Basic Seismological Characterization for Sweetwater County, Wyoming

by

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BACKGROUND

Seismological characterizations of an area can range from an analysis of historic seismicity to a long-term probabilistic seismic hazard assessment. A complete characterization usually includes a summary of historic seismicity, an analysis of the Seismic Zone Map of the Uniform Building Code, deterministic analyses on active faults, "floating earthquake" analyses, and short- or long-term probabilistic seismic hazard analyses.

Presented below, for Sweetwater County, Wyoming, are an analysis of historic seismicity, an analysis of the Uniform Building Code, deterministic analyses of nearby active faults, an analysis of the maximum credible "floating earthquake", and current short- and long-term probabilistic seismic hazard analyses.

Historic Seismicity in Sweetwater County

The enclosed map of "Earthquake Epicenters and Suspected Active Faults with Surficial Expression in Wyoming" (Case and others, 1997) shows the historic distribution of earthquakes in Wyoming. Thirty magnitude 2.0 and greater earthquakes have been recorded in Sweetwater County, exclusive of the trona mine region west of Green River. Trona mine region earthquakes are discussed in a subsequent section.

The first earthquake that was felt and reported in Sweetwater County occurred on April 28, 1888. This intensity IV earthquake, which originated near Rock Springs, did not cause any appreciable damage (Case, 1993).

On July 25, 1910, an intensity V earthquake occurred at the same time that the Union Pacific No. 1 mine in Rock Springs partially collapsed (Cheyenne State Leader, July 26, 1910). It is not known if the mine collapse generated the earthquake or if an earthquake with a tectonic source caused the mine to collapse.

On July 28, 1930, an intensity IV earthquake, with an epicenter near Rock Springs, was felt in Rock Springs and Reliance (Casper Daily Tribune, July 28, 1930). The earthquake awakened many residents, and merchandise on store shelves was disrupted. A portion of a coal mine near Reliance caved in during the disturbance. Whether the earthquake was due to the cave-in or to movement on a fault is not known.

Five earthquakes occurred in Sweetwater County during the 1940s. On March 21, 1942, a non-damaging, intensity III earthquake was felt in the Rock Springs area (Reagor, Stover, and Algermissen, 1985). This event was followed on September 14, 1946, by an intensity IV earthquake. Again, no damage was reported (Reagor, Stover, and Algermissen, 1985). On October 25, 1947, a small earthquake with no assigned intensity or magnitude occurred southeast of Rock Springs (U.S. Geological Survey, 1994). Two intensity IV earthquakes occurred in the Rock Springs area on September 24, 1948. The events rattled dishes in parts of Rock Springs. Local residents thought that a mine cave-in might have caused the earthquake (Casper Tribune-Herald, September 27, 1948).

Only one earthquake was reported in Sweetwater County in the 1950's. On February 21, 1951, the U.S.G.S. National Earthquake Information Center reported that an intensity III earthquake occurred in Sublette County. A check of the original reference and description of this event, however, suggests a location error, as only three people in Rock Springs felt the earthquake (Murphy and Cloud, 1951). The epicenter of this earthquake will therefore be tentatively located in northwestern Sweetwater County, approximately 28 miles north-northwest of Granger. No damage was reported. The second earthquake occurred on October 3, 1956, in far western Sweetwater County, approximately 7 miles southwest of Little America. The earthquake was felt as an intensity IV event in Opal, where windows, doors, and dishes rattled and walls creaked. Loud "earth noises" from the west were heard one second before the shock (Brazee and Cloud, 1958).

Five earthquakes occurred in Sweetwater County in the 1960's. On October 14, 1963, a magnitude 4.5 earthquake was recorded in northeastern Sweetwater County, approximately 30 miles southeast of Atlantic City. No damage was reported (Reagor, Stover, and Algermissen, 1985). A magnitude 3.9 event was recorded on January 5, 1964, approximately 23 miles south of Rock Springs (Reagor, Stover, and Algermissen, 1985). No damage was reported. On September 10, 1964, a magnitude 4.1 earthquake occurred in eastern Sweetwater County, approximately thirty miles west of Rawlins. One Rawlins resident reported that the earthquake caused a crack in the basement of his home in Happy Hollow. No other damage was reported (The Daily Times, September 11, 1964). On November 24, 1966, a small earthquake with no assigned intensity or magnitude occurred a few miles north of Wamsutter (Reagor, Stover, and Algermissen, 1985). The University of Utah Seismograph Stations detected a non-damaging, magnitude 2.4 earthquake on March 19, 1968. This event was centered approximately 17 miles southeast of Rock Springs (U.S. Geological Survey, 1994).

Four earthquakes occurred in Sweetwater County in the 1970's. On August 18, 1971, the University of Utah Seismograph Stations detected a non-damaging magnitude 2.2 earthquake approximately 26 miles south-southeast of Green River (U.S. Geological Survey, 1994). A magnitude 3.2 event occurred on May 29, 1975, approximately 13 miles northeast of Superior. A week later, on June 6, 1975, a magnitude 3.7 earthquake was recorded in the same area. No damage was associated with either of the 1975 events (Coffman and Stover, 1977). On September 10, 1977, the University of Utah Seismograph Stations recorded a non-damaging magnitude 2.2 earthquake approximately 8 miles north of Burntfork.

A number of earthquakes occurred in Sweetwater County in the 1980's. Three magnitude 3.2 earthquakes were recorded in 1984. The first occurred on March 1, 1984, approximately 14 miles southeast of Point of Rocks; the second occurred on September 14, 1984, approximately 13 miles east-southeast of Point of Rocks; and the third, which may have been an explosion, occurred on November 27, 1984, approximately 8 miles southeast of Point of Rocks (Stover, 1988; U.S. Geological Survey, 1994). A magnitude 3.5, intensity IV earthquake was recorded on August 13, 1985, approximately 12 miles northeast of Point of Rocks (U.S. Geological Survey, 1994). Although the earthquake was felt at Point of Rocks, no significant damage was reported. Five earthquakes occurred in Sweetwater County in 1986. On April 29, 1986, a non-damaging magnitude 2.5 earthquake occurred northeast of Pine Mountain in south-central Sweetwater County (Stover and Brewer, 1994). The University of Utah Seismograph Stations recorded a non-damaging magnitude 2.7 earthquake on June 5, 1986. This event was located approximately 14 miles southwest of Green River (Stover and Brewer, 1994; U.S. Geological Survey, 1994). On November 2, 1986, a magnitude 3.3, intensity IV earthquake occurred approximately 11 miles north-northeast of Superior (Stover and Brewer, 1994). No significant damage was reported. Two non-damaging magnitude 2.9 earthquakes occurred on December 4, 1986, approximately 14 and 19 miles northwest of Farson (Stover and Brewer, 1994).

One earthquake was recorded in Sweetwater County in the 1990's. On February 1, 1992, the University of Utah Seismograph Stations recorded a non-damaging magnitude 2.3 earthquake, approximately 7 miles north of Rock Springs.

In 2000, two earthquakes occurred in northeastern Sweetwater County near the town of Bairoil. A magnitude 4.00 event was recorded on May 26, 2000, and a magnitude 3.2 event was recorded four days later on May 30, 2000. People reported feeling both earthquakes (U.S.G.S. National Earthquake Information Center).

Seismic Activity near Sweetwater County Trona Mines

Sweetwater County has several large trona mines west of Green River. Roof falls, pillar failures, and collapses in these underground mines have caused several earthquakes in this region, and are suspected of causing others. Because of poor documentation and poor location accuracy, the seismic origin of some earthquakes in the region cannot be directly related to specific mine activity. All fifteen earthquakes that have been recorded in this area are discussed below.

On March 19, 1985, a magnitude 2.9, intensity IV earthquake occurred approximately 9 miles northwest of Green River (U.S. Geological Survey, 1994). No damage was reported. Since the event occurred in the near-vicinity of mining operations, it is uncertain if it was related to tectonic or mine-related activities.

The University of Utah Seismograph Stations detected a magnitude 3.7 earthquake on June 25, 1994. This earthquake was centered approximately 12 miles west northwest of Green River. No significant damage was reported. This event was attributed to a partial collapse of the General Chemical mine.

On February 3, 1995, one of the largest historic earthquakes in southwestern Wyoming occurred near Little America, Wyoming. A magnitude 5.3, intensity V earthquake was associated with the collapse of a 3,000-foot wide by 7,000-foot long portion of a trona mine operated by the Solvay Minerals, Inc. One miner lost his life as a result of the collapse. Minor damage was reported at a school administration building in Green River and at a motel near Little America. The earthquake was felt in Rock Springs and in Salt Lake City. An indisputable triggering mechanism for the collapse has not been determined, although the U.S. Mine Safety and Health Administration (1996) feels that the most likely failure trigger was "the degradation of the strength of the pillar-floor system over a long period of time".

A magnitude 2.1 earthquake was recorded approximately 13.5 miles northeast of Granger on May 17, 1997 (U.S.G.S. National Earthquake Information Center). It is unclear whether this event was related to tectonic or mine-related activity.

Two earthquakes occurred in the area in 1998. The University of Utah Seismograph Stations recorded a magnitude 2.86 earthquake on January 13, 1998. This tectonic event was centered approximately 8 miles northwest of Granger. On November 10, 1998, a magnitude 2.9 earthquake was recorded approximately 7-8 miles northeast of Granger. No one reported feeling this event (U.S.G.S. National Earthquake Information Center). The origin of the November 10, 1998, earthquake is unknown.

Only one mine-related earthquake occurred in 1999. This magnitude 2.3 earthquake was recorded on November 23, 1999, approximately 5 miles southeast of Granger. It is possible that a poorly documented collapse in 1999 at the General Chemical mine could have caused this event.

On January 30, 2000, the University of Utah Seismograph Stations recorded a magnitude 4.4 earthquake approximately 20 miles west of Green River. This event was felt at Little America. A mine roof collapse at the Solvay mine was found to be the cause of this earthquake.

On July 16, 2000, the U.S.G.S. recorded an earthquake northeast of Granger. The University of Utah reported two earthquakes in this area on July 16, 2000. These events all have conflicting locations and magnitudes. The U.S.G.S. reported that a magnitude 2.7 earthquake occurred approximately 7 miles northeast of Granger, while the University of Utah described magnitude 3.0 and magnitude 1.9 earthquakes approximately 8 miles east-northeast of Granger. Both events in this area are suspected of being mine-related.

These two agencies also reported conflicting magnitudes and locations for an August 17, 2000 earthquake near the Sweetwater County trona mines. The U.S.G.S. recorded a magnitude 3.0

earthquake approximately 11 miles northwest of Green River. On the same day, the University of Utah detected a 3.1 event approximately 20 miles northwest of Green River. A mine-related origin is probable for this earthquake.

On August 24, 2000, the University of Utah recorded an earthquake approximately 21 miles west-northwest of Green River. This magnitude 1.9 event is also suspected of being mine-related.

The University of Utah recorded a magnitude 2.1 earthquake on September 14, 2000. This event, located approximately 12 miles east-northeast of Granger, is suspected of originating from mine-related activity.

Most recently, two earthquakes occurred in the trona mine area in 2001. The University of Utah detected a magnitude 2.46 earthquake on June 2, 2001, approximately 7 miles southwest of Granger. On June 18, 2001, the U.S.G.S. recorded a magnitude 2.6 earthquake centered 10 miles northeast of Granger. The origin of both of these events is unknown.

Regional Historic Seismicity

On April 5, 1999, a magnitude 4.3 earthquake occurred in southwestern Carbon County, approximately 20 miles southeast of Wamsutter. The event was felt in Rawlins, Sinclair, Baggs, Wamsutter, and Rock Springs. Residents of Rawlins reported that pictures fell off walls. The most significant damage occurred between Baggs and Creston Junction, and at Wamsutter. The owner of a ranch house, located approximately 30 miles north of Baggs, reported that cinder block walls in the basement of the home cracked, separated, and may have to be replaced. A motel and associated residence in Wamsutter also suffered cracks in the cinder-block walls of the basement.

Uniform Building Code

The Uniform Building Code (UBC) is a document prepared by the International Conference of Building Officials. Its stated intent is to "provide minimum standards to safeguard life or limb, health, property, and public welfare by regulating and controlling the design, construction, quality of materials, use and occupancy, location and maintenance of all buildings and structures within this jurisdiction and certain equipment specifically regulated herein."

The UBC contains information and guidance on designing buildings and structures to withstand seismic events. With safety in mind, the UBC provides Seismic Zone Maps to help identify which design factors are critical to specific areas of the country. In addition, depending upon the type of building, there is also an "importance factor". The "importance factor" can, in effect, raise the standards that are applied to a building.

The current UBC Seismic Zone Map (Figure 1) (1997) has five seismic zones, ranging from Zone 0 to Zone 4, as can be seen on the enclosed map. The seismic zones are in part defined by the probability of having a certain level of ground shaking (horizontal acceleration) in 50 years. The criteria used for defining boundaries on the Seismic Zone Map were established by the

Seismology Committee of the Structural Engineers Association of California (Building Standards, September-October, 1986). The criteria they developed are as follows:

Zone	Effective Peak Acceleration, % gravity (g)
4	30% and greater
3	20% to less than 30%
2	10% to less than 20%
1	5% to less than 10%
0	less than 5%

The committee assumed that there was a 90% probability that the above values would not be exceeded in 50 years, or a 100% probability that the values would be exceeded in 475 to 500 years.

Sweetwater County is primarily in Seismic Zone 1 of the UBC, although the far western and northwestern portions of the county are in Seismic Zone 2. Since effective peak accelerations (90% chance of non-exceedance in 50 years) can range from 5%g-20%g in these two zones, and there has been some significant historic seismicity in the county, it may be reasonable to assume that an average peak acceleration of 10.0%g could be applied to the design of a non-critical facility located in the county if only the UBC were used. Such acceleration, however, is significantly less than would be suggested through newer building codes.

Recently, the UBC has been replaced by the International Building Code (IBC). The IBC is based upon probabilistic analyses, which are described in a following section. Sweetwater County, the towns and cities of Sweetwater County, and the Wyoming State Fire Marshall's Office are in the process of adopting the IBC and the International Fire Code (IFC).

Deterministic Analysis of Regional Active Faults with a Surficial Expression

Sweetwater County has an active fault system called the Chicken Springs fault system that should be included in a deterministic analysis. The Chicken Springs fault system is composed of a series of east-west trending segments in the northeastern corner of Sweetwater County. In 1996, the Wyoming State Geological Survey investigated the Chicken Springs fault system for the U.S. Nuclear Regulatory Commission and the Kennecott Uranium Company. The most recent activation on the system appears to be Holocene in age. Reconnaissance-level studies indicated that the fault system is capable of generating a magnitude 6.5 earthquake (Shepherd Miller, 1996). A magnitude 6.5 earthquake on the Chicken Springs fault system would generate peak horizontal accelerations of approximately 4%g at Wamsutter and approximately 4.8%g at Rawlins (Campbell, 1987). These accelerations would be roughly equivalent to an intensity V

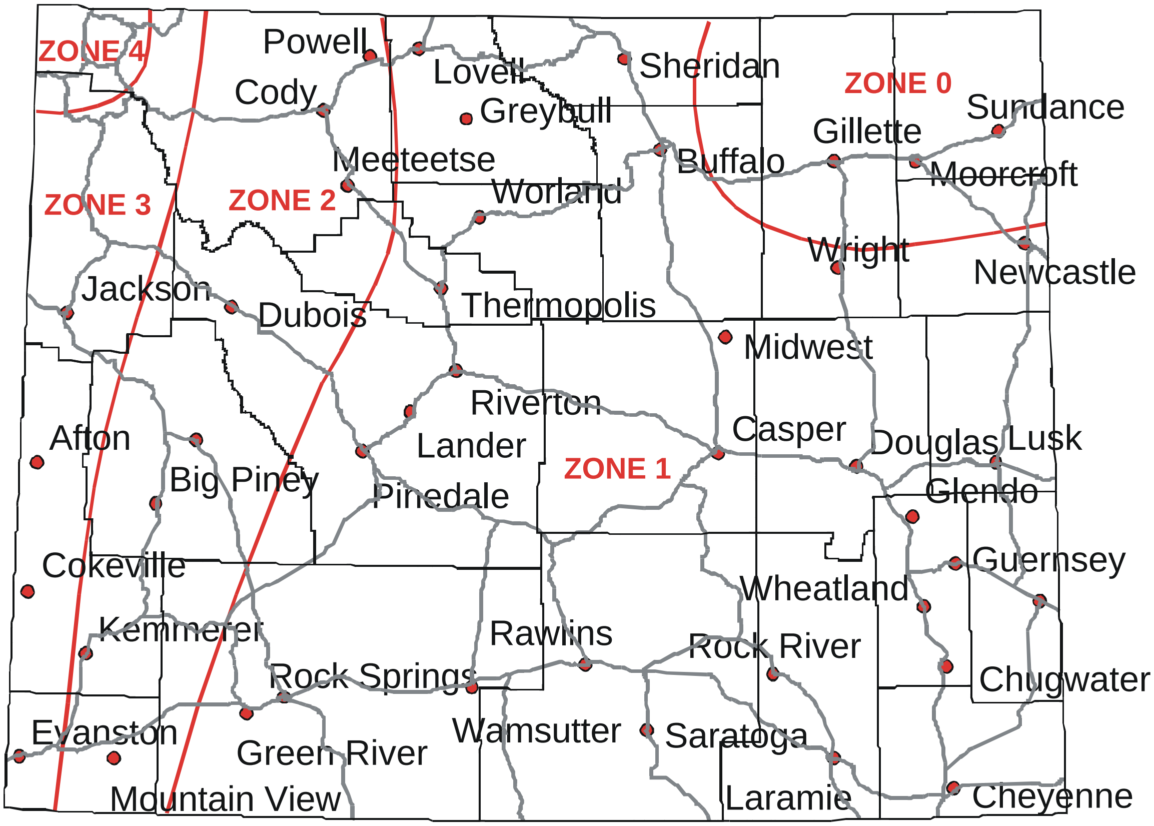

Figure 1. UBC Seismic Zone Map.

earthquake, which may cause some light damage. Bairoil, however, would be subjected to a peak horizontal acceleration of approximately 23%g, or an intensity VII earthquake (Campbell, 1987). Intensity VII events have the potential to cause moderate damage. The rest of the towns in Sweetwater County would be subjected to ground accelerations of less than 1.5%g, which should not cause any damage.

Several other active fault systems exist in southwestern Wyoming. If these fault systems activate, Sweetwater County could be affected. These include the South Granite Mountain, Bear River, Rock Creek, and Grey's River fault systems.

The South Granite Mountain fault system is composed of several northwest-southeast trending fault segments in southeastern Fremont County and northwestern Carbon County. Geomatrix (1988b) divided the South Granite Mountain fault system into five segments. The segments, from east to west, are the Seminoe Mountains segment, the Ferris Mountains segment, the Muddy Gap segment, the Green Mountain segment, and the Crooks Mountain segment. Geomatrix (1988b) discovered evidence of late-Quaternary faulting on the Ferris Mountains and Green Mountain segments of the fault system. They concluded that the Ferris Mountains segment was capable of generating a maximum credible earthquake of magnitude 6.5 – 6.75 with a recurrence interval of 5,000 to 13,000 years. They also concluded that the Green Mountain segment was capable of generating a maximum credible earthquake of magnitude 6.75 with a recurrence interval of 2,000 to 6,000 years (1988b). Geomatrix (1988b) did not find evidence of late-Quaternary movement on the Seminoe Mountains, Muddy Gap, and Crooks Mountain fault segments. These segments, however, may be extensions of the known active faults in the South Granite Mountain fault system. These segments should therefore be considered to be potentially active. Geomatrix (1988b) estimated the length of the Seminoe Mountains segment to be 22.5 miles (36 km). Such a fault length would result in a magnitude 6.85 earthquake if the entire length ruptured (Wells and Coppersmith, 1994). The length of the Crooks Gap fault segment was estimated to be 21.25 miles (34 km) (Geomatrix, 1988b). This fault length could generate a magnitude 6.86 earthquake if the entire length ruptured (Wells and Coppersmith, 1994). The Muddy Gap fault system is approximately 14.4 miles (23 km) in length (Geomatrix, 1988b). If the entire fault ruptured, a magnitude 6.66 earthquake could be generated (Wells and Coppersmith, 1994).

There are two approaches to doing a deterministic analysis on a segmented fault system such as the South Granite Mountain fault system. The first approach involves finding the shortest distance from the area of interest to a specific fault segment. A deterministic analysis is then applied to each individual fault segment. The second approach involves measuring the distance from the area of interest to the closest point on the fault system as a whole. An average magnitude is then used for activation anywhere along the entire fault. For the purposes of this report, the second, more conservative approach will be used. Because the active segments of the South Granite Mountain fault system have been assigned a maximum magnitude of 6.75, it may be reasonable to assume that a magnitude 6.75 earthquake could be generated anywhere along the length of the fault system. A magnitude 6.75 earthquake could generate peak horizontal accelerations of approximately 20%g at Bairoil, 6.1%g at Rawlins, 2.5%g at Wamsutter, and 1.9%g at Superior (Campbell, 1987). These accelerations would be roughly equivalent to an intensity VII earthquake at Bairoil, an intensity V earthquake at Rawlins, and intensity IV earthquakes at Wamsutter and Superior. Bairoil could sustain moderate damage, whereas minor or no damage could occur at Rawlins, Wamsutter, and Superior.

The Bear River fault system is composed of a series of short, north-trending faults and associated scarps in southwestern Uinta County. West (1989) found evidence of Quaternary-age movement on this fault system with a minimum recurrence interval of 1800 years. Over 2320 years have elapsed since the last event. West (1994) suggests that the Bear River fault could generate a maximum magnitude 7.5 earthquake. A magnitude 7.5 event could generate peak horizontal accelerations of approximately 4.7%g at Granger, approximately 2.6%g at Green River, and approximately 1.9%g at Rock Springs (Campbell, 1987). These accelerations are roughly equivalent to an intensity V earthquake at Granger and intensity IV earthquakes in Green River and Rock Springs. Granger may sustain some minor damage, but no damage should occur at Green River and Rock Springs. The rest of Sweetwater County would be subjected to ground accelerations of less than 1.5%g, which should not cause any damage.

Two active fault systems are present near Sweetwater County in western Lincoln County. The Rock Creek fault system is a north-south-trending normal fault located approximately 15 miles west of Kemmerer, Wyoming, near Fossil Butte National Monument. McCalpin and Warren (1992) found evidence of late-Quaternary movement on this system. Based upon a surface rupture length of 24 miles (38 km) and Quaternary displacement amounts, Chambers (1988) estimates that the Rock Creek fault is capable of generating a magnitude 6.9 to 7.2 earthquake. A maximum magnitude 7.2 earthquake could generate peak horizontal accelerations of approximately 4.1%g at Granger (Campbell, 1987). This acceleration is roughly equivalent to an intensity IV earthquake, which should cause no damage. The rest of Sweetwater County would be subjected to ground accelerations of less than 1.5%g, which should not cause any damage.

The other active fault system in Lincoln County is the Grey's River fault system, located on the western side of the Wyoming Range. Evidence of late-Holocene movement has also been identified on this north-south-trending normal fault (Jones and McCalpin, 1992; McCalpin, 1993). Based upon an estimated surface rupture length of 54 km, Jones (1995) suggests that the Grey's River fault system could potentially generate a magnitude 7.1 earthquake. Such an event may create peak horizontal accelerations of approximately 1.8%g at Granger (Campbell, 1987). This acceleration is roughly equivalent to an intensity IV earthquake, which should not cause any damage. The rest of Sweetwater County would be subjected to ground accelerations of less than 1.5%g, which should not cause any damage.

A number of unmapped faults also exist in the Washakie Basin area in southern Sweetwater County. Further field investigation is necessary to determine if any of these faults should be deemed active.

Floating or Random Earthquake Sources

Many federal regulations require an analysis of the earthquake potential in areas where active faults are not exposed, and where earthquakes are tied to buried faults with no surface expression.

Regions with a uniform potential for the occurrence of such earthquakes are called tectonic provinces. Within a tectonic province, earthquakes associated with buried faults are assumed to occur randomly, and as a result can theoretically occur anywhere within that area of uniform earthquake potential. In reality, that random distribution may not be the case, as all earthquakes are associated with specific faults. If all buried faults have not been identified, however, the distribution has to be considered random. "Floating earthquakes" are earthquakes that are considered to occur randomly in a tectonic province.

It is difficult to accurately define tectonic provinces when there is a limited historic earthquake record. When there are no nearby seismic stations that can detect small-magnitude earthquakes, which occur more frequently than larger events, the problem is compounded. Under these conditions, it is common to delineate larger, rather than smaller, tectonic provinces.

The U.S. Geological Survey identified tectonic provinces in a report titled "Probabilistic Estimates of Maximum Acceleration and Velocity in Rock in the Contiguous United States" (Algermissen and others, 1982). In that report, Sweetwater County was classified as being in a tectonic province with a "floating earthquake" maximum magnitude of 6.1. Geomatrix (1988b) suggested using a more extensive regional tectonic province, called the "Wyoming Foreland Structural Province", which is approximately defined by the Idaho-Wyoming Thrust Belt on the west, 104° West longitude on the east, 40° North latitude on the south, and 45° North latitude on the north. Geomatrix (1988b) estimated that the largest "floating" earthquake in the "Wyoming Foreland Structural Province" would have a magnitude in the 6.0 – 6.5 range, with an average value of magnitude 6.25.

Federal or state regulations usually specify if a "floating earthquake" or tectonic province analysis is required for a facility. Usually, those regulations also specify at what distance a floating earthquake is to be placed from a facility. For example, for uranium mill tailings sites, the Nuclear Regulatory Commission requires that a floating earthquake be placed 15 kilometers from the site. That earthquake is then used to determine what horizontal accelerations may occur at the site. A magnitude 6.25 "floating" earthquake, placed 15 kilometers from any structure in Sweetwater County, would generate horizontal accelerations of approximately 15%g at the site. That acceleration would be adequate for designing a uranium mill tailings site, but may be too large for less critical sites, such as a landfill. Critical facilities, such as dams, usually require a more detailed probabilistic analysis of random earthquakes. Based upon probabilistic analyses of random earthquakes in an area distant from exposed active faults (Geomatrix, 1988b), however, placing a magnitude 6.25 earthquake at 15 kilometers from a site will provide a fairly conservative estimate of design ground accelerations.

Probabilistic Seismic Hazard Analyses

The U.S. Geological Survey (USGS) publishes probabilistic acceleration maps for 500-, 1000-, and 2,500-year time frames. The maps show what accelerations may be met or exceeded in those time frames by expressing the probability that the accelerations will be met or exceeded in a shorter time frame. For example, a 10% probability that acceleration may be met or exceeded in 50 years is roughly equivalent to a 100% probability of exceedance in 500 years.

The USGS has recently generated new probabilistic acceleration maps for Wyoming (Case, 2000). Copies of the 500-year (10% probability of exceedance in 50 years), 1000-year (5% probability of exceedance in 50 years), and 2,500-year (2% probability of exceedance in 50 years) maps are attached. Until recently, the 500-year map was often used for planning purposes for average structures, and was the basis of the most current Uniform Building Code. The new International Building Code, however, uses a 2,500-year map as the basis for building design. The maps reflect current perceptions on seismicity in Wyoming. In many areas of Wyoming, ground accelerations shown on the USGS maps can be increased due to local soil conditions. For example, if fairly soft, saturated sediments are present at the surface, and seismic waves are passed through them, surface ground accelerations will usually be greater than would be experienced if only bedrock was present. In this case, the ground accelerations shown on the USGS maps would underestimate the local hazard, as they are based upon accelerations that would be expected if firm soil or rock were present at the surface. Intensity values can be found in Table 1.

Based upon the 500-year map (10% probability of exceedance in 50 years) (Figure 2), the estimated peak horizontal acceleration in Sweetwater County ranges from approximately 5%g in the southeastern corner of the county to nearly 9%g in the northwestern corner of the county. These accelerations are roughly comparable to intensity V earthquakes (3.9%g – 9.2%g). These accelerations are comparable to the accelerations to be expected in Seismic Zone 1 of the Uniform Building Code. Intensity V earthquakes can result in cracked plaster and broken dishes. Rock Springs and Green River would be subjected to accelerations of nearly 7%g or intensity V.

Based upon the 1000-year map (5% probability of exceedance in 50 years) (Figure 3), the estimated peak horizontal acceleration in Sweetwater County ranges from 8%g in the far southeastern corner of the county to over 10%g in the northeastern half of the county. These accelerations are roughly comparable to intensity V earthquakes (3.9%g – 9.2%g) to intensity VI earthquakes (9.2%g – 18%g). Intensity V earthquakes can result in cracked plaster and broken dishes. Intensity VI earthquakes can result in fallen plaster and damaged chimneys. Rock Springs and Green River would be subjected to accelerations of over 10%g or intensity VI.

Based upon the 2500-year map (2% probability of exceedance in 50 years) (Figure 4), the estimated peak horizontal acceleration in Sweetwater County ranges from approximately 13%g in the southeastern corner of the county to over 20%g in the northeastern portion of the county. These accelerations are roughly comparable to intensity VI earthquakes (9.2%g – 18%g) and intensity VII earthquakes (18%g – 34%g). Intensity VI earthquakes can result in fallen plaster and damaged chimneys. Intensity VII earthquakes can result in slight to moderate damage in well-built ordinary structures, and considerable damage in poorly built or badly designed structures, such as unreinforced masonry. Chimneys may be broken. Rock Springs and Green River would be subjected to accelerations of approximately 20%g and 18%g, respectively, or intensity VII.

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

Table 1:

Modified Mercalli Intensity	Acceleration (%g) (PGA)	Perceived Shaking	Potential Damage
I	<0.17	Not felt	None
II	0.17 – 1.4	Weak	None
III	0.17 – 1.4	Weak	None
IV	1.4 – 3.9	Light	None
V	3.9 – 9.2	Moderate	Very Light
VI	9.2 – 18	Strong	Light
VII	18 – 34	Very Strong	Moderate
VIII	34 – 65	Severe	Moderate to Heavy
IX	65 – 124	Violent	Heavy
X	>124	Extreme	Very Heavy
XI	>124	Extreme	Very Heavy
XII	>124	Extreme	Very Heavy

Modified Mercalli Intensity and peak ground acceleration (PGA) (Wald, et al 1999).

Abridged Modified Mercalli Intensity Scale

Intensity value and description:

I Not felt except by a very few under especially favorable circumstances.

II Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.

III Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing automobiles may rock slightly. Vibration like passing of truck. Duration estimated.

IV During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing automobiles rocked noticeably.

V Felt by nearly everyone, many awakened. Some dishes, windows, and so on broken; cracked plaster in a few places; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.

VI Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster and damaged chimneys. Damage slight.

VII Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving cars.

VIII Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving cars disturbed.

IX Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.

X Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed, slopped over banks.

XI Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII Damage total. Waves seen on ground surface. Lines of sight and level distorted. Objects thrown into the air.

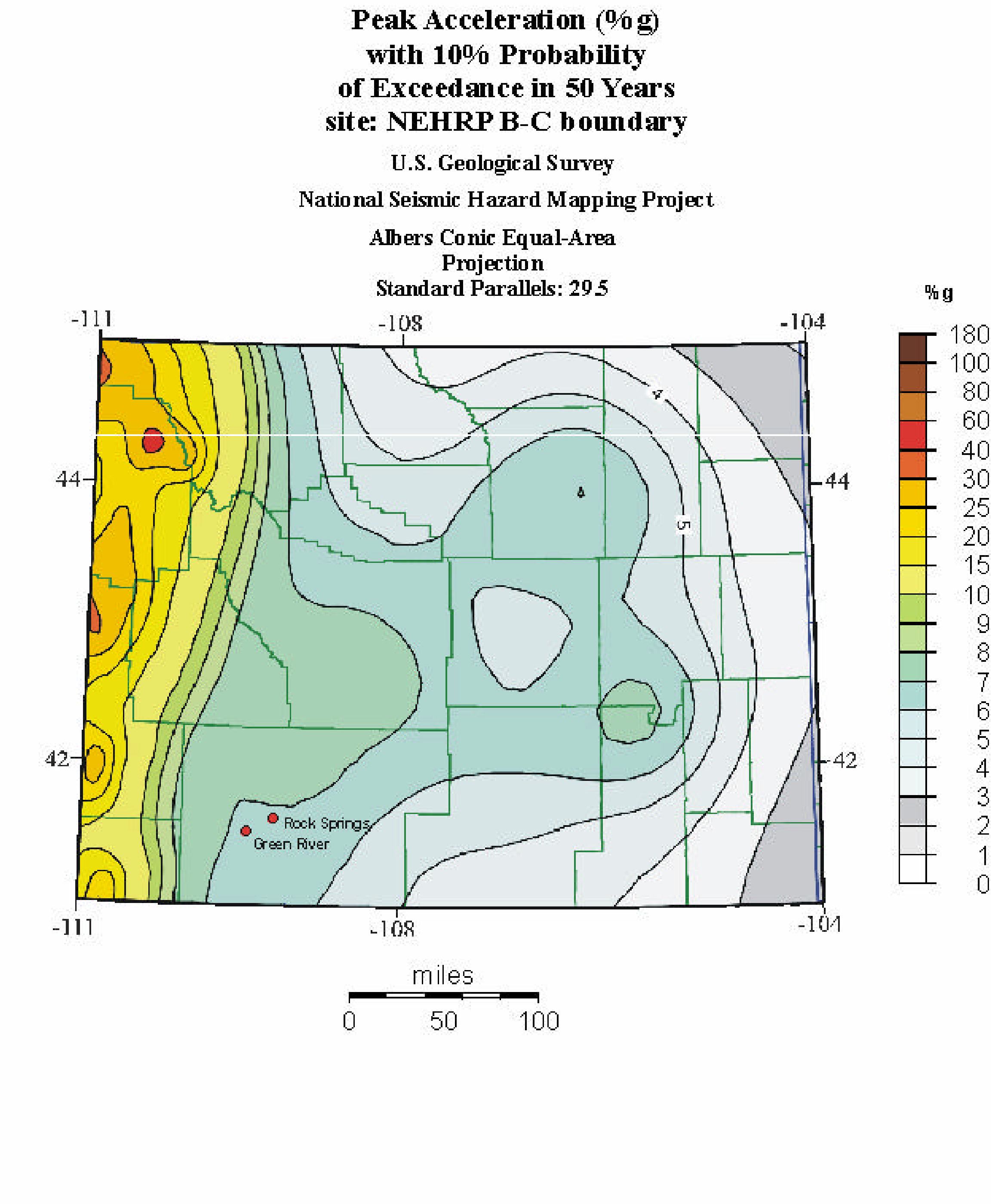

Figure 2. 500-year probabilistic acceleration map (10% probability of exceedance in 50 years).

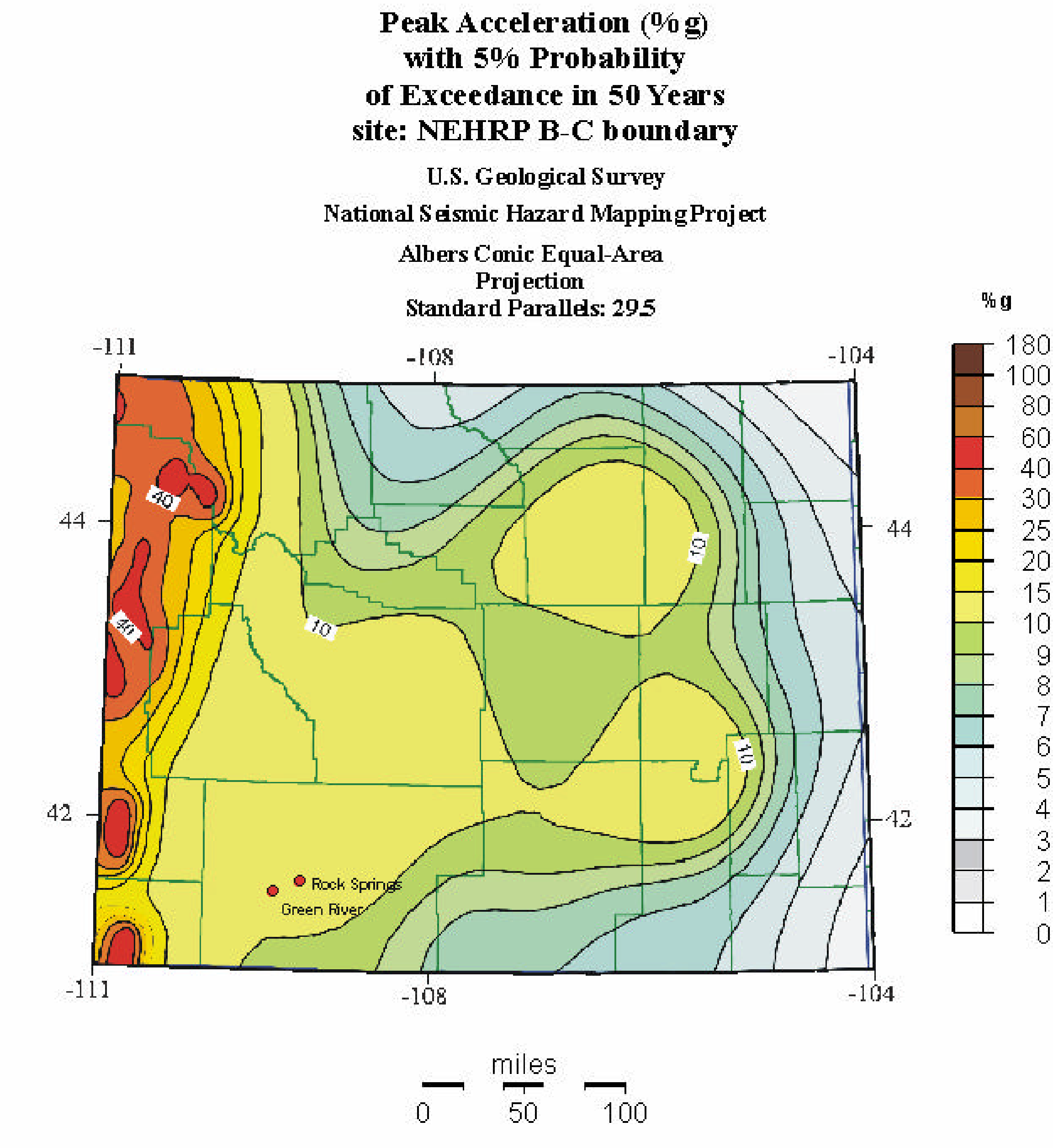

Figure 3. 1000-year probabilistic acceleration map (5% probability of exceedance in 50 years).

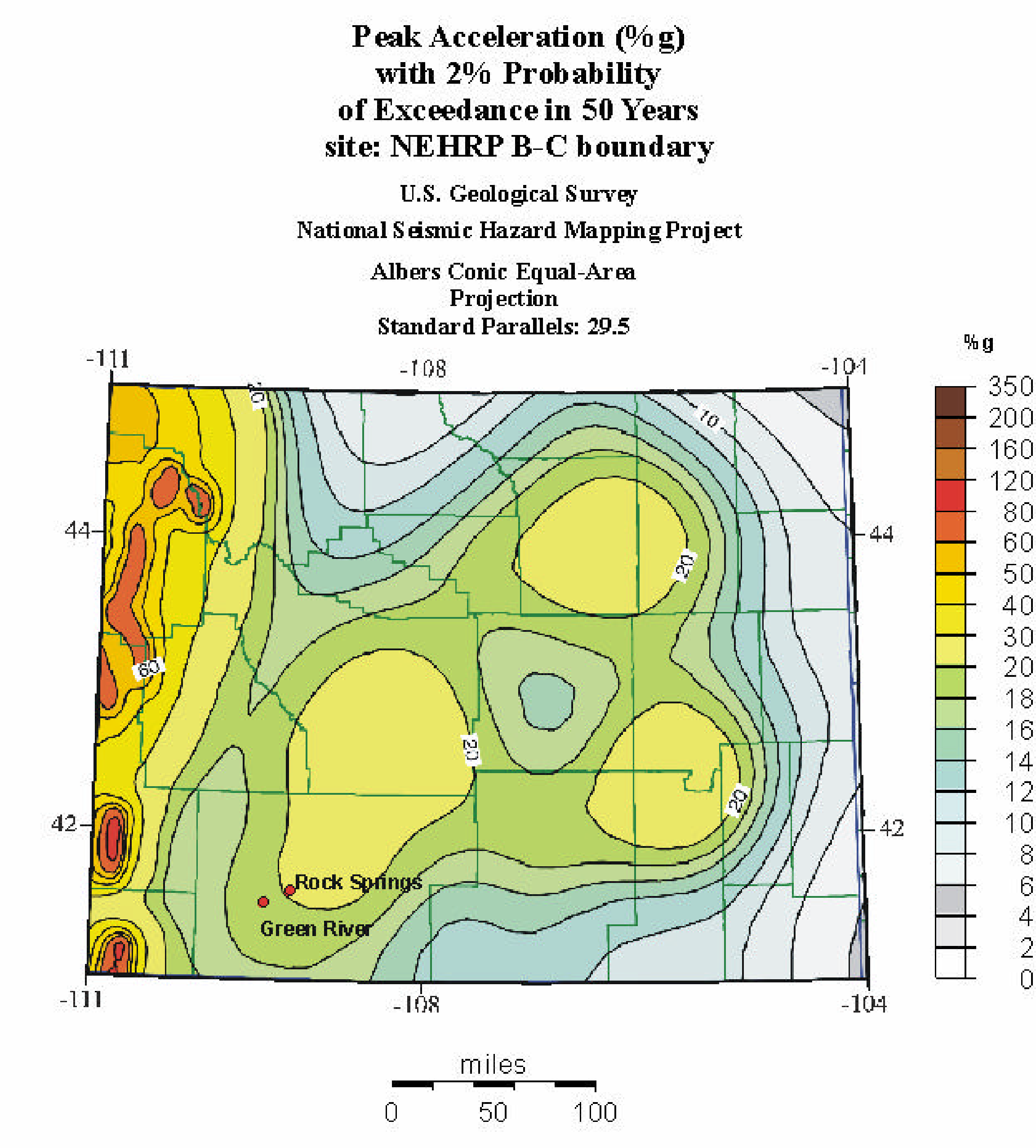

Figure 4. 2500-year probabilistic acceleration map (2% probability of exceedance in 50 years).

Summary

There have been over thirty historic earthquakes with a magnitude greater than 2.0 recorded in Sweetwater County. Because of the limited historic record, it is possible to underestimate the seismic hazard in Sweetwater County if historic earthquakes are used as the sole basis for analysis. Earthquake and ground motion probability maps give a more reasonable estimate of damage potential in areas without exposed active faults at the surface. Most historic earthquakes in Sweetwater County have been associated with buried active faults. Northeastern Sweetwater County, however, does have an exposed active fault system (Chicken Springs fault system).

Current earthquake probability maps that are used in the newest building codes suggest a scenario that would result in moderate damage to buildings and their contents, with damage increasing from the southeast to the north. More specifically, the probability-based or fault activation-based worst-case scenario could result in the following damage at points throughout the county:

Intensity VII Earthquake Areas

Bairoil
Bitter Creek
Eden
Farson
Green River
Point of Rocks
Quealy
Red Desert
Reliance
Rock Springs
Superior
Table Rock

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

Intensity VI Earthquake Areas

Burntfork
Creston Junction
Granger
Little America
McKinnon
Wamsutter
Washam

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

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