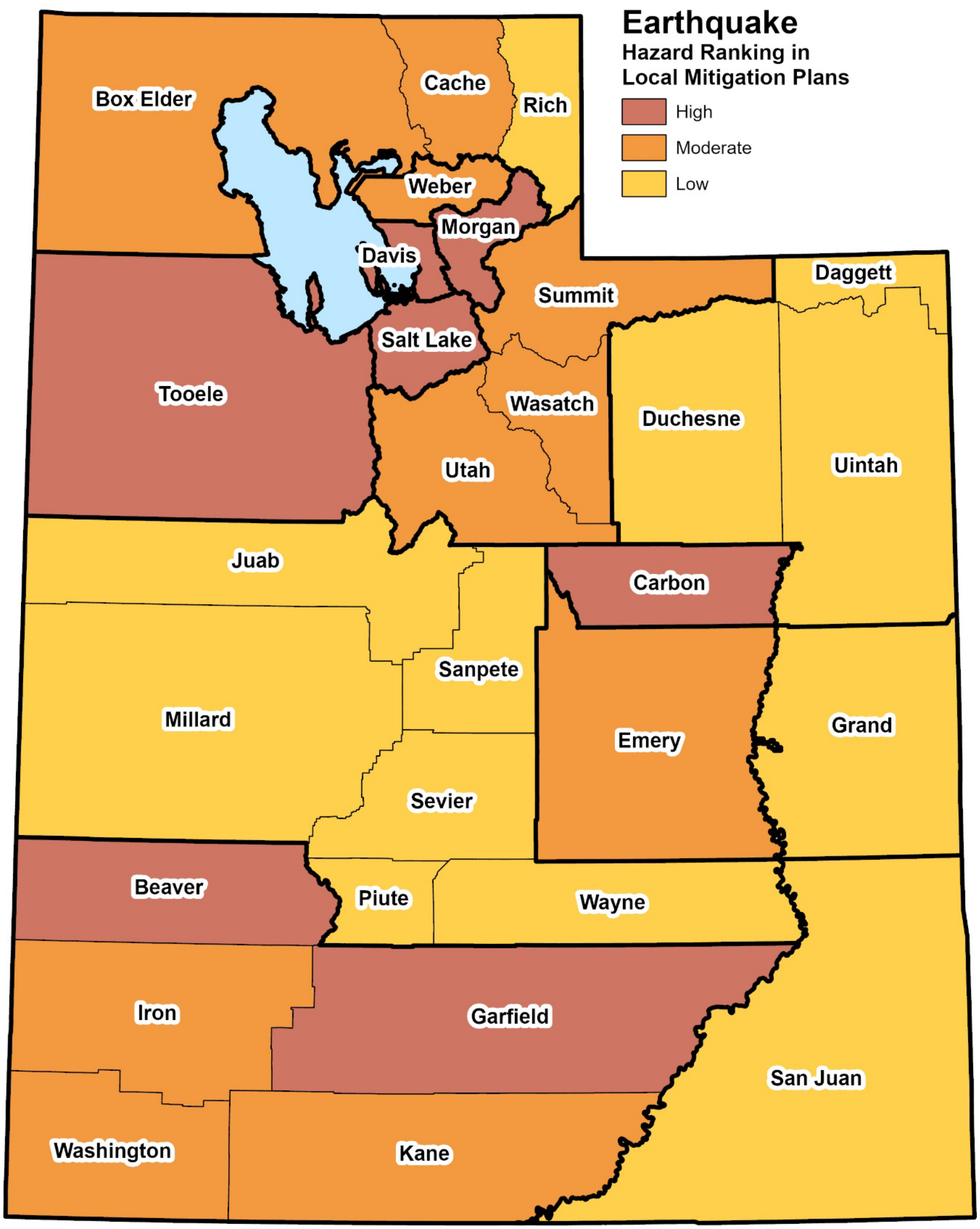
Source: Utah Division of Risk Management

4.9.8 Vulnerability of Jurisdictions

During the 2023 plan update process, a “Plan Roll Up” was conducted to evaluate all current approved county and local HMPs in the state. One of the primary topics evaluated in the plan roll up was the significance rankings of various hazards at the local level. All 29 counties in Utah identified earthquake as a hazard, the given rankings from each county are shown in Figure 4-77.

Seven (7) of Utah’s 29 counties ranked earthquake as a high significance: Beaver, Carbon, Davis, Garfield, Morgan, Salt Lake, and Tooele. Local HMPs for Utah and Cache Counties describe earthquake risk as moderate, despite these counties having the 2nd and 5th greatest economic risk, respectively, according to a Hazus analysis carried out for this 2023 HMP update (see the section titled HAZUS Earthquake Analysis, below). As shown in Figure 4-77, much of the eastern and central portions of the state view earthquake as a low significance hazard, while counties in south-western Utah and those in the Great Salt Lake Region view earthquake as moderate to high significance. This approximately aligns with available data and analysis concerning earthquake activity, probability, the presence and extent of active fault systems, ground shaking potential severity, and the potential for ground surface ruptures or liquefaction.

Figure 4-77 Earthquake Hazard Significance Rating by Local HMPs



Source: Bear River AOG 2021, Carbon 2018, Davis 2022, Emery 2018, Five County AOG 2022, Grand 2018, Mountainland AOG 2022, Morgan 2022, San Juan 2018, Six County AOG 2021, Salt Lake 2020, Tooele 2022, Uintah Basin 2019, and Weber 2016.

HAZUS Earthquake Analysis

Due to the differences in loss estimation techniques and scenarios it was determined that a roll-up of potential losses would not provide a consistent comparison of risk across the state and jurisdictions. Two Hazus earthquake loss scenarios were used instead to reflect risk in a consistent manner. One was an annualized earthquake loss analysis by FEMA-USGS and the other was a probabilistic scenario based on the 2500-year (2% probability of exceedance in 50 years) earthquake, which represents potential losses from a strong earthquake considering a variety of potential seismic sources.

In April of 2023, a joint FEMA-USGS Hazus report was released to provide a nationwide and state-by-state estimate of annualized earthquake losses (AELs) based on the latest census and building stock data, as well as USGS earthquake hazard information. An AEL analysis examines losses across the state in total expected loss per year. The analysis in this report yielded an estimate of the national AEL at $14.7 billion per year. When looking at the state level, 78% of this (or approximately $11.6 billion) is attributable to just three states: California, Washington, and Oregon. Utah falls in fourth place nationally with an AEL of $366.7 million, with much of this expected loss in the Salt Lake City metropolitan area. Utah also falls in fourth place for casualty estimates and fifth for estimated numbers of displaced households. A summary of the results by county in tabular and map form are provided below. Table 4-46 is sorted from greatest to lowest economic losses. Wasatch Front counties have the highest losses and loss ratio (ratio of total economic loss to total building exposure), and generally the highest per capita losses (ratio of loss per person). There are seven counties where HAZUS estimates more than $50 in per capita losses from earthquakes.

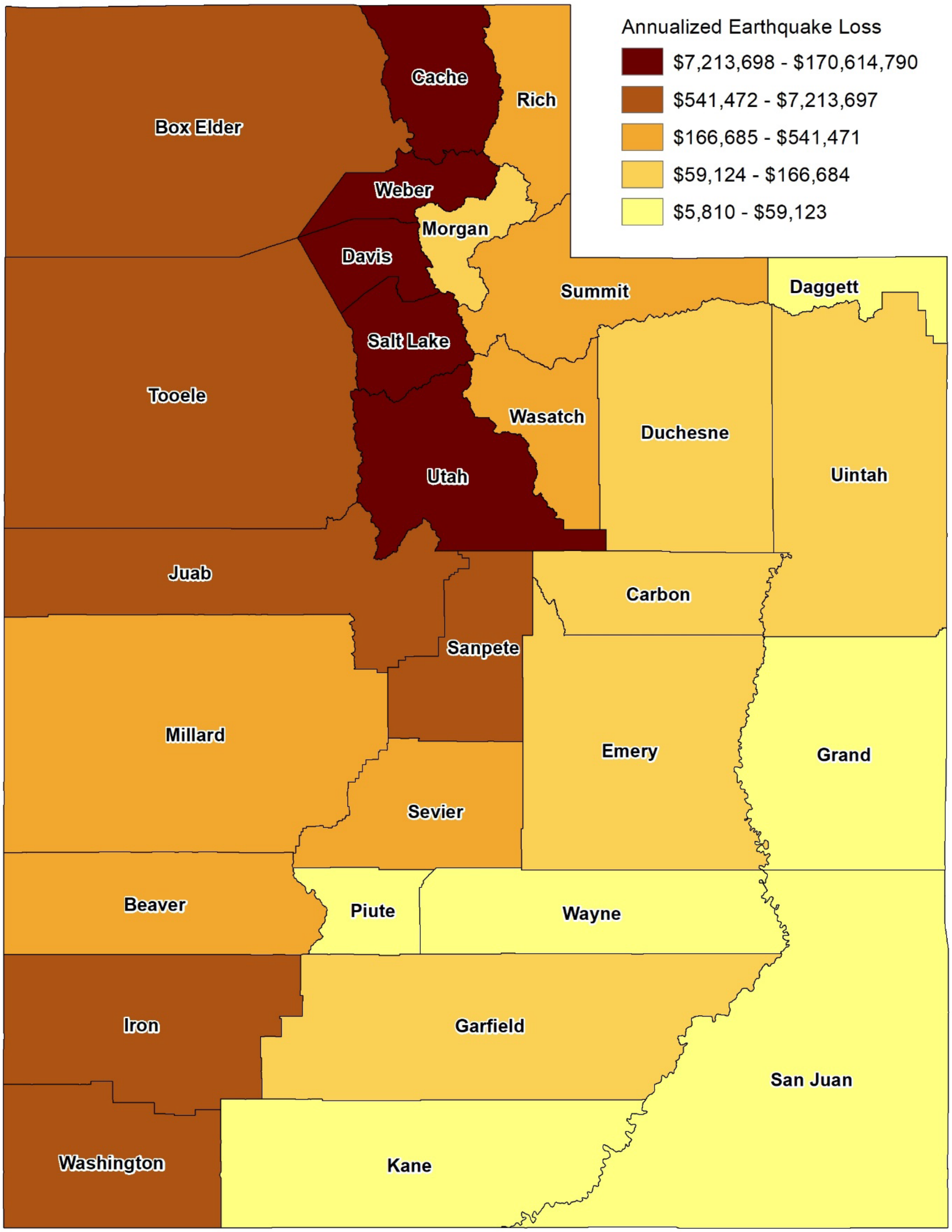
Table 4-46 Hazus Annualized Earthquake Loss (AEL) by County

NAME	ECONOMIC LOSSES	LOSS RATIO	PER CAPITA LOSS	POPULATION
Salt Lake	$170,614,790	22.84%	$144	1,185,238
Utah	$73,103,109	11.61%	$111	659,399
Davis	$44,260,420	5.57%	$122	362,679
Weber	$42,732,971	5.41%	$163	262,223
Cache	$15,710,692	2.19%	$118	133,154
Box Elder	$7,213,697	0.94%	$125	57,666
Iron	$3,086,391	0.29%	$54	57,289
Tooele	$3,009,592	0.55%	$41	72,698
Washington	$1,702,509	0.18%	$9	180,279
Juab	$1,329,953	0.13%	$113	11,786
Sanpete	$691,533	0.11%	$24	28,437
Sevier	$541,471	0.06%	$25	21,522
Millard	$481,330	0.04%	$37	12,975
Summit	$441,934	0.05%	$10	42,357
Wasatch	$435,349	0.09%	$13	34,788
Beaver	$241,181	0.03%	$34	7,072
Rich	$193,613	0.01%	$77	2,510
Duchesne	$166,684	0.01%	$9	19,596
Garfield	$148,098	0.01%	$29	5,083
Uintah	$130,357	0.02%	$4	35,620

NAME	ECONOMIC LOSSES	LOSS RATIO	PER CAPITA LOSS	POPULATION
Carbon	$127,035	0.02%	$6	20,412
Emery	$99,818	0.01%	$10	9,825
Morgan	$77,408	0.02%	$6	12,295
Piute	$59,123	0.01%	$41	1,438
Kane	$56,233	0.004%	$7	7,667
Wayne	$25,621	0.00%	$10	2,486
San Juan	$17,121	0.00%	$1	14,518
Grand	$9,951	0.00%	$1	9,669
Daggett	$5,810	0.00%	$6	935
Total	**$366,713,792**			**3,271,616**

Source: Hazus 6.0 Estimated Annualized Earthquake Losses for the United States FEMA P-366

Figure 4-78 Hazus Estimated Earthquake Annualized Loss by County



Source: FEMA P-366 / April 2023, Hazus 6.0

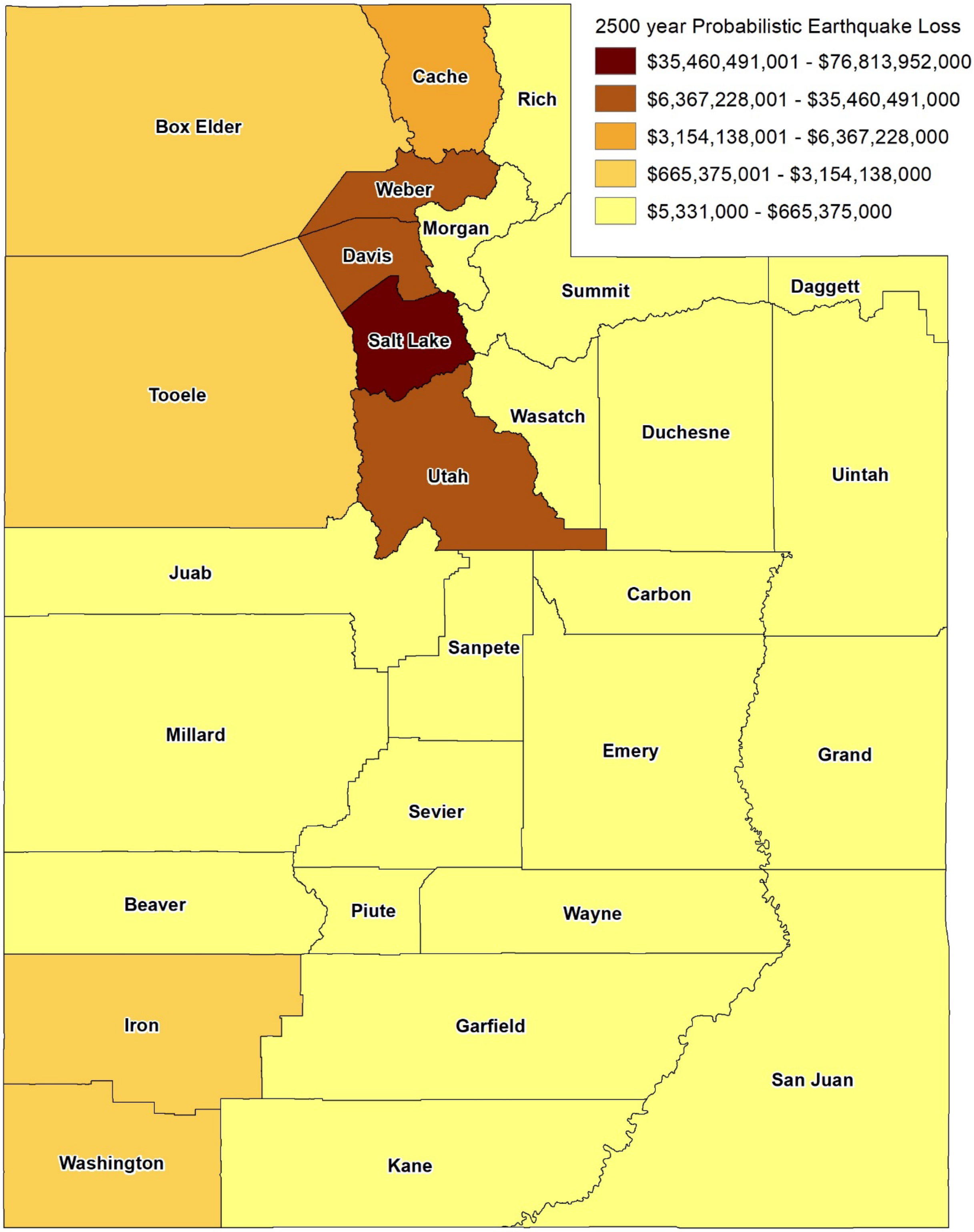
While annualized losses present one method of comparison of earthquake losses over time, the 2500-year (2% probability of exceedance in 50 years) yields loss results that are more typical of a large earthquake. The results are summarized for the entire state and shown by county in the following tables. Similar to the annualized results, the losses are greatest for Wasatch Front counties as seen in Table 4-47 and Figure 4-79.

Table 4-47 Hazus Earthquake Probabilistic 2500-year Scenario Losses

NAME	ECONOMIC LOSSES	LOSS RATIO	PER CAPITA LOSS	POPULATION
Salt Lake	$76,813,952,000	27.31%	$64,809	1,185,238
Utah	$35,460,491,000	23.75%	$53,777	659,399
Davis	$19,551,021,000	24.70%	$53,907	362,679
Weber	$19,097,866,000	26.81%	$72,831	262,223
Cache	$6,367,228,000	21.25%	$47,819	133,154
Box Elder	$3,154,138,000	18.95%	$54,697	57,666
Iron	$1,803,221,000	7.85%	$31,476	57,289
Tooele	$1,441,708,000	8.53%	$19,831	72,698
Washington	$1,274,366,000	2.49%	$7,069	180,279
Juab	$665,375,000	20.11%	$56,455	11,786
Sanpete	$365,233,000	4.56%	$12,844	28,437
Sevier	$294,232,000	3.85%	$13,671	21,522
Millard	$283,533,000	1.51%	$21,852	12,975
Summit	$259,359,000	3.73%	$6,123	42,357
Wasatch	$242,058,000	2.65%	$6,958	34,788
Beaver	$133,100,000	4.95%	$18,821	7,072
Rich	$108,727,000	1.28%	$43,318	2,510
Duchesne	$105,089,000	4.85%	$5,363	19,596
Garfield	$97,418,000	2.09%	$19,165	5,083
Uintah	$91,336,000	1.06%	$2,564	35,620
Carbon	$85,367,000	1.61%	$4,182	20,412
Emery	$74,821,000	1.75%	$7,615	9,825
Morgan	$48,518,000	2.09%	$3,946	12,295
Piute	$46,598,000	0.86%	$32,405	1,438
Kane	$33,930,000	4.140%	$4,425	7,667
Wayne	$19,794,000	0.97%	$7,962	2,486
San Juan	$18,831,000	0.23%	$1,297	14,518
Grand	$10,044,000	0.26%	$1,039	9,669
Daggett	$5,331,000	0.69%	$5,702	935
Total	**$167,952,685,000**			**3,271,616**

Source: Hazus 6.0

Figure 4-79 Hazus 2500 Year Probabilistic Earthquake Loss



Source: Hazus 6.0

Population Impacts

The impact of earthquake hazards on people is severe, particularly where structures collapse. Deaths and injuries are commonly widespread, as is the loss of dwellings. As mentioned above, according to the joint FEMA-USGS Hazus report, Utah falls in fourth place nationally when it comes to casualty estimates and fifth for estimated numbers of displaced households. A large Wasatch Front earthquake is capable of creating severe impacts to the Salt Lake City Metropolitan Area. Damage to roads and bridges can compromise transportation services. Buried utility lines, such as for electricity, communications, water supply, wastewater, and stormwater services can also be damaged and cause further disruption.

Earthquake impacts are not experienced the same by all people in Utah. Vulnerable populations will experience impacts more severely (see Section 3.5.1). People in counties with high earthquake hazards based on annualized losses (Figure 4-78) and high social vulnerability (Figure 3-6 and Figure 3-7) may have more challenges affording retrofits to housing or recovering finically from events. Specific populations at risk include school-aged children that attend schools constructed of unreinforced masonry.

Generally, there is not much overlap with the most socially vulnerable counties with the most highly exposed counties with exceptions somewhat in Washington, Iron, and Weber counties.

Community Lifelines and Infrastructure

Seismic activity in Utah has the potential for significant impacts to community lifelines and infrastructure. At the time of this plan update, the Utah Seismic Safety Commission (USSC) had just released their Legislative Recommendations for 2024 Report. According to the report, without proactive measures, an expected magnitude (M) 7.0 earthquake on the Salt Lake City segment of the Wasatch fault could result in $75 billion in infrastructure damage and short-term economic losses. Some specific impacts identified in the report which are considered perhaps the most vulnerable infrastructure categories include water and sewer infrastructure and Unreinforced Masonry Buildings (URMs). One modeling scenario indicated that around 330,000 homes, or approximately 1 million people, will be left without water three months after a major Wasatch Fault event. Water is a critical aspect of other infrastructure and services, including power, medical care, and fire response. Without water many other systems and infrastructure will remain offline or be unable to function at full capacity, resulting in cascading impacts following a major event.

Another major vulnerability is Unreinforced Masonry Buildings (URMs) throughout the state. The report states that, while URM construction has not been allowed since 1976, there are an estimated 140,000 URMs still existing statewide, including homes, offices, and 130 school campuses where an estimated 72,000 Utah children spend time during school hours. Retrofitting these school campuses would not only reduce the number of casualties and injuries during a major earthquake, but it would also ensure that school facilities could function as emergency shelters and gathering places during and after an earthquake. Other vulnerabilities to Community Lifelines and Infrastructure include transportation, specifically road and rail, as well as physical damage to energy distribution lines, and health, medical, and emergency response facilities.

4.9.9 Changes in Development

Population growth in Utah (Figure 3-5) is expected to be greatest in some of the same counties that experience the greatest annualized earthquake hazards (Figure 4-78). This is especially true of Utah and Salt Lake Counties and in Davis, Weber, and Cache Counties to a somewhat lesser degree. An analysis of development trends in LHMPs (see Section 3.7 Development Trends and Table 3-3 specifically) did yield several concerns with earthquakes, notably in the Wasatch Front including Weber County. The southwestern counties of Beaver, Garfield, Iron, Kane, and Washington also noted expanding development potentially raising vulnerability to earthquakes.

New construction and building in these counties further increase the built environment and property value exposed to seismic hazards. The situation is mitigated to some degree by the statewide adoption of the 2021 International Building Code (IBC) and International Residential Code (IRC) to protect structures against ground shaking. New construction should be less vulnerable to damage from earthquake hazards.

Additionally, the Utah Seismic Safety Commission (USSC) released a second edition of *Putting Down Roots in Earthquake Country: Your Handbook for Earthquakes in Utah* in 2022. This guide will help current and future residents of Utah better understand and prepare for the threat of earthquakes in the state. The guide details how buildings respond to earthquakes, the dangers and vulnerabilities of unreinforced masonry buildings, and the Seven Steps to Earthquake Safety. Utah has taken steps to address seismic vulnerability of unreinforced masonry buildings. Measures to protect and retrofit these building will typically include building codes and regulations, seismic assessments, retrofitting programs, and public awareness. This information is timely, given that the demographic trends in Chapter 3 indicate that the highest projected population growth counties (Utah, Salt Lake, Davis and Washington) coincide with the highest earthquake risk. This growth is leading towards more population exposed to earthquakes, and the potential for many newcomers to Utah that may not be aware of the seismic risk.