3.14 GEOLOGIC HAZARDS

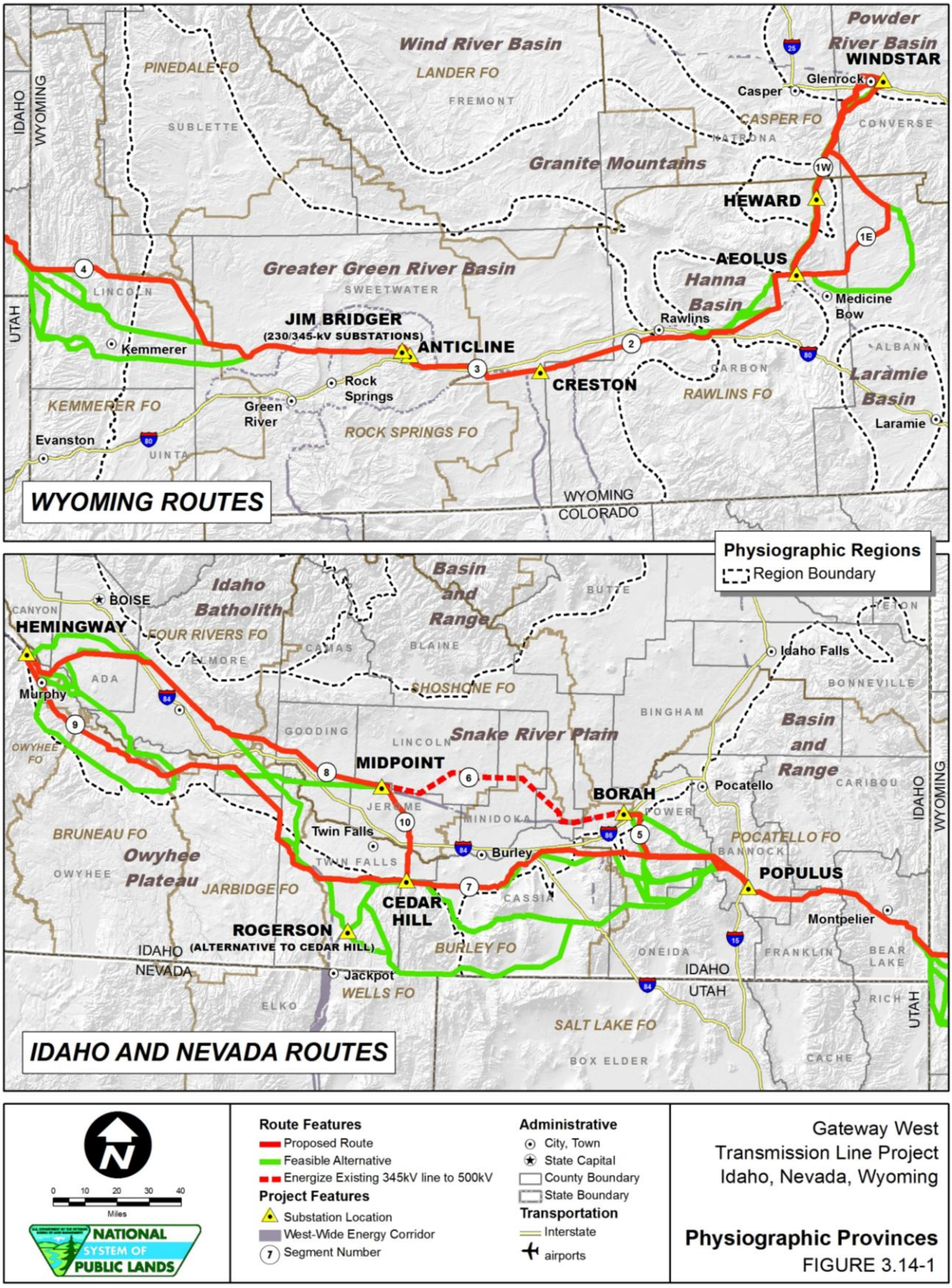
This section addresses potential impacts from geologic hazards on the Proposed Route and Route Alternatives during construction, operations, and decommissioning. The primary reason to define impacts from geologic hazards is to eliminate, minimize, or mitigate effects from these hazards during Project execution. This section analyzes the potential impacts from earthquakes, subsidence, landslides, and shallow bedrock on Project construction and operations. Impacts on minerals are discussed in Section 3.12 – Minerals, and impacts on soils are discussed in Section 3.15 – Soils.

3.14.1 Affected Environment

This section discusses those aspects of the environment that could be impacted by the Project. It starts with a discussion of the Analysis Area considered, identifies the issues that have driven the analysis, describes the method of analysis, and characterizes the existing conditions across the Project in Wyoming and Idaho.

3.14.1.1 Analysis Area

Figure 3.14-1 is a generalized map showing the location of prominent physiographic features along the Project alignment. The Project would be located on land consisting of predominantly north-south trending mountain ranges separated by geographic and structural basins. The eastern portion of the Project (Segments 1 and 2) would be located within the Laramie Mountains and the Shirley Mountains, which consist of pre-Cambrian-age granite and younger sedimentary rocks. Farther west, the geology is dominated by major structural basins, including the Hanna Basin in Carbon County (Segment 2) and the Greater Green River Basin in Sweetwater County (Segments 3 and 4). Mountainous terrain is present along the Idaho-Wyoming border in Segments 4 and 5. Thrust faulting dominated the mountain-building processes in the east portion of the mountains, while block faulting was more common farther west into southeast Idaho and northern Nevada. The mountain ranges consist of predominantly sedimentary or metamorphic rock. West of Borah Substation (Segments 6 through 10), the routes fall within the Snake River Plain, a broad structural valley, with extensive exposures of basalt, thinly covered with silty, mainly wind-blown soil. Some of the southern alternatives (Segments 7 and 9) remain within the basin and range mountain ranges similar to those in southeast Idaho, except with progressively more volcanism as one proceeds west. The nearest active volcanic field is the Wapi Lava Field, which erupted approximately 2,200 years ago. The Wapi Lava Field is within 650 feet of Segment 6, and approximately 8 miles northwest of Borah Substation. The Craters of the Moon Lava Field formed during eight eruptive periods with a recurrence interval averaging 2,000 years, and it has been more than 2,000 years since the last eruption. The Craters of the Moon Lava Field is approximately 29 miles from the Borah Substation and is within 4 miles of Segment 6. The Yellowstone volcano in northwest Wyoming is a caldera-type volcano, approximately 130 miles from the closest Route Alternative. It last erupted approximately 600,000 years ago but frequent hydrothermal activity and seismic events in this area suggest that the volcano could become active again. Neither is expected to affect the Project during its planned service life.


WYOMING ROUTES
Wind River Basin
LANDER FO
PINEDALE FO
FREMONT
SUBLETTE
Powder River Basin
WINDSTAR
Glenrock
Casper
CASPER FO
CONVERSE
NATRONA
Granite Mountains
HEWARD
AEOLUS
Hanna Basin
Medicine Bow
Rawlins
Greater Green River Basin
SWEETWATER
LINCOLN
JIM BRIDGER
(230/345-kV SUBSTATIONS)
ANTICLINE
CRESTON
Kemmerer
Rock Springs
Green River
KEMMERER FO
ROCK SPRINGS FO
RAWLINS FO
CARBON
ALBANY
Laramie Basin
Laramie
Evanston
UINTA
IDAHO
WYOMING
UTAH
WYOMING
COLORADO
Physiographic Regions
Region Boundary
IDAHO AND NEVADA ROUTES
Idaho Batholith
FOUR RIVERS FO
BOISE
HEMINGWAY
Murphy
ADA
CANYON
ELMORE
CAMAS
BLAINE
Basin and Range
BUTTE
Idaho Falls
BONNEVILLE
SHOSHONE FO
BINGHAM
GOODING
LINCOLN
Snake River Plain
MIDPOINT
BORAH
Pocatello
CARIBOU
Basin and Range
OWYHEE FO
BRUNEAU FO
Owyhee Plateau
OWYHEE
JERROME
MINIDOKA
POWER
Twin Falls
TWIN FALLS
Burley
POCATELLO FO
BANNOCK
POPULUS
JARBIDGE FO
CASSIA
CEDAR HILL
ROGERSON
(ALTERNATIVE TO CEDAR HILL)
Jackpot
BURLEY FO
WELLS FO
ELKO
IDAHO
NEVADA
ONEIDA
FRANKLIN
Montpelier
BEAR LAKE
IDAHO
UTAH
RICH
SALT LAKE FO
BOX ELDER
CACHE
Route Features
Proposed Route
Feasible Alternative
Energize Existing 345kV line to 500kV
Project Features
Substation Location
West-Wide Energy Corridor
Segment Number
Administrative
City, Town
State Capital
County Boundary
State Boundary
Transportation
Interstate
airports
0 10 20 30 40
Miles
NATIONAL SYSTEM OF PUBLIC LANDS
Gateway West
Transmission Line Project
Idaho, Nevada, Wyoming
Physiographic Provinces
FIGURE 3.14-1

The Analysis Area for geologic hazards (landslides, subsidence, and shallow bedrock) was defined in a GIS file by buffering the centerlines of the Proposed Route and Route Alternatives out 0.5 mile on either side and dissolving the buffers into a single polygon for each segment. This distance was used because it encompasses the potential geologic hazard area that could affect the stability of the transmission line relative to landslides, subsidence, and shallow bedrock, since each of those features is local in nature. The Analysis Area for earthquake hazard zones was based on the centerline locations for the Proposed Route and Route Alternatives, whereas the Analysis Area for earthquakes was defined by a variable buffer distance around epicenters, or groups of epicenters, of historical earthquakes and extended out to 100 miles for the most severe earthquakes. The distance of 100 miles was chosen because at that distance, the effect on the proposed transmission line from earthquakes would be minimal from even the strongest recorded past earthquakes in the area.

3.14.1.2 Issues to be Analyzed

This review of geologic hazards addressed public comments received during scoping (Tetra Tech 2009a) regarding the potential for impacts to the transmission line from mine subsidence. A detailed analysis of subsidence is presented herein. The following geologic hazard issues were carried through for detailed analysis:

- a full inventory of potentially affected geological resources;
- the potential for earthquakes to damage the transmission line and associated structures;
- the effect subsidence from underground mining would have on the transmission line, and what the hazard to workers or infrastructure would be;
- the effect landslides would have on the transmission line (segments that cross medium or high landslide risk areas are identified);
- the effect construction blasting in shallow bedrock would have on unstable landforms (landslide or subsidence-prone areas or coal-mining areas containing methane), or on adjacent human-made structures not related to the transmission line.

3.14.1.3 Regulatory Framework

The 2006 International Building Code (IBC) provides building standards for structures, including standards for structures located within seismically active areas. Local or state building codes may specify adherence to IBC standards. Management plans of the BLM and Forest Service also provide guidance relative to geologic hazards. The IBC will be used to design all structures considering seismic design criteria.

3.14.1.4 Methods

The environmental effects analyses completed for this assessment were conducted using readily available data and GIS files derived from preliminary centerline and component design for the Proposed Route and Route Alternatives including ROW, access roads, staging areas, and fly yards (see Section 3.1 for details on the development of these files). In all cases, after analysis of impacts was complete and

where impacts were identified, Proponent-proposed measures to reduce impacts were reviewed for sufficiency. Where those measures were determined to be insufficient, additional measures were identified.

Earthquakes

Earthquake hazards were evaluated using two methods, including use of Office of Pipeline Safety (OPS) data, and by reviewing the location and intensity of historic earthquakes within the analysis area. The Federal Emergency Management Agency (FEMA) and the U.S. Department of Transportation, OPS National Disaster Study, National Pipeline Risk Index Technical Report (OPS Study) (1996) was used to evaluate effects from earthquakes. The OPS data provide earthquake hazard rankings for the United States, including those portions of Idaho and Wyoming near the proposed transmission lines. The OPS report utilized information from the USGS National Earthquake Hazards Reduction Program. The USGS compiled a large database of past earthquake magnitudes and locations. Based on those data, earthquake hazards were assigned to all parts of the country. Based on historical earthquake magnitudes and locations, geographic areas were assigned an earthquake hazard ranking, ranging from zero (no earthquake hazard) to 100 (highest earthquake hazard). For this analysis, a high earthquake hazard was assigned for areas with earthquake hazard rankings of 85 to 100. Locations with earthquake hazard rankings between 70 and 84 were considered as medium risk, and rankings less than 70 were considered low risk.

To identify existing earthquake conditions, the centerlines of the Proposed Route and Route Alternatives in each segment were overlaid on the OPS GIS data file and the mileage crossed for each earthquake hazard risk was determined and expressed as a percent for the segment. To disclose overall hazard risk for impacts analysis, the mileage crossed by the entire Proposed Route by segment and for those portions of each segment where alternatives were proposed was identified. Miles of earthquake hazard category were then compared for each segment by alternative.

The locations of historical earthquake epicenters were also reviewed relative to the transmission line routes. Wyoming earthquake data were obtained from the University of Wyoming's Wyoming Geographic Information Science Center (http://uwyo.edu/wygisc/info). Earthquake data for Idaho, Colorado, Nevada, Oregon, and Utah were obtained from the applicable state geologic survey departments.

The damage to structures caused by earthquakes is highly variable and based on many features including, but not limited to, types of building materials and quality of construction, distance from epicenter, earthquake magnitude, and the susceptibility to ground shaking of underlying soil and rock at the site of the structure. Therefore, any relationship between structure damage and distance from earthquake epicenter is only an estimate. However, certain areas are subject to more earthquakes than others and the geographic distribution of earthquakes was considered.

Earthquake magnitude information obtained from University of Nevada, Reno (2008) estimated that earthquakes of Richter magnitude 6.0 to 6.9 may damage buildings for distances of up to 100 kilometers. For this analysis, a 50-mile radius buffer was assigned to earthquakes within these magnitudes. The University of Nevada, Reno (2008) information stated that for earthquakes of magnitude less than 6, some

structures could be damaged over small regions. For earthquakes of that magnitude, a buffer of 20 miles was assigned around each epicenter. University of Nevada, Reno (2008) described earthquakes of magnitude 7 or greater as having the potential for damage over larger areas. For these large earthquakes, a buffer of 100 miles was assigned. To identify the potential for structural damage, the centerlines of the Proposed Route and Route Alternatives in each segment were overlaid on the consolidated buffers derived from each epicenter, or group of epicenters, and the mileage crossed for each set of buffers was summed for each segment and expressed as a percent. To disclose overall risk of structure damage for impacts analysis, the mileage crossed by the entire Proposed Route by segment and for those portions of each segment where alternatives were proposed was identified. Miles of structure damage category were then compared for each segment by alternative.

Landslides

The OPS Study was used to evaluate effects from landslides. The OPS data provide landslide hazard rankings for the United States, including those portions of Idaho and Wyoming near the proposed transmission lines. The OPS report utilized information from USGS and U.S. Natural Resources Conservation Service (NRCS) for locations of swelling clay, landslide incidence, landslide susceptibility, and land subsidence. Based on those four factors, landslide hazard rankings were assigned from zero to 100, where zero represents the lowest ground failure hazard and 100 represents the highest. Landslide hazard rankings of 85 to 100 were assumed to have high risk of landslides, rankings between 70 and 84 were considered to have medium risk, and areas less than 70 were assumed to have low risk. To identify existing landslide potential, the Analysis Area within each segment was overlaid on the OPS data to identify the percent of the segment within each landslide risk category. To evaluate the possible interactions between areas of high landslide potential and the Project, the mileage crossed by the entire Proposed Route by segment and for those portions of each segment where alternatives were proposed was identified. Miles of landslide hazard category were then compared for each segment by alternative.

Subsidence

The locations of underground mineral deposits were obtained from Wyoming Geological Survey (http://www.wsgs.uwyo.edu/GIS/DigitalData). WDEQ also provided the known locations of historic abandoned underground mine sites. It is well-documented that some areas overlying underground mines in southern Wyoming have experienced subsidence. As a conservative measure, it was assumed that any area with underground mineral deposits of coal, trona, or oil and gas and any area with abandoned underground mines had the potential for subsidence.

To identify existing subsidence potential, the Analysis Area within each segment was overlaid on the Wyoming geological survey and WDEQ data to identify the percent of the segment within identified subsidence-prone areas. To evaluate the possible interactions between subsidence-prone areas and the Project, the mileage crossed by the entire Proposed Route by segment and for those portions of each segment where alternatives were proposed was identified. Miles of subsidence-prone areas were then compared for each segment by alternative.

Blasting in Shallow Bedrock

The NRCS State Soil Geographic (STATSGO) database was used to evaluate depth to shallow bedrock (NRCS 1995). The database separates the depth to bedrock into categories, including depths of 1 to 4 feet, 4 to 8 feet, and 8 to 12 feet. No readily available data were found to evaluate depth to bedrock at depths greater than 12 feet. However, Table B-2 in Appendix B indicates that the majority of transmission tower foundations are 20 feet or less, but a few double-circuit 500-kV towers (angle towers or dead-ends) may have foundations ranging from 20 to 30 feet deep. In 2010, drilling began in some areas of Segments 1 through 4 to support geotechnical evaluations for transmission line structures. The drilling was conducted on public land and private land where landowner permission was obtained. As a conservative measure, it was assumed that all shallow bedrock that would need to be removed would require blasting.

To evaluate existing shallow bedrock areas, the Analysis Area within each segment was overlaid on the STATSGO database to identify the percent of the segment containing shallow bedrock. To evaluate the possible interactions between shallow bedrock, including the need for blasting, and the Project, the mileage crossed by the entire Proposed Route by segment and for those portions or each segment where alternatives were proposed was identified. Miles of route crossing shallow bedrock areas were then compared for each segment by alternative.

A comment was received that methane could accumulate in shallow voids in the subsurface, including monitoring wells. This methane, if present in a blasting area, could cause unintended explosions. The locations of current coal leases, presented in Section 3.12 – Minerals, were compared to the Proposed Route and Route Alternatives. Information from WDEQ, Abandoned Mine Lands Division, was also reviewed to assess the location of historic coal mines and those locations were compared to the Proposed Route and Route Alternatives. Similarly, blasting could cause subsidence in unstable areas.

To evaluate the risks of subsidence or contact with methane in shallow blasting areas, the Analysis Area within each segment was overlaid on the STATSGO database to identify the percent of the segment containing shallow bedrock, merged with subsidence areas, then merged again with coal-producing areas. To evaluate the possible interactions between blasting, subsidence, and methane potential, the route mileages for intersected areas (bedrock vs. subsidence, and bedrock vs. coal) were then compared for each segment by alternative.

Depth to Bedrock Confirmation from Geotechnical Boreholes

In 2010, drilling began in some areas to support geotechnical evaluations for transmission line structures. The drilling was conducted on public land and private land where landowner permission was obtained. As of the date of this EIS, available information includes a total of 124 boreholes that were advanced along Segments 1 through 4. Total depths drilled ranged from 15 feet to 66.5 feet. Drilling logs were reviewed to evaluate depth to bedrock. Shallow bedrock (less than 20 feet deep) was found in 11 of the boreholes. The locations of these boreholes were compared to the

locations where STATSGO information indicated shallow bedrock. Where differences were found between the two information sources, it is noted in the text below.

3.14.1.5 Existing Conditions

Geologic processes within the Project area, including earthquakes, landslides, and subsidence, could occur during the life of the Project. Existing conditions that could lead to geologic hazards affecting the transmission lines and associated facilities such as substations access roads or communication facilities are described below. In addition, shallow depth to bedrock could require blasting. The resulting damage may result in adverse environmental effects.

Earthquakes

The Proposed Route and Route Alternatives across Wyoming and Idaho would be located in areas where earthquakes could occur. A summary of earthquakes that have occurred within the past 100 years, as well as an earthquake risk database, were reviewed in assessing the potential effects from earthquakes. Based on the data provided, earthquakes are most common in a north-south trending area along the Idaho-Wyoming border. Figure 3.14-2 shows the locations of earthquake epicenters, including Quaternary faults crossing the transmission lines, and corresponding buffer zones. The largest historical earthquakes have been in the Yellowstone area of northwest Wyoming, and in south and central Idaho. However, the frequency of earthquakes appears less in Idaho than in Wyoming. The data indicate that historical earthquakes have likely been felt in all of the segments.

Table 3.14-1 presents the percent of low, medium, and high earthquake risk within the Analysis Area by segment. Table 3.14-2 presents the Analysis Area within the buffers assumed for recent earthquake epicenters by segment. Parts of Segments 4, 5, 6, and 7 contain medium to high risks of earthquakes. Portions of Segments 5, 6, 7, 8, 9, and 10 have experienced an earthquake of greater than magnitude 7.

Table 3.14-1. OPS Earthquake Hazard Risk by Segment

Segment Number	Earthquake Zone Rank by Percent of Analysis Area		
	Low < 70	**Medium 70 to 84**	**High 85 to 100**
1	100	–	–
2	100	–	–
3	100	–	–
4	38	14	48
5	–	12	88
6	49	51	–
7	35	28	37
8	100	–	–
9	100	–	–
10	100	–	–

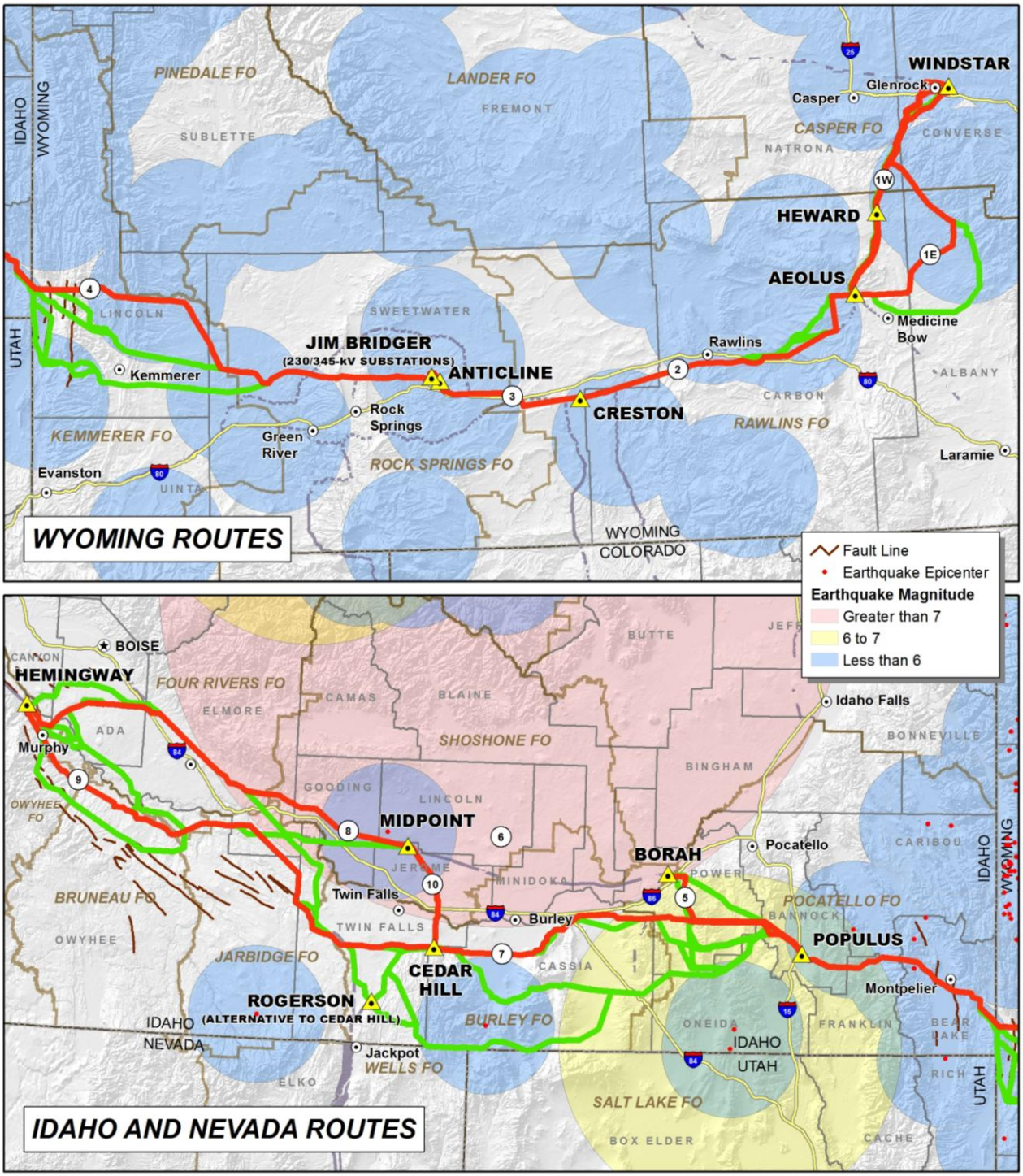

WYOMING ROUTES
PINEDALE FO
LANDER FO
FREMONT
SUBLETTE
IDAHO
WYOMING
UTAH
WINDSTAR
Glenrock
Casper
CASPER FO
NATRONA
CONVERSE
HEWARD
AEOLUS
Medicine Bow
LINCOLN
SWEETWATER
JIM BRIDGER
(230/345-kV SUBSTATIONS)
ANTICLINE
Kemmerer
Rock Springs
Green River
CRESTON
Rawlins
CARBON
RAWLINS FO
ALBANY
Laramie
KEMMERER FO
ROCK SPRINGS FO
Evanston
UINTA
WYOMING
COLORADO
Fault Line
Earthquake Epicenter
Earthquake Magnitude
Greater than 7
6 to 7
Less than 6
IDAHO AND NEVADA ROUTES
BOISE
CANYON
HEMINGWAY
FOUR RIVERS FO
ELMORE
CAMAS
BLAINE
BUTTE
Idaho Falls
ADA
Murphy
SHOSHONE FO
BONNEVILLE
BINGHAM
GOODING
LINCOLN
OWYHEE FO
MIDPOINT
BORAH
Pocatello
CARIBOU
JEROME
MINIDOKA
POWER
BRUNEAU FO
Twin Falls
Burley
POCATELLO FO
BANNOCK
TWIN FALLS
OWYHEE
POPULUS
JARBIDGE FO
CEDAR HILL
CASSIA
Montpelier
ROGERSON
(ALTERNATIVE TO CEDAR HILL)
BURLEY FO
ONEIDA
FRANKLIN
BEAR LAKE
IDAHO
NEVADA
Jackpot
WELLS FO
ELKO
RICH
SALT LAKE FO
BOX ELDER
CACHE
0 10 20 30 40
Miles
NATIONAL SYSTEM OF PUBLIC LANDS
Route Features
Proposed Route
Feasible Alternative
Energize Existing 345kV line to 500kV
Project Features
Substation Location
West-Wide Energy Corridor
Segment Number
Administrative
City, Town
State Capital
County Boundary
State Boundary
Transportation
Interstate
airports
Gateway West
Transmission Line Project
Idaho, Nevada, Wyoming
Earthquake Epicenters
FIGURE 3.14-2

Table 3.14-2. Earthquake Magnitude Buffers by Segment

Segment Number	Earthquake Buffer Zone by Percent of Analysis Area		
	Magnitude 0.1 to 6	Magnitude 6.0 to 6.9	Magnitude >7
1	69	–	–
2	95	–	–
3	72	–	–
4	80	6	–
5	11	93	4[1/]
6	49	–	100
7	24	47	1
8	21	–	47
9	–	–	6
10	42	–	76

1/ Some areas are in more than one earthquake magnitude zone; therefore, total percentage can exceed 100.

Landslides

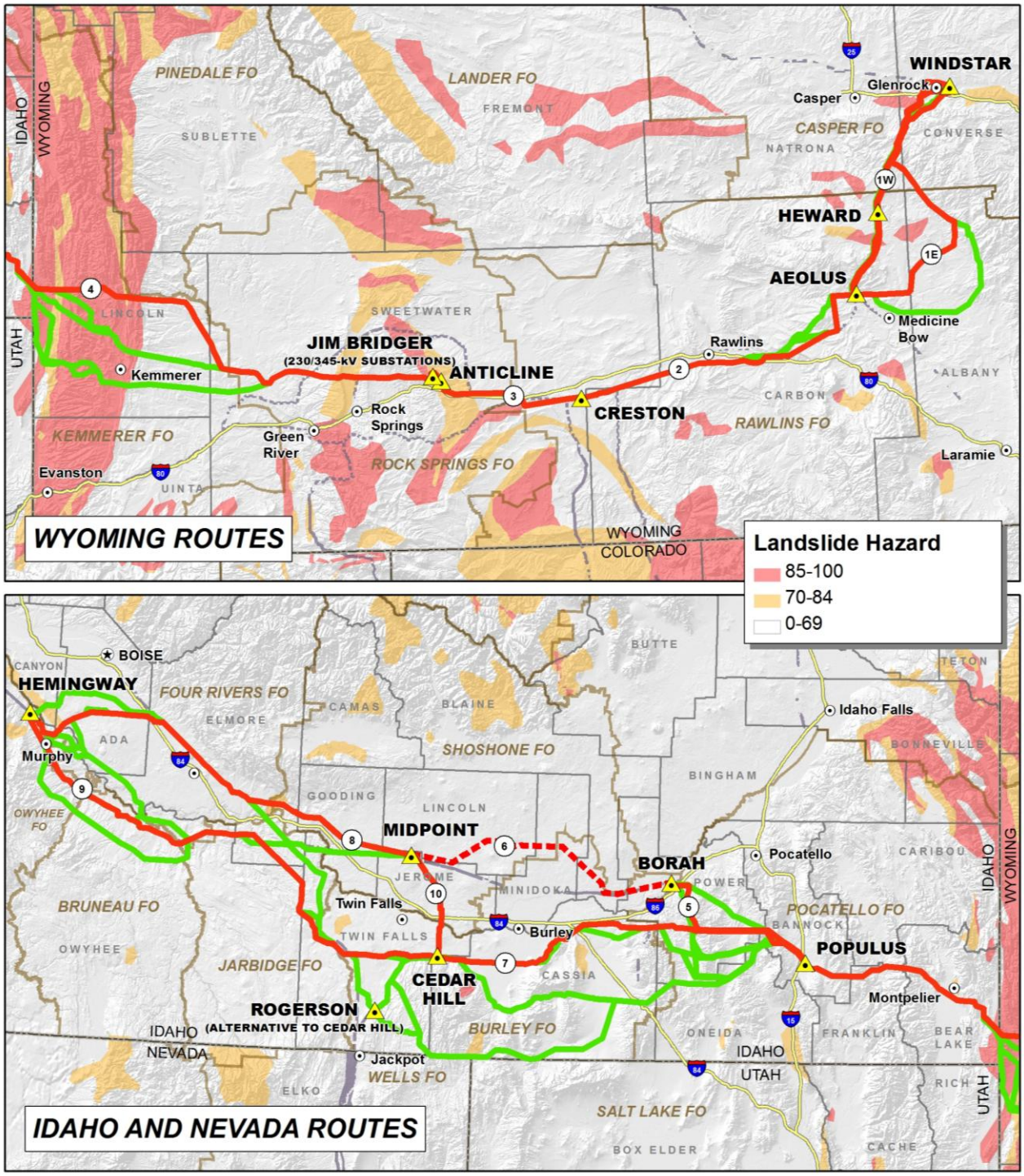
Landslides, including mudflows, mudslides, rock flows, rock slides, and debris flows could occur in mountainous portions of the Project area. Landslides are often triggered by other natural events, including earthquakes, or precipitation sufficient to cause earth movements. Certain geologic formations such as the Green River Formation are known to be more susceptible to landslides than others (Aase 2008). Table 3.14-3 presents the percent of low, medium, and high landslide risk within the Analysis Area by segment. The greatest landslide risks are in Segment 4, where 45 percent of the routes cross areas of medium to high landslide risks. Segment 3 contains medium landslide risk to 37 percent of the route (see Figure 3.14-3). Small portions (less than 5 percent) of medium or high landslide risk are also present in Segments 1, 7, and 8.

Table 3.14-3. OPS Landslide Risk by Segment

Segment Number	Landslide Hazard Rankings by Percent of Analysis Area		
	0 to 69	70 to 84	85 to 100
1	97	–	3
2	100	–	–
3	63	37	<1
4	55	10	35
5	100	–	–
6	100	–	–
7	99	1	–
8	96	4	–
9	100	–	–
10	100	–	–

Subsidence

Subsidence is the vertical sinking of earth, typically because of a natural or man-made void in underlying rock formations. Geologic areas with extensive limestone caves or large natural voids in basalt flows possess the potential for natural subsidence; however, there are no large areas of cavernous limestone or natural voids in the area crossed by the Proposed Route and Alternatives. Man-caused subsidence occurs in areas overlying extensive underground mine workings or in areas of aquifer drawdown


WYOMING ROUTES
PINEDALE FO
LANDER FO
FREMONT
SUBLETTE
IDAHO
WYOMING
UTAH
WINDSTAR
Glenrock
Casper
CASPER FO
NATRONA
CONVERSE
HEWARD
AEOLUS
Medicine Bow
Rawlins
ALBANY
CARBON
RAWLINS FO
LINCOLN
SWEETWATER
JIM BRIDGER
(230/345-kV SUBSTATIONS)
ANTICLINE
CRESTON
Kemmerer
Rock Springs
Green River
KEMMERER FO
ROCK SPRINGS FO
Evanston
UINTA
Laramie
WYOMING
COLORADO
Landslide Hazard
85-100
70-84
0-69
IDAHO AND NEVADA ROUTES
BOISE
CANYON
HEMINGWAY
FOUR RIVERS FO
ELMORE
ADA
Murphy
OWYHEE FO
BRUNEAU FO
OWYHEE
CAMAS
BLAINE
BUTTE
SHOSHONE FO
GOODING
LINCOLN
MIDPOINT
JEROME
MINIDOKA
Twin Falls
TWIN FALLS
Burley
JARBIDGE FO
CEDAR HILL
CASSIA
ROGERSON
(ALTERNATIVE TO CEDAR HILL)
BURLEY FO
IDAHO
NEVADA
Jackpot
WELLS FO
ELKO
BORAH
POWER
Pocatello
BINGHAM
Idaho Falls
TETON
BONNEVILLE
CARIBOU
POCATELLO FO
BANNOCK
POPULUS
Montpelier
ONEIDA
FRANKLIN
BEAR LAKE
IDAHO
UTAH
RICH
SALT LAKE FO
BOX ELDER
CACHE
0 10 20 30 40
Miles
NATIONAL SYSTEM OF PUBLIC LANDS
Route Features
Proposed Route
Feasible Alternative
Energize Existing 345kV line to 500kV
Project Features
Substation Location
West-Wide Energy Corridor
Segment Number
Administrative
City, Town
State Capital
County Boundary
State Boundary
Transportation
Interstate
airports
Gateway West
Transmission Line Project
Idaho, Nevada, Wyoming
Landslide Zones
FIGURE 3.14-3

or removal of other fluids, such as natural gas or crude oil. Underground trona and coal mines are particularly susceptible to subsidence because of their large extent. The subsidence potential analyzed in this assessment is associated with current and historic underground mine workings in southern Wyoming. Figures 3.12-1 through 3.12-4 show the locations of trona, oil and gas, coal, and uranium leases in Wyoming.

Table 3.14-4 presents the percent of the Analysis Area within each segment where subsidence could occur, based on the presence of mineral leases. Mineral extractions that could result in subsidence only occur in Segments 1 through 4. A total of 22 percent of the Analysis Area in these four segments is located in areas of possible subsidence.

Table 3.14-4. Potential Subsidence Areas by Segment

Segment Number	Mineral Lease Area as a Percent of Analysis Area				
	Coal	Oil and Gas	Trona	Abandoned Mines	Total Percent of Analysis Area
1	–	3	–	1	4
2	1	28	–	9	38
3	3	39	–	–	42
4	< 1	20	1	1	22

Shallow Bedrock

Table 3.14-5 presents the percent of the extent of shallow bedrock within the Analysis Area by segment. The STATSGO data indicate that shallow bedrock is found in all segments of the Project except Segment 2. As of the date of this EIS, a total of 124 boreholes have been advanced in Segments 1 through 4. Total depths drilled ranged from 15 feet to 66.5 feet. The drilling data indicate that 11 borings contained bedrock at depths less than 20 feet including one of the geotechnical borings in Segment 2, intercepted bedrock at a depth of 15 feet. Therefore, it is assumed that shallow bedrock could be encountered in any of the segments. The drilling data will be used by project engineers to identify additional areas containing shallow bedrock that may require blasting. Due to the lack of depth-to-bedrock data deeper than 12 feet, the amount of shallow bedrock presented in Table 3.14-5 and Table B-9, Appendix B likely underestimates the amount of shallow bedrock that will be intercepted during construction.

Table 3.14-5. Areas of Shallow Bedrock by Segment

Segment Number	Depth to Bedrock (feet) by Percent of Analysis Area			
	1 to 4	4 to 8	8 to 12	Total Percent of Analysis Area
1	10	14	11	35
2	–	–	–	–
3	67	6	–	73
4	38	1	2	41
5	8	24	–	32
6	47	29	–	76
7	12	19	17	48
8	16	51	14	81
9	24	39	15	78
10	21	2	2	25

3.14.2 Direct and Indirect Effects

This section is organized to present effects from geologic hazards on construction, then operations, followed by decommissioning activities for the proposed Project. Route Alternatives are analyzed in detail below in Section 3.14.2.3. There is a Design Variation involving use of two single-circuit structures proposed by the Proponents for Segments 2, 3, and 4 (see Section 2.2 for details), which is analyzed below in Section 3.14.2.4, and a Structure Variation that is analyzed in Section 3.14.2.5. The Proponents have also proposed a Schedule Variation, analyzed in Section 3.14.2.6, in which one of the two single circuits to be constructed in Segments 2, 3, and 4 and a portion of Segment 1W would be built on an extended schedule with construction beginning approximately 2.5 years after completion of the initial construction.

Mitigation measures or EPMs are presented in detail within this section only if it is the first time they have been discussed in Chapter 3; all other measures are referenced or summarized. A comprehensive list of all Proponent-proposed EPMs and Agency-required mitigation measures can be found in Table 2.7-1 of Chapter 2.

Plan Amendments

Proposed amendments are summarized in Table 2.2-1 of Chapter 2 and detailed in Appendices F and G. Amendments are needed to permit the Project to cross various areas of BLM-managed and NFS lands. Effects described for areas requiring an amendment in order for the Project to be built would only occur if the amendment were approved. Amendments that alter land management designations could change future use of these areas. No amendments specific to geologic hazards are proposed for the Project and no impacts to geologic hazards resulting from approving the amendments beyond the impacts of the Project are anticipated.

3.14.2.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not be constructed or operated. No Project-related impacts due to geologic hazards would occur.

3.14.2.2 Effects Common to All Action Alternatives

Construction

Transmission lines and associated facilities could be negatively affected by geologic hazards, including earthquakes, landslides, subsidence, and blast vibrations in shallow bedrock. Earthquakes could occur in any segment of the Project. Project construction, operations, or decommissioning would have no effect on earthquake risks. However, ground shaking and displacement related to earthquakes may damage human-made structures, including transmission lines and substations. The risk interval from geologic hazards during construction is approximately 2 years.

Natural events, such as earthquakes, or excessive rain or snow fall, can trigger landslides that could damage transmission lines and associated structures. The potential for landslides is slope dependent, with steep slopes containing greater landslide potential than shallow slopes. Construction activities can result in human-caused landslides in landslide-prone areas. Removal of soil at the base of an unstable slope can decrease slope stability and result in a landslide. Excavation and/or blasting

in geological hazard areas at substations, transmission tower sites, or during road building could destabilize slopes, resulting in landslides, soil erosion, and stream sedimentation. Midslope road construction, concentration of drainage water on unstable ground, and removal of vegetation during construction can trigger landslides (CDC 2003).

To minimize failures due to landslides, the Agencies have identified the following mitigation measure:

GEO-1 A site-specific landslide mitigation plan that addresses measures to be taken in the design, construction, and operation to minimize failure due to landslides must be prepared and submitted by the Proponents with the construction POD prior to issuance of a ROW grant on federally managed lands.

The Wyoming Department of Homeland Security in their Multi-Hazard Mitigation Plan (2008) indicates that significant mine subsidence problems have occurred in all of the southern Wyoming counties, including those containing Segments 1 through 4. They estimate that mine subsidence has resulted in approximately $85 million in damage. Therefore, the assessment assumed that areas containing trona and coal leases may be prone to mine subsidence. Subsidence is also known to occur over areas with extensive oil and gas extraction. The construction interval for subsidence effects would be approximately 2 years.

To minimize impacts due to subsidence, the following mitigation measure has been proposed by the Agencies and adopted by the Proponents:

GEO-2 Review the final location of the preferred alternative with affected mine operators and lessees to ensure all measures are taken to protect against subsidence.

Foundations for transmission line towers can be as deep as 20 feet below ground surface. Construction in areas of shallow bedrock may require blasting. The vibrations generated by blasting can also result in slope instability, damage to nearby structures, damage to water wells, and disturbance to wildlife. Ground shaking from blasting could result in subsidence or landslides in unstable areas. Voids within bedrock in coal-producing areas of Segments 1 through 4 could contain methane; the location of coal-producing areas is described in Section 3.12 – Minerals. Blasting in areas containing methane could result in dangerous explosions. Blasting may also impact undiscovered cultural or paleontological resources. Paleontological effects are discussed in Section 3.13 – Paleontological Resources.

Table 3.14-6 presents the percent of the Analysis Area by segment where blasting of shallow bedrock may increase the potential for landslides, subsidence, or contact with methane.

Table 3.14-6. Risks from Blasting by Segment

Segment Number	Risks from Blasting (by Hazard) by Percent of Analysis Area			
	Blasting / Landslides[1/]	Blasting / Subsidence	Blasting / Coal Mines	Total Percent Area of Blasting Hazards
1	–	<1	–	<1
2	–	–	–	–
3	24	28	1	43[2/]
4	29	12	<1	32
5	–	–	–	–
6	–	–	–	–
7	1	–	–	1
8	1	–	–	1
9	–	–	–	–
10	–	–	–	–

1/ Represents medium to high landslide risks, as shown on Table 3.14-3.
2/ Some blasting area categories overlap. Therefore, total blasting hazard area can be less than the sum of the categories.

The Proponents would comply with all state and federal regulations regarding blasting. A Blasting Plan would be developed and used during construction. The Proponents have committed to implementing the following EPMs:

BLA-1 The Blasting Plan will identify blasting procedures including safety, use, storage, and transportation of explosives that will be employed where blasting is needed, and will specify the locations of needed blasting.

BLA-2 All blasting will be performed by registered licensed blasters who will be required to secure all necessary permits and comply with regulatory requirements in connection with the transportation, storage, and use of explosives, and blast vibration limits for nearby structures, utilities, wildlife, and fish (where blasting is conducted in waterbodies).

Operations

There is more risk from natural geologic hazards during operations than during construction of the Project because of the longer time interval for operation. The risk varies proportionally to the length of time of construction (2 years) versus the operational life of the Project (50 years). Ground shaking and displacement related to earthquakes may damage human-made structures, including transmission lines and substations, which could result in interruption of power and/or environmental consequences. Naturally occurring landslides could occur in areas of instability. However, the risks of Project-related landslides would be less than those during construction because Project areas disturbed during construction would be stabilized. The risk from subsidence would occur over a longer period during operations than during construction. The 50-year operations interval could also result in additional mining that could render more areas subject to subsidence risks. Blasting is not anticipated during the operations phase of the Project and therefore would have no effects during that phase.

Decommissioning

The decommissioning time interval for risks from natural geologic hazards (earthquakes, landslide, subsidence) is similar to the construction interval, about 2 years. Decommissioning would involve some ground disturbance, including vegetation removal, which could result in temporary increased risks for landslides on unstable slopes. No blasting is anticipated during Project decommissioning.

Summary

In summary, all phases of the Project would be subject to the effects of naturally occurring geologic hazards, such as earthquakes, landslides, and subsidence. The greatest risk from Project-caused geologic hazards would occur during construction. Construction activities could cause slope instability such as landslides and damage to structures. Blasting in areas of shallow bedrock could cause landslide or subsidence in unstable areas, damage to structures including water wells, and disturbance of wildlife. The Proponents would account for the risks of damage from earthquakes by designing and constructing transmission structures to withstand seismic forces and also wind/ice combination loads, which are considered more stringent than the loads induced due to ground motion.

The Proponents are committed to conducting all construction activities in accordance with the EPMs presented in Appendix C. The EPMs include mitigation measures for traffic and transportation management; reclamation, revegetation, and weed management; stormwater pollution prevention; spill prevention; cultural and paleontological mitigation; and blasting.

3.14.2.3 Proposed Route and Alternatives by Segment

This section evaluates the Proposed Action and the differences between the Proposed Route and Route Alternatives for hazards associated with earthquakes, landslides, subsidence, and blasting of shallow bedrock.

Table 3.14-7 is a summary table showing where geological hazard effects are present along the Proposed Route and Route Alternatives. The effects by segment are presented in the following paragraph. Tables D.14-1 through D.14-7 in Appendix D show the presence of geologic hazard conditions for the Proposed Route as well as a comparison between Route Alternative and the comparison portion of the Proposed Route for miles crossed.

Segment 1E

Segment 1E, as proposed, would link the Windstar and Aeolus Substations in south-central Wyoming with a 100.6-mile 230-kV single-circuit transmission line. Twenty acres of the expansion of Windstar and Aeolus Substations and 0.5 acre for one regeneration site are attributed to Segment 1E. Alternative 1E-A is a 16.1-mile alternative along the north end of Segment 1E, which was the Proponents' initial proposal before moving the Proposed Route at the suggestion of local landowners to avoid the more settled area around Glenrock. Alternative 1E-B is 21.4 miles longer than the Proposed Route but is being considered by the Proponents because it would avoid a Wyoming-designated sage-grouse core area to the east. The BLM has required the consideration of Alternative 1E-C, which parallels Segment 1W 230-kV lines into the Aeolus Substation (see Appendix A, Figure A-2).

Table 3.14-7. Summary of Potential Geologic Hazards in Proposed Routes and Alternatives

Segment Number	Route	Total Route Miles	Geologic Hazards				
			Earthquake Hazard[1/]	Earthquake Buffer[2/]	Landslide Hazard	Subsidence	Shallow Bedrock
1E	Proposed – Total Length	100.6				Yes	Yes
	Proposed – Comparison Portion for Alternative 1E-A	17.6				Yes	Yes
	Alternative 1E-A	16.1				Yes	Yes
	Proposed – Comparison Portion for Alternative 1E-B	37.9				Yes	Yes
	Alternative 1E-B	59.3				Yes	Yes
	Proposed – Comparison Portion for Alternative 1E-C	75.4				Yes	Yes
	Alternative 1E-C	48.7			Yes	Yes	Yes
1W(a)	Proposed – Total Length	76.5			Yes	Yes	Yes
	Proposed – Comparison Portion for Alternative 1W-A	20.3				Yes	Yes
	Alternative 1W-A	16.2				Yes	Yes
1W(c)	Proposed – Total Length	70.6			Yes	Yes	Yes
2	Proposed – Total Length	96.7				Yes	
	Proposed – Comparison Portion for Alternative 2A	28.8				Yes	
	Alternative 2A	28.4				Yes	
	Proposed – Comparison Portion for Alternative 2B	7.0				Yes	
	Alternative 2B	6.2				Yes	
	Proposed – Comparison Portion for Alternative 2C	28.4				Yes	
	Alternative 2C	24.4				Yes	
3	Proposed – Total Length	56.4			Yes	Yes	Yes
4	Proposed – Total Length	203.0	Yes	Yes	Yes	Yes	Yes
	Proposed – Comparison Portion for Alternatives 4A,B,C,D,E,F	90.2	Yes	Yes	Yes	Yes	Yes
	Alternative 4A	85.2	Yes	Yes	Yes	Yes	Yes
	Alternative 4B	100.2	Yes	Yes	Yes	Yes	Yes
	Alternative 4C	101.6	Yes	Yes	Yes	Yes	Yes
	Alternative 4D	100.8	Yes	Yes	Yes	Yes	Yes
	Alternative 4E	102.2	Yes	Yes	Yes	Yes	Yes
	Alternative 4F	87.5	Yes	Yes	Yes	Yes	Yes
5	Proposed – Total Length	54.6	Yes	Yes			Yes
	Proposed – Comparison Portion for Alternatives 5A,B	25.3	Yes	Yes			Yes
	Alternative 5A	33.7	Yes	Yes			Yes

Table 3.14-7. Summary of Potential Geologic Hazards in Proposed Routes and Alternatives (continued)

Segment Number	Route	Total Route Miles	Geologic Hazards				
			Earthquake Hazard[1/]	Earthquake Buffer[2/]	Landslide Hazard	Subsidence	Shallow Bedrock
5 (cont.)	Alternative 5B	44.4	Yes	Yes			Yes
	Proposed – Comparison Portion for Alternative 5C	33.2	Yes	Yes			Yes
	Alternative 5C	26.1	Yes	Yes			Yes
	Proposed – Comparison Portion for Alternative 5D	19.4	Yes	Yes			Yes
	Alternative 5D	17.5	Yes	Yes			Yes
	Proposed – Comparison Portion for Alternative 5E	5.8	Yes	Yes			
	Alternative 5E	5.3	Yes	Yes			
6	Proposed – Total Length	0.5	Yes	Yes			
7	Proposed – Total Length	118.1	Yes	Yes			Yes
	Proposed – Comparison Portion for Alternatives 7A, B	35.2	Yes	Yes			Yes
	Alternative 7A	38.0	Yes	Yes			Yes
	Alternative 7B	46.4	Yes	Yes			Yes
	Proposed – Comparison Portion for Alternative 7C	20.1	Yes	Yes			Yes
	Alternative 7C	20.3	Yes	Yes			Yes
	Proposed – Comparison Portion for Alternative 7D	6.2	Yes				Yes
	Alternative 7D	6.8	Yes				Yes
	Proposed – Comparison Portion for Alternative 7E	3.8					Yes
	Alternative 7E	4.5					Yes
	Proposed – Comparison Portion for Alternative 7F	10.5					Yes
	Alternative 7F	10.8	Yes				Yes
	Proposed – Comparison Portion for Alternative 7G	3.1					Yes
	Alternative 7G	3.2					Yes
	Proposed – Comparison Portion for Alternative 7H and 7I	118.1	Yes	Yes			Yes
	Alternative 7H	127.5	Yes	Yes			Yes
	Alternative 7I	173.4	Yes	Yes	Yes		Yes
	Proposed – Comparison Portion 7/9 for Alternative 7J[3/]	143.9	Yes	Yes			Yes
	Alternative 7J[3/]	202.1	Yes	Yes	Yes		Yes

Table 3.14-7. Summary of Potential Geologic Hazards in Proposed Routes and Alternatives (continued)

Segment Number	Route	Total Route Miles	Geologic Hazards				
			Earthquake Hazard[1/]	Earthquake Buffer[2/]	Landslide Hazard	Subsidence	Shallow Bedrock
8	Proposed – Total Length	131.0	Yes	Yes	Yes		Yes
	Proposed – Comparison Portion for Alternative 8A	51.4		Yes	Yes		Yes
	Alternative 8A	53.6		Yes			Yes
	Proposed – Comparison Portion for Alternative 8B	45.3			Yes		Yes
	Alternative 8B	45.8			Yes		Yes
	Proposed – Comparison Portion for Alternative 8C	6.5					Yes
	Alternative 8C	6.4					Yes
	Proposed – Comparison Portion for Alternative 8D	6.9					Yes
	Alternative 8D	8.1					Yes
	Proposed – Comparison Portion for Alternative 8E	7.0	Yes	Yes	Yes		Yes
	Alternative 8E	18.5	Yes	Yes			Yes
9	Proposed – Total Length	161.7					Yes
	Proposed – Comparison Portion for Alternative 9A	7.8					Yes
	Alternative 9A	7.7					Yes
	Proposed – Comparison Portion for Alternative 9B	49.5					Yes
	Alternative 9B	53.2		Yes			Yes
	Proposed – Comparison Portion for Alternative 9C	14.7					Yes
	Alternative 9C	15.3					Yes
	Proposed – Comparison Portion for Alternatives 9D, 9E, 9F, 9G, and 9H	57.2					Yes
	Alternative 9D	58.4					Yes
	Alternative 9E	68.7					Yes
	Alternative 9F	62.9					Yes
	Alternative 9G	56.4					Yes
	Alternative 9H	61.0					Yes
10	Proposed – Total Length	33.6		Yes			Yes

1/ Based on OPS data (see Section 3.14.1.4).
2/ Based on historical earthquake epicenters (see Section 3.14.1.4).
3/ Alternative 7J connects with Segment 9 approximately 25.8 miles west of the proposed Cedar Hill Substation, which is the western terminus of Segment 7 and the beginning point for Segment 9. The table above compares 7J (202 miles) with the corresponding portion of Segment 7/9 (118.1 miles of Segment 7 and 25.8 miles of Segment 9, for a total of 143.9 miles). All other Segment 7 alternatives are compared to Segment 7 of the Proposed Route (118.1 miles) only.

Earthquake and landslide risks are low in this segment for the Proposed Route and all Route Alternatives. The Proposed Route contains shallow bedrock, and about 5 percent of the construction disturbance area contains subsidence potential due to blasting. Alternatives 1E-A, 1E-B, and 1E-C all contain less subsidence potential than the comparison portion of the Proposed Route. Alternatives 1E-B and 1E-C avoid crossing abandoned mines, while the construction disturbance areas of all three comparison portions cross at least 14 acres of abandoned mines. Alternative 1E-B is 21.4 miles longer than the comparison portion of the Proposed Route, resulting in a longer distance for exposure to earthquake risks. The route with the least geologic hazards potential would be Alternatives 1E-A and 1E-C in combination with the remainder of the Proposed Route.

Segment 1W

Segment 1W is composed of two parts, Segment 1W(a) and 1W(c), both of which would consist of a new 230-kV line for part of their length and a reconstruction of an existing 230-kV line for the remaining part. Segment 1W(a) would be about 76.5 miles long, and would extend from the Windstar Substation to the Aeolus Substation. Segment 1W(c) would be about 70.6 miles long, and would extend from the Dave Johnston Power Plant to the Aeolus Substation. Alternative 1W-A is a 16.2-mile alternative located near the town of Glenrock, which was the Proponents' initial proposal before moving the Proposed Route at the suggestion of local landowners in order to avoid the more settled area around Glenrock. Twenty acres of the proposed expansion at the Windstar and Aeolus Substations are attributed to Segment 1W(a) and 3 acres of the expansion at the Heward Substation and 17 acres of the expansion at the Windstar and Aeolus Substations are attributed to Segment 1W(c). There are no Route Alternatives proposed south of that point (see Appendix A, Figure A-2).

Earthquake hazards are low in this segment. The transmission line crosses the South Granite Mountain Fault in this segment, a west-northwest trending Class B fault that is potentially Quaternary in age. Project structures would need to be engineered to withstand seismic forces, including differential movement across fault zones. Approximately 6 percent of the Proposed Route is located in high landslide risk; otherwise, landslide risks are low. Implementing mitigation measure GEO-1 would assist in mitigating the construction effects to landslide-prone areas.

Low percentages of construction and operations disturbance areas are present in areas of potential subsidence. The construction acreage of Alternative 1W-A contains only 19 percent of the subsidence potential area in the comparison portion of the Proposed Route. Nine Segment 1 exploratory boring logs were reviewed that contained shallow bedrock, eight of which contained shallow bedrock in areas not identified by STATSGO. This suggests that Table 3.14-5 may underestimate the areas of shallow bedrock for the Segment 1 Analysis Area. However, blasting would not occur in areas of subsidence. Using Alternative 1W-A in combination with the remainder of Segment 1W would have the lowest potential for geologic hazards.

Segment 2

Segment 2, as proposed, would link the Aeolus and Creston Substations in southeast Wyoming with two 500-kV circuits on one structure. One circuit would be operated at

230 kV during the initial phase of the Project. Its total proposed length is 96.7 miles. Fifty-two acres of the expansion of the Aeolus Substation and the construction of the Creston Substation and 0.5 acre for one regeneration site are attributed to Segment 2. There are three Route Alternatives, two of which are near the community of Fort Fred Steele. Alternative 2A at 28.4 miles long is being considered by the BLM because it remains in the WWE corridor nearer the town and the state historic site, and Alternative 2B, at 6.2 miles, is closer to the community than the comparison portion of the Proposed Route and was the initially proposed route before the Proponents responded to local suggestions and relocated the Proposed Route farther to the south. Alternative 2C is a 24.4-mile alternative located north of Hanna, Wyoming. It is being evaluated at the recommendation of the Wyoming Governor's office to follow a utility corridor approved by that office for minimizing effects to sage-grouse (see Appendix A, Figure A-3).

Segment 2 contains a moderate risk from geologic hazards, mainly from potential subsidence. This segment contains low earthquake and landslide risks. According to NRCS STATSGO soil data, Segment 2 is the only segment where shallow bedrock is not present. The east half of Segment 2 is located within a coal-producing area (see Section 3.12). The route overlies several miles of continuous historic underground coal mines near Hanna, Wyoming, on the east end of the route. According to the WDEQ (Parfitt 2010), underground workings in this area are extensive and not well-mapped. Some subsidence has already occurred in this area. This portion of the route should receive an engineering review relative to potential subsidence prior to construction. In addition, voids in bedrock near coal deposits could contain methane. Shallow bedrock is not reported in Segment 2, but if blasting is necessary, the Proponents should follow the Blasting Plan procedures BLA-1 and BLA-2 for blasting in areas of possible coal-related methane. Subsidence potential occurs in some of the constructional and operations disturbance areas. As shown in Tables D.14-4 and D.14-5 in Appendix D, Alternative 2A has a larger area of subsidence in the operations and construction disturbance areas than the comparison portion of the Proposed Route. Alternatives 2B and 2C have smaller areas of subsidence in the construction and operations areas. Mitigation measure GEO-2 has been identified by the Agencies as a means of substantially reducing the potential for subsidence impact.

Segment 3

Segment 3, as proposed, would link the Creston and Anticline Substations in southeast Wyoming with two 500-kV circuits on one structure. One circuit would be operated at 230 kV during the initial phase of the Project. Its total proposed length between those two substations is 46.7 miles. Sixty-nine acres of the construction of the Anticline and Creston Substations are attributed to Segment 3. Segment 3 would also link the Anticline and Jim Bridger Substations with a 4.3-mile 230-kV line and a 5.5-mile 345-kV line and includes the 10-acre expansion of the Jim Bridger 345-kV Substation. There are no alternatives proposed along this segment (see Appendix A, Figure A-4).

Segment 3 contains low risk from earthquakes. Approximately 37 percent of the route is located in areas containing medium landslide risk. To minimize failures due to landslides, the Agencies have identified a landslide mitigation plan be prepared (GEO-1) that addresses measures to be taken in the Project design, construction, and operation.

Subsidence will be possible in operations and construction disturbance areas because 42 percent of the Analysis Area is underlain by mining leases. Shallow bedrock possibly requiring blasting is present over 73 percent of the route. Blasting in areas of potential subsidence may cause subsidence. The west end of Segment 3, including the area of the Anticline Substation, is located within a coal-producing area (see Section 3.12). If blasting of shallow bedrock is necessary in this vicinity, the Proponents should follow the EPM procedures outlined in Appendix C-1, Attachment E, for blasting where methane may occur. The Proponents intend to prepare a site-specific Blasting Plan prior to construction that incorporates covering blasting procedures, use of qualified blasters, site control and protection measures, and compensation for repair of damage. Mitigation measure GEO-2 has been identified by the Agencies as a means of substantially reducing the potential for subsidence impact.

Segment 4

Segment 4, as proposed, would link the Anticline Substation near the Jim Bridger Power Plant in southwestern Wyoming with the Populus Substation in Idaho with two 500-kV circuits on one structure. Its total proposed length is 203 miles. Eighty-nine acres of the construction of the Anticline Substation and the expansion of the Populus Substation and 1.5 acres for three regeneration sites are attributed to Segment 4. It has six Route Alternatives in the middle portion of its route but the first 52 miles to the east and the last 61 miles to the west (in Idaho) do not have any Route Alternatives. The middle section of the Proposed Route is 90.2 miles long, and its Route Alternatives vary from 85 to 102 miles long. These alternatives were proposed by the Wyoming Governor's office (4A, paralleling the existing 345-kV lines throughout); by the BLM Kemmerer FO (4B through 4E, including edits from various cooperating agencies), with the intent to avoid impacts to cultural resources to the extent practical; and by the Proponents (4F, attempting to avoid impacts to cultural resources while still remaining north of the existing lines) (see Appendix A, Figures A-5 and A-6).

Segment 4 and all of its alternatives stand out as containing the greatest potential geologic hazards of all segments. None of the Segment 4 alternatives offer a way of avoiding the multiple hazards present. Large portions of Segment 4 contain medium to high risk of earthquakes and Segment 4 routes cross several north/south-trending Quaternary faults, including the Rock Creek Fault, Eastern and Western Bear Valley Faults, and the Sublette Flat Fault. Project structures would need to be engineered to account for differential movement across active faults. Historical earthquakes have been in the magnitude 6.0 to 6.9 range, medium-size earthquakes capable of damage of structures for distances up to 100 kilometers.

Segment 4 also contains the highest risk from landslides. This segment and all the alternatives contain large areas of medium to high landslide risk, including approximately 0.5 mile of the Proposed Route on the western edge of the Caribou-Targhee NF. In the mid-1980s, a landslide failure near Viva Naughton Reservoir in southwest Wyoming (near Route Alternatives 4A and 4F) necessitated the re-alignment of the existing Bridger to Borah 345-kV transmission lines. To minimize failures due to landslides, the Agencies have identified mitigation measures (GEO-1, GEO-3, and GEO-4) to be taken in the Project design, construction, and operation.

GEO-3 On-site slope stability examinations will be performed on NFS lands for slopes over 40 percent prior to designing project features that require the removal of forest.

GEO-4 A site-specific soil analysis shall be conducted prior to construction to verify any areas identified as unstable or marginally unstable in the Caribou National Forest Soil Resource Inventory.

Using the STATSGO database information, approximately 32 percent of the Proposed Route is located on shallow bedrock. Results of the Segment 4 drilling log review indicate that five borings advanced in areas assumed to contain shallow bedrock did not encounter any, and one boring contained shallow bedrock in an area not anticipated by STATSGO. Therefore, shallow bedrock should be expected in Segment 4, but the bedrock percentages reported here are approximate. Much of the shallow bedrock is located within areas of medium to high landslide risk or in areas of potential subsidence. Blasting in these areas may cause landslides or subsidence. Trona mining companies in this segment indicated that subsidence has occurred near some of the previously mined areas, and they recommended avoidance of trona mining areas to avoid construction on subsidence-prone areas, as well as to avoid interference with mining operations (Hodgson 2008). The Proponents used active mining areas as a constraint when siting alternatives for the transmission line. Segment 4 includes three coal-producing locations (see Section 3.12 – Minerals). Blasting in these areas should occur using the EPM procedures BLA-1 and BLA-2 outlined in Appendix C-1 for blasting in areas of possible methane. The Proponents intend to prepare a site-specific Blasting Plan prior to construction that incorporates covering blasting procedures, use of qualified blasters, site control and protection measures and compensation for repair of damage. Mitigation measure GEO-2 has been identified by the Agencies as a means of substantially reducing the potential for subsidence impact.

In summary, the Proposed Route and all Route Alternatives contain the same landslide risk zones. Therefore, the risks are proportional to the segment lengths. As shown in Table 3.14-7, Alternatives 4A and 4F are shorter than the comparison portion of the Proposed Route and Alternatives 4B, 4C, 4D, and 4E are longer. Alternative 4A is the shortest of all and would have the lowest risk from landslides. Alternative 4A also has the least exposure to subsidence risk for the same reasons as landslide risk.

Segment 5

Segment 5, as proposed, would link the Populus and Borah Substations with a 54.6-mile single-circuit 500-kV line. Forty-four acres of the expansion of the Populus and Borah Substations are attributed to Segment 5. There are five Route Alternatives including two proposed by the BLM to avoid the Deep Creek Mountains (5A and 5B; 8 miles and 19 miles longer than the comparison portion of the Proposed Route), one preferred by Power County that crosses the Fort Hall Indian Reservation (5C; 6 miles shorter than the comparison portion of the Proposed Route), one originally proposed by the Proponents (5D; 2 miles shorter than the comparison portion of the Proposed Route but located within more agricultural lands), and one proposed by Power County as an alternative approach to the Borah Substation (5E) (see Appendix A, Figure A-7).

Earthquake risks in Segment 5 are medium to high. Portions of Segments 5 through 10 are located within the 100-mile buffer of historic earthquakes with magnitudes greater than 7.0. Landslide risks are low in this segment. Less than 27 percent of this segment is located in shallow bedrock, none of which is located in an area of subsidence or landslides. Therefore, the risk of initiating landslides or subsidence from blasting should be minimal. Subsidence was not identified in Segments 5 through 10 because underground mining has generally not occurred within the Project area in these segments.

The Proponents intend to prepare a site-specific Blasting Plan in accordance with the EPMs in Appendix C-1, Attachment E, prior to construction that incorporates covering blasting procedures, use of qualified blasters, site control and protection measures, and compensation for repair of damage.

In summary, earthquake risks are the only important risk from geologic hazards in Segment 5. Since the earthquake risk includes the entire segment, the risks are proportional to the lengths. Alternatives 5C and 5D are shorter than the comparison portion of the Proposed Route and therefore have less risk. Alternatives 5A and 5B are longer, with Alternative 5B being the longest and resulting in the greatest exposure to earthquake-related risks.

Segment 6

Segment 6 is an existing transmission line linking the Borah and Midpoint Substations; it is now operated at 345 kV but would be changed to operate at 500 kV. This segment has no Route Alternatives. Existing support structures would be used and impacts would be limited to within approximately 0.25 mile from each substation to allow for moving the entry point into the substation to the new 500-kV bay. Thirty-one acres of the expansion of the Borah and Midpoint Substations are attributed to Segment 6. Changes in the two substations would allow it to be operated at 500 kV (see Appendix A, Figure A-8).

Segment 7

Segment 7, as proposed, would link the Populus and Cedar Hill Substations with a 118.1-mile single-circuit 500-kV line. Forty-two acres of the expansion of the Populus and the construction of the Cedar Hill Substations and 1 acre for two regeneration sites are attributed to Segment 7. In addition to the Proposed Route, which is principally on private lands, Route Alternatives have been proposed by the BLM to avoid the Deep Creek Mountains (7A and 7B; which are 5 miles and 11 miles longer than the comparison portion of the Proposed Route), by local landowners (7C, 7D, 7E, 7F, and 7G, which all represent minor adjustments proposed to address local issues), by local landowners to avoid private agricultural lands (7I or the State Line Route, which is 55 miles longer than the Proposed Route and would require 0.5 acre for an additional regeneration site), and by the Proponents to avoid the State Line Route (7H, which is 10 miles longer than the Proposed Route). Alternative 7J, which is a variant of the State Line Route also proposed by local landowners, would not terminate at the Cedar Hill Substation. This alternative, referred to as the Rogerson Alternative, would require a different substation be constructed near a 345-kV existing transmission line (approximately 24 miles southwest of the Cedar Hill Substation; see Appendix A, Figure A-9). The tables and discussion in this document

compare 7J (202 miles) with the corresponding portion of Segment 7/9 (118.1 miles of Segment 7 and 25.8 miles of Segment 9, for a total of 143.9 miles). All other Segment 7 alternatives are compared to Segment 7 of the Proposed Route (118.1 miles) only.

Earthquake risks in Segment 7 are variable with an approximately even mix of low, medium, and high risk. Landslide risks are low, with the exception of one 4.3-mile interval of Alternatives 7I/7J that contains medium landslide risk. This interval also contains shallow bedrock that, if blasted, may increase the landslide risk.

The Proponents intend to prepare a site-specific Blasting Plan in accordance with the EPMs in Appendix C-1, Attachment E, prior to construction that incorporates covering blasting procedures, use of qualified blasters, site control and protection measures, and compensation for repair of damage.

In summary, earthquake risks are the only important risk from geologic hazards for Segment 7. The Proposed Route is the shortest route and therefore would have the lowest exposure to geologic hazard risks.

Segment 8

Segment 8, as proposed, would link the Midpoint and Hemingway Substations. This 131-mile single-circuit 500-kV transmission line would stay north of the Snake River until crossing through the SRBOP parallel to an existing 500-kV transmission line before ending at the Hemingway Substation. Thirteen acres of the expansion of the Midpoint Substation and 0.5 acre for a regeneration site are attributed to Segment 8. There are five Route Alternatives: 8A, which follows the WWE corridor but crosses the Snake River and I-84 twice (while the Proposed Route would stay north of this area); 8B and 8C, which represent the old routes originally proposed by the Proponents but that have now been changed to avoid the cities of Kuna and Mayfield, respectively; 8D, which represents a small revision involving a rebuild of the existing transmission line to move both away from the National Guard Maneuver Area; and 8E, which was proposed by the BLM in order to avoid crossing the Halverson Bar non-motorized portion of the Guffey Butte-Black Butte Archaeological District (see Appendix A, Figure A-10).

The earthquake and landslide risks in Segment 8 are generally low except that the eastern half of the Proposed Route does fall at the edge of the buffer for a high risk earthquake zone. Shallow bedrock is present, but except for about 2 miles in Alternative 8B, any necessary blasting would not occur in landslide-prone areas.

The Proponents intend to prepare a site-specific Blasting Plan in accordance with the EPMs in Appendix C-1, Attachment E, prior to construction that incorporates covering blasting procedures, use of qualified blasters, site control and protection measures, and compensation for repair of damage.

In summary, the Segment 8 Proposed Route and Route Alternatives possess similar risks from geologic hazards and the risks are relatively low.

Segment 9

Segment 9, as proposed, would link the Cedar Hill and Hemingway Substations with a 161.7 mile single-circuit 500-kV transmission line which skirts the Jarbidge and Owyhee Military Operating Areas to the north, then follows the WWE corridor just north of the

Saylor Creek Air Force Range, passing through Owyhee County before entering into the Hemingway Substation. Fifteen acres of the construction of the Cedar Hill Substation and 1 acre for two regeneration sites are attributed to Segment 9. There are eight Route Alternatives proposed, including 9A, which was the Proponents' Proposed Route until moving to avoid the Hollister area; 9B, which is being considered by the BLM because it follows the WWE corridor and parallels existing utility corridors; 9C, which was the Proponents' Proposed Route until moving to avoid the Castleford area; and 9D and 9E, proposed by the Owyhee County Task Force, that cross more public lands north and south of the Proposed Route, respectively, than the Proposed Route. Most of Alternative 9D would be within the SRBOP. Alternatives 9F, 9G, and 9H were proposed to avoid crossing the non-motorized area south of C.J. Strike Reservoir. Alternatives 9G and 9H provide an alternate route location south of Alternative 8E (see Appendix A, Figure A-11).

Segment 9 contains low risks from earthquakes and landslides. Shallow bedrock is present, but because landslide risk is low, blasting would probably not cause landslides.

The Proponents intend to prepare a site-specific Blasting Plan in accordance with the EPMs in Appendix C-1, Attachment E, prior to construction that incorporates covering blasting procedures, use of qualified blasters, site control and protection measures, and compensation for repair of damage.

In summary, the Segment 9 Proposed Route and all Route Alternatives have low exposure to risks from geologic hazards.

Segment 10

Segment 10, as proposed, would link the Cedar Hill and Midpoint Substations with a 33.6-mile single-circuit 500-kV line, following a WWE corridor for most of its distance. Twenty-eight acres of the expansion of the Midpoint Substation and of the construction of the Cedar Hill Substation are attributed to Segment 10. There are no Route Alternatives proposed along this segment (see Appendix A, Figure A-12).

Segment 10 also contains low risks from earthquakes and landslides except that the northern three quarters of the Segment are within the edge of the buffer for a high risk earthquake zone. Blasting of shallow bedrock would not be likely to cause slope instabilities.

The Proponents intend to prepare a site-specific Blasting Plan in accordance with the EPMs in Appendix C-1, Attachment E, prior to construction that incorporates covering blasting procedures, use of qualified blasters, site control and protection measures, and compensation for repair of damage.

3.14.2.4 Design Variation

A Design Variation is being considered that would consist of constructing two single-circuit lines in Segments 2 through 4 instead of a single double-circuit line (which is the design assessed above). The disturbance footprint of the two single-circuit towers is greater than that of the double-circuit tower, in part because the requested ROW would be wider, but also because helicopter-assisted construction could be implemented in these areas due to the lighter weight of the towers, which would require additional fly

yards. The additional ROW space and the fly yards would cause additional temporary disturbance during construction. Across Segments 2, 3, and 4, the additional disturbance of the single-circuit tower alternative ranges from 25 to 30 percent greater than the comparable portions of the double-circuit tower disturbance under the proposed design. The two single circuits require more ground disturbance, but would be designed and constructed to the same standards as the Proposed Action. The exposure of either design to geologic hazards is equivalent. The effects from the two single-circuit lines would be slightly greater than from the double-circuit line, because there is more area of disturbance.

3.14.2.5 Structure Variation

The proposed guyed Structure Variation would add four guy wires about 140 feet long from a point about 100 feet up in each tower to four guy anchors spaced in a square around the tower (Appendix B, Figure B-6). This would not change the amount of disturbance during construction or operations appreciably. Therefore, there is no appreciable difference in impact on geologic hazards from the use of this Structure Variation when compared to the use of self-supporting lattice towers. Guyed structures would not be more susceptible to geologic hazards than the self-supporting lattice structures.

3.14.2.6 Schedule Variation

The Schedule Variation uses the two single-circuit Design Variation described above but extends construction over a longer timeframe. Initially only one of the eventual two single-circuit lines would be constructed with the second to be constructed at a later date. The Schedule Variation proposes that the first single-circuit transmission line in Segments 2, 3, and 4 would be built as soon as a ROW grant is issued, but that the second line would not begin construction until late 2018. This would mean nearly 2 years between the end of construction for the first line and beginning of construction for the second line. Any staging areas and fly yards that had been used for the first stage would have been revegetated after construction was complete and would have to be cleared again. There would be two sets of construction disturbances adding movement, noise, and dust to the area of construction in two instances in any given area. The extended construction schedule variation would not substantially alter the risk of geologic hazards.

3.14.3 Mitigation Measures

To minimize or avoid impacts on geologic hazards, the Proponents have committed to EPMs that would be implemented Project-wide as outlined in this section and in Appendix C.

The following mitigation measures identified by the Agencies are required on federally managed lands. The Agencies recommend that the Proponents incorporate the measures into their EPMs and apply them Project-wide.

GEO-1 A site-specific landslide mitigation plan that addresses measures to be taken in the design, construction, and operation to minimize failure due to landslides must be prepared and submitted by the Proponents with the

construction POD prior to issuance of a ROW grant on federally managed lands.

GEO-3 On-site slope stability examinations will be performed on NFS lands for slopes over 40 percent prior to designing project features that require the removal of forest.

GEO 4 A site-specific soil analysis shall be conducted prior to construction to verify any areas identified as unstable or marginally unstable in the Caribou National Forest Soil Resource Inventory.

In addition, the following mitigation measure has been proposed by the Agencies and adopted by the Proponents:

GEO-2 Review the final location of the preferred alternative with affected mine operators and lessees to ensure all measures are taken to protect against subsidence.