3.1 EARTH RESOURCES

3.1.1 Affected Environment

This section provides a summary discussion of geologic and soil characteristics pertinent to the project area. Supporting technical detail is provided in **Appendix A**.

3.1.1.1 General Physiography

The proposed location for the Desert Claim wind energy facility is on the western edge of the Columbia Plateau, approximately 50 miles (80 kilometers [km]) east of the Cascade Range divide. The proposed project area is located within the Kittitas Valley, a wide segment of the Yakima River Valley that is the topographic expression of a broad synclinal basin (inward dipping fold) within the Yakima Fold Belt. The project area rises gradually to the north to Table Mountain in the Wenatchee Mountain Range. Manastash Ridge forms the southern boundary of the Kittitas Valley.

Two project alternatives involving other sites are addressed in this EIS. The site for Alternative 1 is located along the eastern margin of the Kittitas Valley, approximately 14 miles to the southeast of the Desert Claim project area. The site for Alternative 2 is located near the western edge of the Kittitas Valley, approximately 5 miles to the west of the Desert Claim site. All three sites are located within the same physiographic province, and the discussion of regional geology provided in **Section 3.1.1.2** and **Appendix A** is applicable to all three sites. Following a description of geologic and soil conditions applicable to the Desert Claim project area, comparable conditions for the Alternative 1 and Alternative 2 sites is provided in **Sections 3.1.1.6** and **3.1.1.7**, respectively.

The Kittitas Valley is filled with eroded sediments from surrounding ridges and Pleistocene-age glacial outwash deposits, up to a level approximately 1,600 feet above the Yakima River in the project area. Older glacial and nonglacial deposits have been carved by Recent-age (postglacial) alluvial material, leaving remnant terraces up to 200 feet above the surrounding topography.

3.1.1.2 Regional Geology

The Columbia Plateau of central and eastern Washington is underlain by the Miocene-age flows of the Columbia River Basalt Group (CRBG). The Grande Ronde Basalt flow was the largest of the CRBG flows and underlies Kittitas Valley, continuing approximately 15 miles northeast and up-valley of the project area to lap onto the eastern margin of the Cascade Range. Interfingered with the basalt flows are sandstones, siltstones, and conglomerates of the Ellensburg Formation that are derived from sediment eroded or erupted from the Cascade Range.

Regional tectonic stresses caused north-south compression and east-west extension in central Washington during emplacement of the CRBG. The stresses created the southeast-trending ridges and valleys of the Yakima Fold Belt. Kittitas Valley and the Wenatchee Mountains are a resulting valley and ridge, respectively, of the Yakima Fold Belt. The stress regime creating the Yakima Fold Belt is likely still active today (Reidel et al. 1994).

Kittitas Valley in the vicinity of the project is filled with Pliocene-age to Recent-age alluvial material derived from the surrounding basalt mountains and glacial deposits. Pleistocene-age glaciers originating in the upper Yakima River Valley contributed sediment from their source to the Kittitas Valley. Outwash

(glacial sand and gravel) of Kittitas Drift extends to the central Kittitas Valley in the project vicinity. Older Thorp Gravel deposits (composed of sand and gravel) in Kittitas Valley are of Pliocene-age and may not be of glacial origin. Younger, post-glacial, sediments are derived from the surrounding basalt mountains to create alluvial fans and deposits in the project vicinity (see **Appendix A** for further details).

3.1.1.3 Desert Claim Project Area Geology

Geologic conditions of the Desert Claim project area were evaluated using data obtained from field explorations by Associated Earth Sciences, Inc. (AESI) and AESI's review of regional geologic maps and publications. Additional text and figures describing the geologic conditions of the project area and the locations of AESI's field explorations are included in **Appendix A**. Detailed exploration logs documenting the findings of the field studies are available for review from Kittitas County.

The surficial geology of the project area consists of Recent-age postglacial alluvial fans and other stream deposits that overlie and carve into older Pleistocene-age sidestream glacial outwash (Kittitas Drift) and Pliocene-age sidestream alluvium (Thorp Gravel). Erosion by the younger streams has carved distinct terraces in the older deposits. Miocene-age Grande Ronde Basalt underlies the sediments described above and the entire project area. It crops out on the northernmost property of the project and other isolated locations. A small outcrop of Miocene-age volcaniclastic Ellensburg Formation was located on the northeastern portion of the project area at the base of a Thorp Gravel terrace. **Appendix A** provides a detailed description of the geologic units present in the project area and field observations of those units.

The ridges and valleys in the region have a general northwest-to-southeast structural orientation. Folds and faults identified in the bedrock at and in the vicinity of the project area often follow this northwest-southeast trend. This trend corresponds to the same general trend of the Olympic-Wallowa Lineament (OWL), a 500-km alignment of folds and faults stretching from northeast Oregon across Washington to the Puget Sound area. Recent tectonic studies (McCaffrey et al. 2000) indicate that the OWL may be an active structure that divides Washington from a tectonic block of earth crust that includes most of Oregon and is rotating relative to Washington. A detailed discussion of this structure and the tectonic environment is in **Appendix A, Section 3.1.**

Growth of anticlines south of the Kittitas Valley may have influenced the accumulation of the Pliocene-age Thorp Gravel in the Kittitas Valley that is contemporaneous with the accumulation of deposits farther east on the Columbia Plateau (Ringold Formation). Focal mechanisms of earthquakes indicate modern north-south compressive stress in some eastern basins analogous to the Kittitas Valley; suggesting that structures in central Washington have grown during the Pliocene and younger epochs. Waitt (1979) cited many references that indicate faults cutting the Grande Ronde Basalt and Ellensburg Formation are associated with many of the anticlines in central Washington. He suggested that if some of the folds are growing, some of the faults may be at least intermittently active, but there is little evidence that Pleistocene sediment in central Washington is either folded or faulted. Waitt (1979) concluded that faults peripheral to the Kittitas Valley evidently do not disrupt modern sidestream fans and can be dated only as post-Miocene-age and pre-late Holocene-age (Recent-age).

Thorp Gravel terraces are interrupted by three east-trending, north-facing fault scarps related to regional bedrock structures. Tabor et al. (1982) mapped the structures; one occurs immediately south of Section 31 (Township 19 North, Range 19 East), Section 35, and Section 36 (Township 19 North, Range 18 East). Part of this fault trace is shown on **Figure A-1** in **Appendix A**. The trace of a second structure is apparent in the Thorp Gravel terrace approximately 2 km west of the project area boundary. The third structure is

marked by small terraces of Thorp Gravel that end abruptly approximately 8 km southwest of the project area boundary. The Thorp Gravel appears to be the youngest deposits that are demonstrably deformed by these structures. The younger Kittitas Drift deposits are not demonstrably offset. This bounds the likely age of faulting to be between 3.7 and 0.13 million years.

3.1.1.4 Project Area Soils

General Conditions

Physical and chemical weathering of surficial glacial deposits, nonglacial deposits, and bedrock has resulted in the formation of various types of surface soils on the project site. Surface soils data were obtained from the Natural Resource Conservation Service (NRCS) office located in Spokane, Washington. The NRCS soil survey of Kittitas County has not been completed as of the date of this report. Draft versions of soil maps and descriptions were available for the project site (NRCS 2003a). Individual soil units have been mapped by the NRCS on recent orthophotoquads of the site vicinity. **Figure A-4** in **Appendix A** presents a surface soils map for the project area based on the orthophotoquads obtained from the NRCS and modified as determined from site-specific subsurface investigations.

Comprehensive descriptions for map units shown in **Figure A-4** are not currently available. However, draft engineering and selected physical properties of each soil unit were obtained from the NRCS and are summarized in **Table A-1** (NRCS 2003a). Also, soil profiles for most on-site soils are available from the NRCS database via the Internet (NRCS 2003a). Based on this information, descriptions of each unit are presented in **Appendix A, Section 2.2**.

The five factors typically used to define the type, characteristics and formation of specific soils are: (1) parent material; (2) climate; (3) topography; (4) organisms (biota); and (5) time. The soils of the wind energy site formed over young glacial, nonglacial alluvial deposits, and basalt bedrock. Climatic conditions are semiarid. Average annual precipitation is 8.9 inches and average annual snowfall is 27.9 inches. Summers are warm and dry, and winters are cold and somewhat moist. Topography is gentle over most of the site. Steeper slopes are found on the northernmost property. On-site elevations range from 1,900 to 3,500 feet. Sagebrush and grasses cover most of the site. Organism activity and diversity is low due to the dry climate. The soil units exhibit a direct relationship to the characteristics listed above.

Geologic and Soil Unit Correlation

Grande Ronde Basalt

Soils that form over Grande Ronde Basalt are characterized by brown, stony/cobbly and ashy loam. Gray and yellow hues are present as well. These soils are moderately deep to deep, and well drained. Permeability is moderate and runoff varies with slope.

Thorp Gravel

Soils that form over Thorp Gravel are characterized by brown, gravelly and ashy loam. Gray and yellow hues are present as well. These soils typically have a cemented zone 1 to 2 feet below ground surface. Thorp Gravel soils are very shallow to moderately deep and well drained. Permeability is slow to moderately slow and runoff is slow to medium.

Kittitas Drift

Soils that form over Kittitas Drift are characterized by brown and gray, gravelly/cobbly and ashy loam. Yellow hues are present as well. Fine sand, silt, and clay are often present in the matrix. Some Kittitas Drift soils have a cemented zone 1 to 2 feet below ground surface. These soils are well drained and vary in depth. Permeability is slow to moderately slow and runoff varies.

Recent Alluvium

Soils that form over recent alluvium are characterized by brown, gravelly/cobbly and ashy loam. Gray and yellow hues are present as well. Soils that have a cemented zone are found where streams are actively depositing material over Thorp Gravel and Kittitas Drift terraces. These soils are well and moderately well drained, and vary in depth. Permeability is slow to moderate and runoff varies.

Permafrost Mounds

Throughout the Thorp Gravel deposits in the project area, round or ellipsoidal mounds are present. The sagebrush that covers the surrounding soil is absent and the mounds are covered in grasses. The mounds are the result of intensive frost action during a periglacial climate that occurred after Thorp Gravel deposition. The freeze/thaw action sorted fine material from coarse material such that a layer of fine sand and silt is now present at the surface of the mounds and coarser grains are encountered several feet below ground surface. These soils are typically well drained and permeable (Kaatz 1959).

3.1.1.5 Project Area Geologic Hazards

Geologically hazardous areas are defined in Section 17A.02.150 of the Kittitas County Code (Critical Areas Ordinance [CAO]) as, "…areas that because of their susceptibility to erosion, sliding, earthquake, or other geological events, are not suited to the siting of major commercial, residential, or industrial development consistent with public health or safety concerns without proper engineering consideration and design." The following sections discuss the existing and/or potential erosion, landslide, and seismic hazards in the Desert Claim Wind Power Project area.

Erosion Hazards

Erosion hazard areas are identified by Kittitas County in Section 17A.02.080 of the Critical Areas Ordinance (CAO) as, "…those geologically hazardous areas containing soils which may experience or have experienced a severe to very severe surface erosion process." The CAO (Section 17A.06.015) also states that, "Areas identified as high risk erosion/landslide geologic hazard areas including cliff or talus slopes, may require specialized engineering to ascertain the property is suitable for development purposes." In response to these ordinance requirements, an analysis of the existing erosion hazard potential of the project area was conducted.

An understanding of where and how erosion occurs is required to evaluate potential erosion impacts (and to subsequently provide mitigation) as a result of the proposed project. Movement of sediment begins by a process called gross erosion that can be broken down into sheet erosion and channel erosion.

Sheet erosion is caused by shallow "sheets" of water flowing over the cleared land surface and transporting soil particles that have been detached by raindrops. The shallow surface flow rarely moves as

a uniform sheet for more than a few feet before concentrating in surface irregularities and resulting in rill erosion that causes additional sediment transport. This erosion process is continuous over several storm or normal rainfall events. If the rills become more than a few inches deep, then the erosive regime changes to gully erosion where concentrated water flow can transport large quantities of sediment during a single storm event. This type of large-scale gully erosion process usually occurs on slopes greater than 20 percent.

Different soil types and geologic parent materials can have widely differing susceptibilities toward each erosive process. As an example, bedrock in the project area typically develops soil horizons that are significantly less dense than the underlying strata. These soils are susceptible to sheet erosion or channel erosion (concentrated flows) due to their lower density and percentage of fines. However, the underlying bedrock is generally resistant to erosion. As a result, gully erosion is not common in bedrock areas. Conversely, the coarse-grained alluvium and glacial outwash deposits develop soil horizons that are much less susceptible to sheet erosion, primarily due to their high permeability preventing the development of sheet flow during normal rainfall events. However, both the soil and the parent material (mostly sand, gravel, and cobbles) are susceptible to gully erosion under concentrated flow regimes.

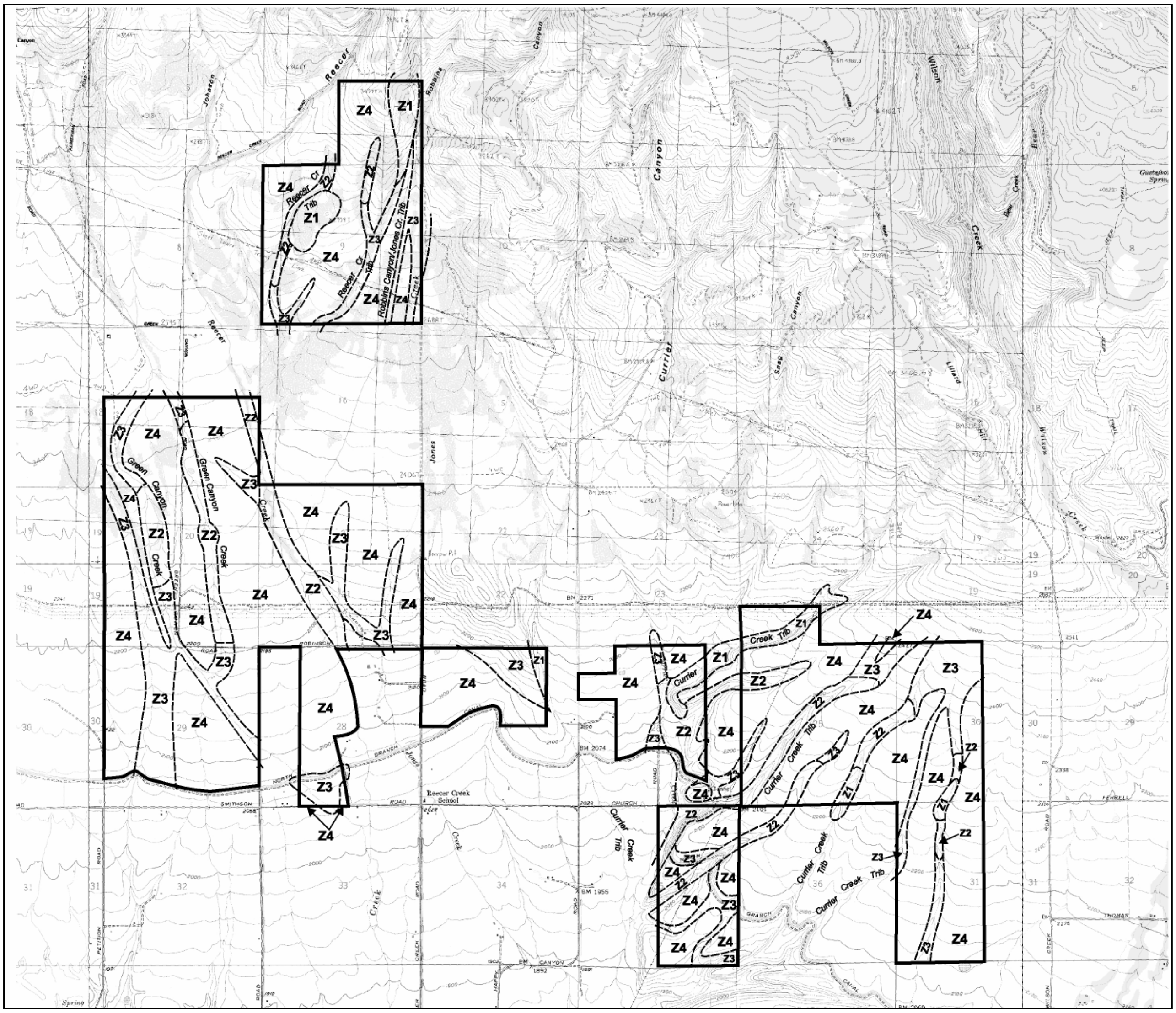
Slope gradients and vegetation also play an important role in determining erosion impacts. In general, steeper slopes have a higher susceptibility to erosion as surface water has the capability of achieving higher velocities and, hence, has more energy available to erode and transport sediments. Higher amounts of surface vegetation often reduce the potential development of concentrated flows by dispersing rainfall, impeding surface water flow, and reducing surface water velocities.

In general, project area erosion hazards are limited in extent and severity. Evidence of erosion in the project area was observed from two primary sources: (1) along stream drainages and irrigation ditches; and (2) along existing paved and dirt roads. Four zones with differing degrees of potential erosion hazard were mapped in the project area based on existing erosion occurrences, the sediment characteristics and slope gradients. The erosion noted on the site at the time of fieldwork and erosion hazard zones are discussed further below. The erosion hazard zones are shown on **Figure 3.1-1**.

Erosion Hazard Zone 1

Erosion Hazard Zone 1 is considered to possess a high to severe risk of erosion from sheet and concentrated flows under existing conditions. Areas classified as Erosion Hazard Zone 1 include areas of steep slopes in drainages and along edges of the Thorp Gravel terrace, in the eastern part of the project area; the landslide area in Section 9, in the northernmost project parcel; and steep slopes associated with bedrock outcrops.

Valley walls of Currier Creek tributaries that cross the Thorp Gravel terrace in Sections 25, 26, 30 and 31 (in the eastern part of the project area) become steep locally, with slopes in excess of 45 percent. Active or recent erosion was observed in these areas during field reconnaissance. Areas of bare soil and eroded side banks were observed at the base of the valley walls. The Thorp Gravel deposits possess a high risk of erosion during concentrated flows on steeper slopes due to their coarse-grained nature. Although sheet flow will infiltrate quickly on coarse-grained terraces of low to moderate slopes, concentrated flow on steep slopes will entrain coarse sediment that is not bound by a fine-grained matrix.



LEGEND

Project area

EROSION HAZARD ZONES

Z1	**High to severe hazard**
Z2	**Moderate hazard**
Z3	**Moderate to low hazard**
Z4	**Low hazard**

N

0 4000

SCALE IN FEET

REFERENCE: TOPO MAP FROM DELORME

Source: Associated Earth Sciences, Inc.

Huckell/Weinman Associates, Inc. HWA

Kittitas County Desert Claim Wind Power Project EIS

Figure 3.1-1

Erosion Hazard Zones

Steep slopes in excess of 50 percent characterize the margins of the Thorp Gravel terrace. Loose colluvium of angular basalt gravel covers the lower half of the slopes, which are sparsely vegetated. Evidence of recent erosion was not observed on these slopes during fieldwork. However, because these deposits occur on steep slopes, are coarse-grained and lack a binding matrix, there is a high risk of erosion during concentrated flows.

In Sections 26 and 24, Currier Creek and a tributary traverse Quaternary alluvial deposits at the base of the Thorp Gravel terrace. Soils developed on the alluvial deposits are loose and contain fine-grained material. The finer-grained portions of the recent alluvial deposits are susceptible to both sheet and concentrated flows that may, in part, originate from terrace runoff. Localized bank erosion was encountered during field reconnaissance, resulting in near-vertical stream banks, 4 to 10 feet high, that expose a substratum of loose, silty sand with subangular gravel.

The northeast portion of Section 27 (near the center of the project area) and the portion of Section 4 (the northern end of the project area) included in the project area are underlain by Grande Ronde Basalt. Soils in these areas are coarse, shallow and well drained. They possess moderate to slow rates of permeability and rapid runoff rates on steep slopes. In Section 27, the bedrock is truncated by a northwest-trending fault mapped by Tabor et al. (1982). The slope is steep (in excess of 50 percent) and drops approximately 100 feet to a drainage ravine. In Section 4, slopes are generally 30 to 50 percent. Colluvium of broken basalt gravel is present on the lower half of bedrock slopes. Soils in these areas of the project are considered a high erosion risk because of the steep slopes, the relatively low soil permeability, and anticipated high runoff rates.

A tributary of Reecer Creek traverses Section 9 near a mapped landslide deposit (Tabor et al. 1982). The landslide deposit forms moderate slopes and is covered with relatively loose, coarse-grained soils that have a moderate to very rapid runoff rate, thereby being susceptible to sheet and concentrated erosion.

Erosion Hazard Zone 2

Erosion Hazard Zone 2 is considered to possess a moderate risk of erosion from sheet and concentrated flows under existing conditions. Areas classified as Erosion Hazard Zone 2 include portions of drainage ravines and ditches throughout the project area and some slopes that exist at the edges of Kittitas Drift terraces.

Drainages that cross the Thorp Gravel terrace in Sections 25, 26, 30, 31 and 35 (the eastern project parcels) are tributary to Currier Creek. They have low to moderate slopes with isolated areas of steep slopes described as Erosion Hazard Zone 1. Soils in this area are high in gravel content, well drained and possess slow runoff rates. They are generally resistant to erosion on low to moderate slopes. Minor amounts of erosion were observed at the base of some valley walls during field reconnaissance.

Portions of Green Canyon Creek traverse Section 20 (near the western edge of the project area) where irrigation ponds and ditches exist, predominately in recent alluvial deposits of low slopes. During fieldwork, the drainage ditches were observed to be incised up to 3 feet, and bank erosion occurred in meander bends of the drainages. Soils in this area are high in sand and silt content with some gravel. They are predominately well drained with moderate permeability rates. The fine-grained component of the soil would be easily entrained in sheet and concentrated flows; however, the low slopes reduce the risk of erosion.

Some locations in Section 20 contain drainage ditches that traverse the margins of Kittitas Drift terraces and flow onto recent alluvial plains of low slopes. The terrace soils are predominately coarse-grained and resistant to erosion on low slopes. The edges of the terraces have moderate to steep slopes that increase the risk of erosion, as observed in fieldwork. A stream channel that traverses the terrace margin was incised up to 4 feet until the presence of a cemented durapan layer appeared to inhibit erosion, thereby forming a small bench that extended for several feet in the drainage. In a reach of higher slope gradient, an increase in erosion resulted in incision continuing through the durapan layer and to the recent alluvial plain.

Reecer Creek traverses Section 21 in recent alluvial deposits located on low slopes. The soils are deep, moderately drained, and predominately fine-grained, consisting of clay and silt. The channel of Reecer Creek is incised where it crosses Reecer Creek Road. Bank erosion has resulted in near-vertical banks 8 to 10 feet high. Erosion was noted in the channel along the road caused by concentrated road runoff. Due to the observed erosion and high percentage of fine-grained material in this area, the risk of erosion is considered moderate.

A tributary of Reecer Creek traverses the western portion of Section 9 near the mapped landslide deposit (Tabor et al. 1982). Soils in this area are coarse-grained and have localized steep slopes. Minor erosion was noted at the base of valley walls, and this area is considered to be a moderate risk of erosion.

Erosion Hazard Zone 3

Erosion Hazard Zone 3 is considered to possess a moderate to low risk of erosion from sheet and concentrated flows under existing conditions. Areas classified as Erosion Hazard Zone 3 include portions of drainages throughout the project area and observed wetland areas.

Portions of drainages on the Thorp Gravel terrace in Sections 25, 26, 30, 31 and 35 have relatively low slopes and pose a low risk of erosion under concentrated flow.

Wetland areas were noted on the south side of the North Branch Canal in Sections 35 and 28. The wetland areas are due to leakage from the canal. The ground was observed to be marshy with standing water and vegetated with wetland plants. The soils in this area are moderately well drained, and consist of sandy and clayey loam with gravel. Although no erosion features were observed, this area does have a low risk of erosion under conditions of concentrated flow, due to the shallow slope and slow runoff rate of the soils.

Section 29 (the southwest corner of the project area) consists predominately of a recent alluvial plain with a very low slope gradient. Several irrigation drainage ditches cross the section and natural drainages exist in small swales. Soils are deep, well drained, and fine-grained. Minor incision was encountered in the main drainage ditch that traverses the section. The fine-grained soils are susceptible to erosion from concentrated flow.

Drainages in the eastern portion of Section 9 are tributary to Jones Creek. Soils that exist in these drainages are typically well drained and are predominately fine-grained with some gravel. Minor incision was encountered in some portions of the drainages. The fine-grained soils are susceptible to erosion from concentrated flow. The Reecer Creek tributary in the western portion of Section 9 traverses a coarse-grained Kittitas Drift terrace. Drainage walls were observed to have minor erosion at the base and areas of bare soil. This tributary channel is relatively wide and the active channel meanders across the entire

width. Concentrated flow could result in active channel migration and incision. Therefore, this tributary drainage has a low to moderate risk of erosion from concentrated flow.

Erosion Hazard Zone 4

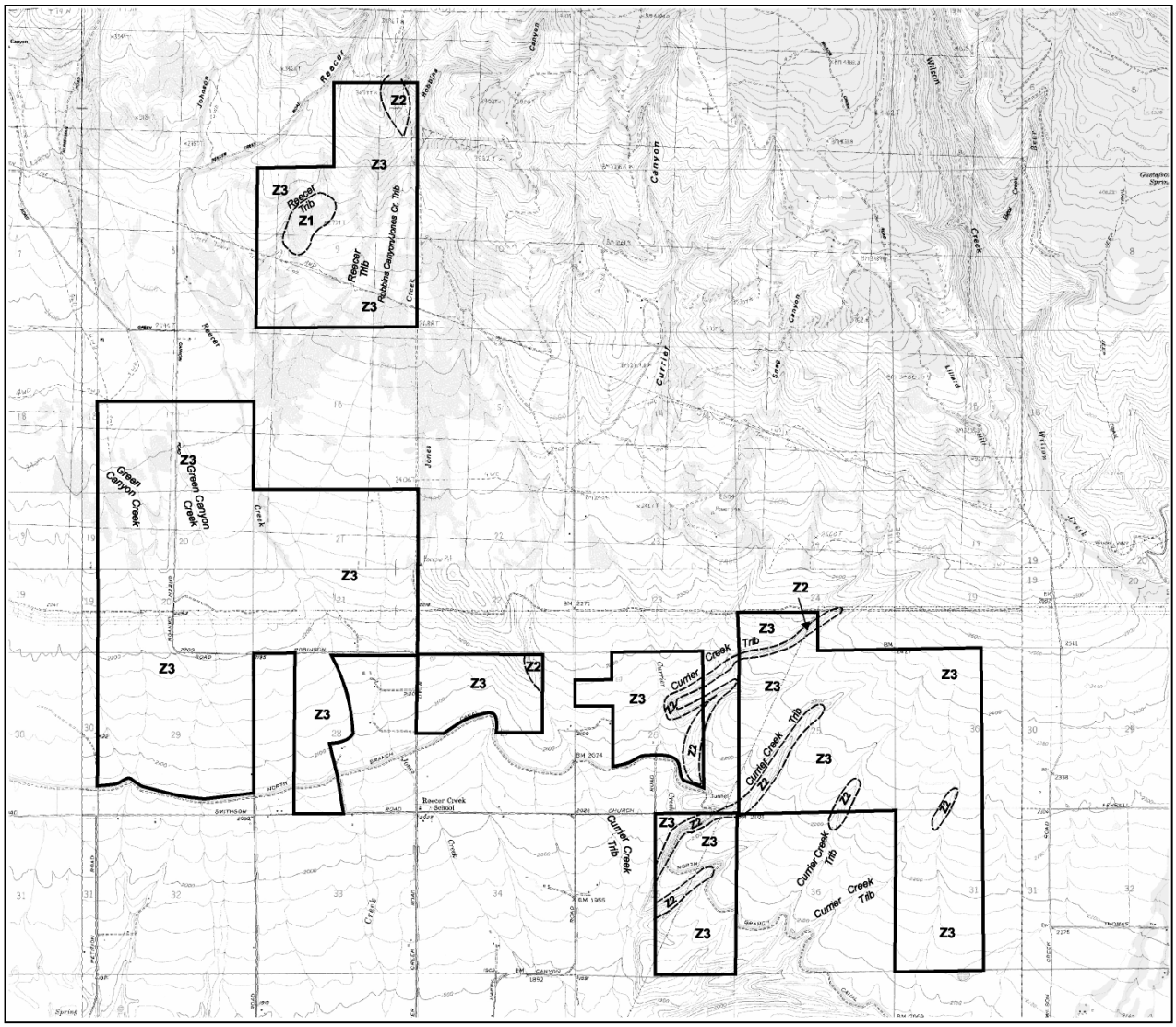
Erosion Hazard Zone 4 is characterized by slopes less than 20 percent. This zone encompasses the remaining portions of the project area, including the upper, flatter surfaces of the Thorp Gravel and Kittitas Drift terraces, and the recent alluvial plains. Under existing conditions, Erosion Hazard Zone 4 is considered to possess a low risk of erosion. However, the erosion risk for this area could increase with unmitigated concentrated flows.

Landslide Hazards

Landslide hazard areas are defined by Kittitas County in Section 17A.02.200 of the CAO as, "…geologically hazardous areas subject to severe risk of landslide based on a combination of geologic, topographic, and hydrologic factors, including bedrock, soil, slope gradient, slope aspect, geologic structure, groundwater, or other factors." The CAO (Section 17A.06.015) also states that, "Areas identified as high risk erosion/landslide geologic hazard areas including cliff or talus slopes, may require specialized engineering to ascertain the property is suitable for development purposes." Kittitas County's requirements for setbacks from slopes are based on the 1997 *Uniform Building Code* (UBC). Chapter 18 of the 1997 UBC offers slope setback distances for structures on or adjacent to slopes that are steeper than 33.3 percent (1H:3V [Horizontal:Vertical]). The code requires that structures be set back from the top of a slope a distance equivalent to $^{1}/_{3}$ its height, although the setback distance need not exceed 40 feet. Setbacks from toes of slopes should be measured a distance equal to ½ the height of the slope, although the setback need not exceed 15 feet. These setbacks are general guidelines that do not take into account geology, slope gradients, ground water conditions, landslide history or erosion history. In recognition of this, the 1997 UBC approves alternate setback approaches that may "include consideration of material, height of slope, slope gradient, load intensity and erosion characteristics of slope material." A landslide analysis of the project area and adjacent areas was conducted in accordance to these criteria.

Generally, there are three types of landslides that commonly occur in the vicinity of the project. The first type is termed earth slump. This type of earth movement is deep-seated and usually involves the regolith (topsoil and weathered zone) and the underlying sedimentary units. Slides of this type can be very large. The second type is termed debris slump or debris flow, and usually involves the upper few feet of the regolith. This type of slide is very dependent on the moisture content and weathering characteristics of the sediment, and stabilization may include surface water control and/or regrading. A third type is termed rock falls. Rock falls form by the free falling or rolling of material from a vertical or near-vertical exposure. The movement is rapid to very rapid and may be preceded by minor, progressive spalling. Rock falls typically occur on bedrock cliffs.

The landslide hazard for the Desert Claim Wind Power Project area has been subdivided into three hazard zones based on observed landsliding, sediment characteristics, and degree of slope. Evidence of landsliding was observed in and along stream drainages and at the base of Thorp Gravel terraces. Two distinct landslide features were observed during field reconnaissance. The landslide hazard zones are illustrated in **Figure 3.1-2** and are described below.



LEGEND

Project area

LANDSLIDE HAZARD ZONES

Z1	**High hazard**
Z2	**Moderate hazard**
Z3	**Low hazard**

N

0 4000

SCALE IN FEET

REFERENCE: TOPO MAP FROM DELORME

Source: Associated Earth Sciences, Inc.

Huckell/Weinman Associates, Inc. HWA

Kittitas County Desert Claim Wind Power Project EIS

Figure 3.1-2

Landslide Hazard Zones

Landslide Hazard Zone 1

Landslide Hazard Zone 1 is considered to possess a high landslide hazard, particularly during a seismic event. Zone 1 within the project area includes the large landslide in Section 9 mapped by Tabor et al. (1982). The landslide occupies an area of approximately 36 acres. It has a hummocky surface and consists of relatively loose, fine-grained sediment with some gravel. The feature is fully vegetated and probably represents an ancient event. The slide covers the eastern drainage wall of a Reecer Creek tributary and the toe extends into the stream valley bottom, limiting the width of the active streambed. Active erosion of the toe will occur during high concentrated flow events.

Landslide Hazard Zone 2

Landslide Hazard Zone 2 is considered to possess a moderate landslide hazard, particularly during an earthquake, due to the steep slope gradients and the height of the slopes. Within the project area, Landslide Hazard Zone 2 is characterized by moderate to steep slopes (>40 percent) underlain by unconsolidated alluvial deposits, and includes the stream drainages and the margins of the Thorp Gravel terrace. The edges of the Grande Ronde Basalt bedrock outcrops in Sections 35 and 28 consist of steep slopes covered with a loose colluvium of broken basalt gravel. This area is considered to possess a moderate risk of rock falls.

Landslide Hazard Zone 3

Areas classified as Landslide Hazard Zone 3 encompass the remaining portions of the project area, including the upper, flatter surfaces of the Thorp Gravel and Kittitas Drift terraces and the recent alluvial plains. Drainages of moderate to low slopes across the project area are also considered to possess a low landslide hazard. This landslide hazard zone is considered to possess a low risk of slope instability under existing conditions due to low slope gradients.

Seismic Hazards

The proposed Desert Claim project location is in an area of low to moderate historical seismicity. **Table A-2** summarizes historical and recorded seismic events greater than magnitude (M) 3.0 in the vicinity of the site, as obtained from the University of Washington's Pacific Northwest Seismograph Network (PNSN). Two earthquakes within an area of approximately 1 degree latitude by 1 degree longitude surrounding the project area had a measured magnitude of 5.0 or greater (M 5.0 and M 6.8). The M 5.0 event occurred in 1943 and was located just north of Table Mountain in the Wenatchee Mountains of the Cascade Range, about 14 to 17 miles north of the project area. The M 6.8 event occurred in 1872 and was located approximately 55 miles northwest of the project area. All other earthquakes are M 4.3 or less. Both the M 5.0 and the M 6.8 earthquakes occurred prior to the operation of the PNSN. Two M 4.3 earthquakes located about 27 miles southwest and 34 miles northeast of the project area are the largest seismic events recorded in the site vicinity since the installation of the PNSN. One earthquake (M 3.0) epicenter is located in the project area and is discussed below.

The Kittitas County CAO (Section 17A.02.260) defines seismic hazard areas as, *"…geologically hazardous areas subject to risk of earthquake damage."* Four types of potential geologic hazards are usually associated with large seismic events: ground rupture along a surficial fault zone; ground motion response; liquefaction; and seismically induced landslides.

Surficial Fault Zones

Geologic structures that relate to surficial fault zones near the project area are described in **Section 3.1.1.3.** The anticlines of the Yakima Fold Belt are underlain and often caused by thrust faults. Recent studies indicate that the Yakima Fold Belt is actively accommodating north-south shortening of central Washington (McCaffrey et al. 2000) as discussed in **Appendix A, Section 3.1**. Several generally east-west trending faults are mapped within the Yakima Fold Belt (Bakun et al. 2002, Tabor et al. 1982). However, evidence of Quaternary deformation has not been identified to date.

The 1872 earthquake (M 6.8) is important in quantifying the seismic hazard in central and eastern Washington because it is the largest historical earthquake in Washington east of the crest of the Cascade Range. Bakun et al. (2002) suggest that the earthquake was shallow, based on aftershock patterns, and the epicenter was located south of Lake Chelan (as shown on **Figure A-5**). The rupture plane of the 1872 earthquake has not been located and may represent a recent rupture within the Yakima Fold Belt or deeper Cascade Range crystalline rock that does not have surface expression. Bakun et al. (2002) suggest that events as large as M 6.8 can reasonably be expected over most of south to central Washington.

There are northwest-southeast trending faults that cross the project area as mapped by Tabor et al. (1982) (the inferred fault traces are shown on **Figure A-1**). Currier Creek drainage patterns appear to be influenced by this fault near the center of the project area in Section 22 (Township 19 North, Range 18 East). The fault is not visible under recent alluvial deposits, but may be continuous from Section 22, trending northwest to cut diagonally across Section 9 (Township 19 North, Range 18 East). In Section 9, the fault trace crosses a landslide deposit mapped by Tabor et al. (1982). The landslide block was observed in the field and the mapped area on **Figure A-1** was adjusted as per field and aerial photography observations. The landslide material is part of the Kittitas Drift; therefore the material was deposited approximately 130,000 to 140,000 years before the present. The landslide is fully vegetated and does not represent a recent disturbance. Landslide movement may have been due to seismicity along the fault at some time after deposition.

AESI identified northwest-trending lineaments on stereo pair aerial photographs on the eastern Thorp Gravel terrace (Section 25, Township 19 North, Range 18 East and Sections 30 and 31, Township 19 North, Range 19 East). However, these lineaments were not visible during field exploration. The 1995 M 3.0 earthquake that occurred in the project area was located on the eastern side of the property on the Thorp Gravel terrace near a fault mapped by Tabor et al. (1982). Deformation along the fault affects the Pliocene-age Thorp Gravel terrace. More recent activity along the fault system is possible, however, offset has not been documented in post-Pliocene-age deposits.

Ground Motion Response

Ground motion from an earthquake results from shear, pressure, and surface waves propagating through the earth's crust from the earthquake's hypocenter. The ground motion caused by these waves is the seismic shaking felt during an earthquake. The intensity of the shaking felt at a given location during and immediately after an earthquake, is a result of several variables including: 1) the magnitude of the earthquake; 2) distance from the earthquake; 3) depth of the earthquake; 4) the type of rocks and unconsolidated sediments underlying a given site; and 5) attenuation of the seismic energy between the earthquake and a given site. Although the project site is located in an area of relatively low to moderate historical seismicity, there are several sources of large earthquakes in western Washington and possibly within central Washington, as indicated by the 1872 event.

The February 2001 Nisqually earthquake provided direct observation of ground motion during a large regional earthquake. The University of Washington's PNSN created a "shake map" of peak acceleration and velocity from wave forms collected during the earthquake. Peak acceleration is the maximum acceleration experienced by a particle at the earth's surface during the course of the earthquake motion. The event was located between Olympia and Tacoma, 33 miles deep, approximately 95 miles east of the project areas. The shake map shows light shaking within 20 miles of the project area (peak acceleration of 1 to 4 percent of the acceleration of gravity (g) [g = 9.8 meters per second]) (http://www.ess.washington.edu/shake/0102281854/intensity.html).

The United States Geological Survey (USGS) has created seismic hazard maps to predict the expected peak ground acceleration from earthquakes (Frankel et al. 2002). According to this work, in the next 50 years there is a 10 percent chance that ground motions will exceed 15 percent g in the vicinity of the project. This work contributed to the 1997 *Uniform Building Code* (UBC) determinations of seismic zones in the Pacific Northwest. The UBC's seismic zone classifications are used to determine the strengths of various components of a building or structure needed to resist earthquake damage caused by ground motion. Design guidelines for minimizing earthquake damage to structures based on anticipated ground motions for a specific region are included in the UBC. The seismic zones used by the UBC range from Seismic Zone 0 (area of low seismic risk) to Seismic Zone 4 (area of high seismic risk). The project is located within Seismic Zone 2B as classified by the 1997 UBC.

Unconsolidated young deposits may amplify ground motion. Ground motion in these areas will likely be more intense than predicted for hard rock sites.

Liquefaction

Liquefaction is the process in which soil loses strength or stiffness during vibratory shaking, such as that caused by earthquakes, and temporarily behaves as a liquid. Shaking during an earthquake can cause an increase in pore water pressure in the soil, and decrease the soil shear strength. Soils are considered to liquefy when nearly all of the weight of the soil is supported by the pore water pressure and becomes relatively unstable. The seismically-induced loss of soil strength can result in failure of the ground surface and can be expressed as landslides or lateral spreads, surface cracks and settlement, and/or sand boils. Seismically induced liquefaction typically occurs in loose, saturated, non-cohesive sandy and silty soils commonly associated with recent river, lake, and beach sedimentation. In addition, seismically induced liquefaction can be associated with areas of loose, saturated fill.

AESI's field exploration and review of area well logs indicate that unconsolidated sediments up to 300 feet thick underlie much of the project. Some material is young stream deposits that are relatively loose and fine-grained and may be subject to liquefaction under strong seismic shaking, however these sediments are expected to be thin. The majority of the property is underlain by well-drained sand and gravel deposits that are not susceptible to liquefaction. Based on the results of the field exploration program, experience with similar soil types, and understanding of the regional seismicity, it is likely that the potential for liquefaction at the project area is low. However, unconsolidated soils underlying wetlands and stream corridors may be susceptible to liquefaction during larger seismic events, although most of the susceptible soil layers are likely relatively thin.

Seismically-Induced Landslides

Earthquake vibration may cause unstable material to fail by influencing existing planes of weakness within bedrock (such as bedding planes or fault planes) or within unconsolidated material. The USGS documented many earthquake-induced landslides throughout the Puget Lowland that occurred due to shaking from the 2001 Nisqually event, and several researchers have correlated previous mass movements in Lake Washington to the A.D. 900 earthquake on the Seattle Fault (Jacoby et al. 1992; Karlin and Abella 1992, 1996). Although landslides were identified on the project area (see the **Landslide Hazards** section above), it is unknown whether these landslides were induced by associated seismic events. The risk of seismically-induced landslides occurring on the site is generally interpreted to be low due to the relatively moderate slope gradients and soil characteristics. Locally, along steep slopes, the risk of seismically-induced landslides is considered moderate.

3.1.1.6 Alternative 1: Wild Horse Site

The Wild Horse site is located in the eastern part of Kittitas County. With the exception of Whiskey Dick Mountain, much of the site is a relatively flat plateau with steep-sided drainages eroded into it. Slopes within the area generally range from less than 5 degrees on the flat plateau area and ridgelines, and up to 40 degrees on Whiskey Dick Mountain and in side drainages. Most streams originate as springs that exist approximately between elevations 3,300 and 3,400 feet above mean sea level. Two streams flow southwest in the direction of the Yakima River, while the remaining ephemeral and spring-fed streams flow primarily eastward from the Wild Horse site into the Columbia River.

Geologic conditions under the Wild Horse site are generally as described in **Section 3.1.1.2** and **Appendix A**. The Wild Horse site is located within the Yakima Fold Belt. Relatively thin deposits of silt and clay (mainly wind derived) overlie basalt bedrock of the Miocene-age Grande Ronde Basalt flows. The basalt is dark gray, fine-grained, and very hard but fractured into angular to subrounded cobbles within a few feet of the ground surface. In most of the test pits excavated in the area, the basalt in the upper few feet is fractured, but fracture density and rock mass quality increases downward rapidly. Most test pits were terminated within 3 feet of the ground surface and were unable to be excavated further by the backhoe. A localized outcrop of sedimentary rock consisting of interbedded, weakly-cemented, volcaniclastic sandstone, siltstone, and minor dark mudstone is mapped in the southeast portion of the Wild Horse area. This unit is part of the Ellensburg Formation and occurs interbedded and on top of Grande Ronde Basalt flows. Locally it has an average thickness of 16 to 33 feet. Based on observations and documentation of springs in the area, it appears that the springs are located along a relatively horizontal low-permeability zone that likely correlates with the sedimentary unit.

A large landslide, estimated to be approximately 1/3 square mile in area and almost a mile long, is located in the vicinity of the Wild Horse site. The elevation ranges from approximately 3000 feet to 3700 feet over the length of the slide, with a corresponding average ground slope of approximately 2 horizontal to 1 vertical. The surface of this landslide is irregular and hummocky, and springs appear to be emanating from some areas of the slide. Native vegetation was observed at the surface throughout the slide area, suggesting that activity on the slide was either historical or is of a rate slow enough to enable the establishment of native vegetation. No faults are mapped within the project area for Alternative 1, but a few faults are mapped within approximately 4 miles to the southwest. Many of these faults are inferred, and there is no indication that these faults had been active in the late Quaternary. Mineral resources in the immediate vicinity of the Wild Horse site include a small inactive borrow pit near the northwest corner of the site.

Surficial materials consist primarily of a thin veneer of wind-deposited, brown, silty clay varying in thickness from a few inches to 3 feet. A thin alluvial deposit containing cobbles overlies bedrock in some locations. In general, soils on the Wild Horse site have a slow to moderate permeability resulting in a moderate to relatively high runoff potential. This material is dry to moist, and contains locally clayey zones that retain more moisture. These soils are typically present in the upper 12 inches, although areas were observed where clay and fine-grained material was present in the upper 8.5 feet. At most locations on the site, the thickness of soil overlying bedrock is minimal. Bedrock is either very near or outcropping at the surface.

Geologic hazards that reasonably could be expected to occur at the Wild Horse site include seismic hazards generated from earthquakes, volcanic eruptions, erosion, and landslides. Maps of specific erosion and landslide hazard areas within the Wild Horse site have not been prepared. Within the State of Washington, the USGS recognizes five volcanoes as either active or potentially active: Mount Baker, Glacier Peak, Mount Rainier, Mount Adams, and Mount St. Helens. In the last 200 years, only Mount St. Helens has erupted more than once (USGS, 2000a). The Uniform Building Code Seismic Risk Map of the United States shows that the Wild Horse site, along with all of eastern Washington and Eastern Oregon, is located in Seismic Zone 2B. This seismic zone corresponds to an intensity VII earthquake on the Modified Mercalli Scale, which can produce moderate damage, should one occur. Information from the USGS seismograph records shows that the Wild Horse area has experienced very low seismicity since 1959. However, numerous small earthquakes with magnitudes between 3 and 4 have been recorded within 60 miles of the site (see **Appendix A**). The closest earthquakes were magnitude 3.3 and 3.4 events that occurred 7 and 9 miles from the site, respectively. The largest historical event was an estimated magnitude 7.0 earthquake that occurred in 1872, centered approximately 57 miles to the northwest in the Cascade Mountains.

3.1.1.7 Alternative 2: Springwood Ranch Site

The following information on baseline conditions for the Springwood Ranch site is largely incorporated from the MountainStar Master Planned Resort Draft EIS, Vol. II, Appendix B (Kittitas County, 1999).

Site Geology

The Springwood Ranch property is located along the south side of the Yakima River approximately 12 miles southeast of Cle Elum. The site consists of terraced upland surfaces incised by the Yakima River, Taneum Creek and several intermittent drainages. The Yakima River has eroded a relatively steep-walled canyon along most of the eastern limits of the property in the north and central portions of the site.

Shallow bedrock beneath the site consists of the Grande Ronde Basalt and the Ellensburg Formation. Both the Grande Ronde Basalt and the Ellensburg Formation outcrop along some of the bluffs adjacent to the Yakima River (Converse, 1989). Unconsolidated sediments overlying the bedrock include Pleistocene glacial deposits, recent alluvium and landslide debris. Loess deposits mantle many of the glacial deposits at the site.

The Pleistocene glacial deposits, consisting of Kittitas-age and Lakedale-age glacial outwash and till, comprise most of the surficial sediments in the upland areas (Converse, 1989). The glacial outwash deposits consist primarily of sand, gravel, cobbles and boulders. The till consists of poorly sorted sediments containing varying amounts of clay, silt, sand, gravel and boulders. Till covers a large portion

of the northern half of the Springwood Ranch site, and forms a portion of the end moraine described by Porter (1976) as the outer limit of the Swauk Prairie ice advance.

Surface Soils

Most of the surficial soils on the Springwood Ranch site range from about ½ to 6 feet in thickness, and often include a mantle of loess. The loess consists of about equal parts sand, silt and clay (NRCS, 1998). Soils formed on till, outwash and alluvium consist primarily of sand and gravel, with silt and clay typically comprising less than 50 percent of the sand-size or smaller particles (NRCS, 1998). Many of the soils mapped at the site include a layer of weathered "hardpan" located at depths ranging from 7 to 60 inches. Soils mapped at the Springwood Ranch site include the following soil series: Amabilis, Argixerolls, Kayak, Lablue, Maxhill, McDaniel, Metser, Millhouse, Nint, Qualla, Reelow, Reeser, Sketter, Swauk, and Weirman (NRCS, 1998).

Geologic Hazards

The Springwood Ranch site is located in an area of relatively low historical seismicity, and within Seismic Zone 2B of the 1997 UBC. There are no identified active surface faults or lineaments in the vicinity. Portions of the Yakima River and Taneum Creek floodplains may be underlain by soils susceptible to seismically induced liquefaction.

Most of the shoreline of the Yakima River along the northeastern boundary of the Springwood Ranch site has been mapped as high erosion hazard and landslide hazard area. Most of the traverse of Taneum Creek through the site is bounded by soils with moderate erosion potential. Some soils with high erosion potential are also located at the mouth of Taneum Creek.

Evidence of past landslides was observed along portions of the steep bluffs along the Yakima River; many seem to be the result of meandering of the river and consequent undercutting and oversteepening of the valley sidewalls. These areas are considered to have a high landslide potential and generally occur within the outwash deposits and the Ellensburg Formation. Areas with moderate to low landslide potential occur along the side slopes of on-site terraces, portions of the Yakima River Valley slopes, and slopes along Taneum Creek near the confluence with the Yakima River. Gradients of these slopes are generally between 35 percent and 50 percent. Low landslide potential was identified for the relatively flat terraces (0 to 15 percent gradients) and bedrock slopes in the northern portion of the site.

3.1.2 Environmental Impacts of the Proposed Action

The following section describes potential environmental impacts relative to geologic hazards that might result from the proposed Desert Claim Wind Power Project. The analysis of potential impacts associated with geologic hazards includes erosion hazards, landslide hazards and seismic hazards. The analysis has been updated for the Final EIS, based on a site-specific evaluation of the modified project configuration presented in **Section 2.2**. The modifications to the project resulted in shifting of the proposed locations for the wind turbines, access roads, power collections cables and other project facilities. These modified locations have been reviewed against the distribution of erosion, landslide and seismic hazards within the project area to provide an update of the impact analysis presented in the Draft EIS.

The following discussion of potential impacts to earth resources focuses on expected construction of the entire Desert Claim project within a single construction period of approximately 9 to 12 months in

duration. Pending conditions applicable to potential approval of the project, it is possible the applicant would elect to schedule project construction in multiple phases (such as 3 phases of 40 turbines each, for example). If phased construction occurred, each phase of construction activity would likely be up to about 9 months long and the total duration of construction activity could be more than 2 years (although there would likely be intervals of at least several months between phases). The effect of phased construction on the level of earth resource impacts would be to extend the total duration of temporary disturbance impacts from project construction, but to reduce the intensity or magnitude of impacts for any individual phase. Potential construction impacts related to erosion, landslide or seismic hazards in a phased-construction scenario would still be equivalent to those resulting from development of the project during a single construction period.

3.1.2.1 Erosion Hazards

Construction

Under existing conditions, the project area has been subdivided into four erosion hazard zones based on geology, hydrology, and slope gradient conditions. These erosion hazard zones are described in **Section 3.1.1.5** and are graphically illustrated in **Figure 3.1-1**. Erosion impact potential from the project would be greatest in the zones of highest erosion hazard. Existence of high erosion hazard in a given area does not indicate that construction activity in that area would necessarily result in high erosion impacts, however. As indicated in the Kittitas County Critical Areas Ordinance (CAO) (KCC 17A.06.015) "Areas identified as high risk erosion/landslide geologic hazard areas *may require specialized engineering* [emphasis added] to ascertain the property is suitable for development purposes." Consequently, facility engineering and erosion control practices can often be employed to satisfactorily limit erosion impacts, even in areas of high erosion hazard.

Erosion is considered to be both a long-term and short-term hazard for the project, although the risks would generally be the greatest during the construction phase. Project activities that might induce new or additional erosion beyond existing conditions are clearing and grading activities, uncontrolled stormwater runoff, and structural changes to existing drainages. The extent and magnitude of an individual erosion incident would be dependent on the triggering event for that incident.

Clearing and grading activities during construction would increase the erosion potential on and adjacent to the project area through the removal of vegetation and the direct exposure of soil to precipitation and runoff. The most significant increase in erosion hazard potential would be during the construction phase when earthwork activities commence. Unless otherwise mitigated, erosion would produce sediment that could be transported to on-site surface water features. Uncontrolled gully erosion could lead to oversteepening of the slopes and subsequent slope instability hazards. The majority of clearing and grading would take place during construction of the access roads (including underground cable trenching) and turbine pads. Significant clearing and grading would also occur during construction of the project O&M building and substation (see **Section 2.2**).

Erosion impacts from clearing and grading activities could occur in all areas of the project that would be disturbed for construction. Portions of the access road alignments cross each erosion hazard zone, and the potential for erosion from clearing and grading for the roads would generally correspond to the distribution of erosion hazard along the access road routes. For the modified project configuration described in **Section 2.2**, 97 of the 120 proposed turbine locations (81 percent of the total) are within areas of Erosion Hazard Zone 4 (low erosion hazard), while five turbine locations (4 percent) in the

northern portion of the project area are within Erosion Hazard Zone 1 (high erosion hazard) and are also located near an active landslide area or adjacent to steep slopes (see additional discussion below). Six turbine locations (5 percent) near the center of the project area are within Erosion Hazard Zone 2 and are along streams or on steep slopes. The remaining 12 turbine locations (10 percent of the total) are within Erosion Hazard Zone 3; these locations are in the central and western portions of the project area and are adjacent to steep slopes, near streams or in wetland areas created by leakage from the North Branch Canal. The O&M building and the alternative substation locations, as described in **Section 2.2**, would be located within areas considered low in erosion hazards (Erosion Hazard Zone 4).

Uncontrolled stormwater runoff from road construction into stream and irrigation drainages could increase erosion and sediment transport hazards. The majority of streambeds observed in fieldwork are lined with gravel and cobbles and underlain by coarse-grained alluvial and glacial outwash deposits. It is probable that erosion in these drainages during project construction would be limited, as the gravel and cobbles of the streambed and underlying formation tend to armor and protect the streambed from incision. However, uncontrolled stormwater runoff on drainage sidewalls or steep slopes along the edge of Thorp Gravel and Kittitas Drift terraces could cause erosion. The material making up these slopes is coarse-grained and lacks a binding matrix, and is susceptible to erosion from concentrated flow. Therefore, a key to limiting potential erosion impacts in these areas is to ensure that stormwater runoff is controlled.

Increases in stormwater runoff into existing drainages would increase stream capacity (ability to carry sediment). Some streams on-site are small, active stream channels that meander within a larger drainage ravine. At times of high flow, the active stream channel can reoccupy previously abandoned channels within the drainage ravine or form new ones. Consequently, during high-flow events the stream transports additional sediment that would be deposited at a downstream location. This downstream deposition could further alter the course of the stream. Roads constructed within the streambed would be subject to the risk of damage from meander-triggered erosion and sediment transport hazards unless proper mitigation measures were provided.

Potential erosion impacts during construction of the project could result from clearing and grading activities, uncontrolled stormwater runoff, and changes to existing drainages. Overall, minor soil loss is expected from ground-disturbing activities during the construction phase of the project because: (1) the total area of surface disturbance would be less than 350 acres out of 5,237 acres (i.e., approximately 6 percent of the total project area); (2) surface disturbance would be temporary in duration, occurring for only a portion of the 9-to-12-month construction period for any disturbed site; (3) standard construction practices include source control measures that involve covering disturbed areas and soil stockpiles; and (4) standard construction practices include prompt revegetation of temporarily disturbed areas. In addition to limiting soil erosion at the source, standard construction practices include a variety of measures to control stormwater runoff from construction areas, and thereby limit transport of eroded soil and the associated consequences. Consequently, potential erosion impacts can be mitigated to acceptable levels during and after construction with the proper implementation of best management practices (BMPs), even in areas where a high to severe erosion risk may be present. Use of these BMPs is a standard condition for construction stormwater discharge permits that are required for construction projects of this scale (see additional discussion in **Section 3.1.5.1**). Based on the required use of construction BMPs, erosion impacts from construction of the Desert Claim project would be limited in area, duration and intensity, and therefore would be insignificant.

Operation

Following project construction and during project operation, the risk of erosion would be similar to existing conditions. However, impervious surfaces, although minimal, would be created from the O&M building, portions of the substation, small portions of project access roads, and footings of the turbines/transformers. Uncontrolled stormwater runoff from impervious surfaces or from drainage conveyance systems (pipes, swales, outfalls) could pose a risk of erosion, particularly on steep slopes. With use of proper stormwater management measures, which are also standard practice, runoff from impervious surfaces can be controlled and long-term erosion impacts can be minimized. Based on application of these stormwater management measures, long-term erosion impacts during project operation would be insignificant.

Decommissioning

Potential erosion impacts from decommissioning the proposed project would be similar to those for construction of the project and would be low. The proposed project is assumed to have a life of 30 years. Decommissioning at the end of the project life would consist of removing the wind turbine nacelles, blades, towers, and then removing foundations, cables, and other underground facilities to a depth of 4 feet below grade. Decommissioning would also include removal of project roads and restoration of all disturbed land. Consequently, decommissioning would result in ground disturbance within an area similar to the temporary disturbance from construction. The standard erosion control practices employed during construction would also be applied to decommissioning as needed, resulting in insignificant erosion impacts from the decommissioning phase of project activity.

3.1.2.2 Landslide Hazards

As discussed previously, three types of landslides are considered possible in the region of the Desert Claim Wind Power Project. These include earth slumps, debris flows/slumps and rock falls. The subject property was subdivided into three landslide hazard zones based on topographic, geologic, geomorphic, and hydrologic information (see **Figure 3.1-2**). The highest landslide hazard under existing conditions is in Zone 1, which is located along the slopes of a Reecer Creek tributary in Section 9, where a large debris flow or earth slump has been documented (Tabor et al. 1982).

Sloping ground has an inherent risk of instability. In some cases, due to low-slope gradients and geologic and hydrologic conditions, the landslide risks may be considered low. The risk typically increases where ongoing or historic landslide activity has occurred. Landslides are naturally occurring phenomena, although the risk of a landslide could be increased as a result of land use practices or development activity. The magnitude and extent of a landslide incident would be dependent on the nature of the triggering mechanism. Landslides are considered both a long- and short-term hazard for the property. Depending on the characteristics of a slide, avoidance of the hazard zone may be the most economic and prudent mitigation alternative. This is generally the case for large or deep-seated landslides, where structures would be set back from the zone of influence. For other landslide areas, the risk of slope movement can be reduced to an acceptable level by proper grading, drainage control, and/or the use of retaining structures.

Project construction (or decommissioning) activities that might induce new or additional landsliding beyond existing conditions are clearing and grading activities, uncontrolled stormwater runoff, and structural changes to existing drainages. Clearing of vegetation that would normally reduce stormwater

runoff volume and rates could increase the existing landslide hazard potential in all landslide hazard zones (1, 2, and 3). This could result in concentrated stormwater runoff on cleared slopes that could precipitate erosion and oversteepening of the hillside and result in slope instability.

Uncontrolled grading (earthwork) activities could also increase the existing landslide hazards. Fill soils placed on or adjacent to steep slopes might increase the driving forces of the soil column and result in slope failures. Grading typically modifies surface drainage patterns. If the new drainage pattern resulted in an increase in either surface or subsurface water flow on or near a slope, landslides could develop. In addition, improperly placed fill soils could fail due to inadequate compaction effort, use of organic material or soft, fine-grained soils, placement of material at oversteepened gradients or other factors. Cut slopes could also fail due to removing the toe support for a slope, or from improper drainage control.

As discussed in **Erosion Hazards** above, increases in stormwater runoff into existing drainages could lead to stream meandering beyond natural conditions. Changes in the position of the streams could occur as new channels are formed or old channels reoccupied. These changes in stream position could result in stream erosion at the toe of slopes and reactivate existing landslides or create new landslides. As also discussed in **Section 3.1.2.1**, however, standard construction practices that limit soil loss and control stormwater runoff are typical requirements under construction stormwater discharge permits. The same control measures that address erosion hazards also serve to limit impacts associated with potential landslide hazards.

Based on the modified project configuration described in **Section 2.2**, three turbines and associated sections of project access road and underground power collection cables would be located within the recommended setback area (a 125-foot buffer) of Landslide Hazard Zone 1 in Section 9. Two of these turbine locations appear to be very close to the edge of the area disturbed by the historic slide. Constructing these facilities in the proposed locations could result in instability that could trigger future landslides. Using micro-siting prior to final project design, it might be possible to relocate these turbines outside of the buffer to avoid this potential impact. If these turbines were not or could not be relocated, site-specific geotechnical studies designed to evaluate and address the landslide hazard would be required. This would be consistent with the Kittitas County Critical Areas Ordinance (CAO), which states that areas identified as high landslide hazard areas *may require specialized engineering* [emphasis added] to ascertain whether the property is suitable for development purposes (KCC 17A.06.015). Facility engineering and land stabilization practices can often be employed to satisfactorily limit potential landslide impacts, even in areas of high landslide hazard. Consequently, potential landslide impacts during construction (or decommissioning) are expected to be mitigated to a level of insignificance with the proper implementation of best management practices (BMPs). The methods most likely to be employed would be additional land stabilization features incorporated within or added to the proposed turbine foundations (see **Figure 2-6**) that would account for the added soil forces from the active landslide.

The landslide risk during project operation would be similar to existing conditions. Areas disturbed during construction would be stabilized, primarily through revegetation following construction. Additional stormwater runoff created by the addition of impervious surfaces at the project could still pose a risk to erosion, oversteepening of slopes and slope instability. With use of proper stormwater management measures that are standard practice, however, runoff from impervious surfaces can be controlled and long-term risks to land stability can be minimized. Therefore, all potential landslide impacts during project operation are expected to be mitigated with the proper implementation of best management practices (BMPs), even in areas where a high landslide risk may be present.

3.1.2.3 Seismic Hazards

As described in **Section 3.1.1.5**, the project area is located in a region of relatively low to moderate historical seismicity. The seismic sources capable of producing earthquakes of sufficient magnitude in the vicinity of the project area include the subduction zone (over 100 miles west) and east-west trending faults in the Yakima Fold Belt that are actively accommodating north to south compression of Washington. One large earthquake in recorded time (1872) is suggested to be of this nature, but a recurrence interval is not known (see **Section 3.1.1.5** and **Appendix A, Section 3.1**). Review of readily available data for earthquake hazards in Washington indicated that historical seismicity in the site vicinity has not resulted in widespread damage to surrounding communities.

As discussed previously, the hazards associated with seismic events felt in the project area include surface rupture, seismically induced landslides, soil liquefaction and ground motion (shaking). Siting and design of project facilities should consider existing seismic risks present in the area, as discussed in the subsequent paragraphs. However, development of the proposed project would have no influence on the level of seismic hazard applicable to the project vicinity, and would not result in potential seismic-related impacts on adjacent uses or properties.

Section 3.1.1.5 describes surface faulting mapped and identified in the project vicinity. The current proposed locations of several turbines are near potential faulting on the eastern Thorp Gravel terrace. AESI's review of aerial photographs identified several northwest-trending lineaments that cross the terrace. One moderate (M 3.0) earthquake epicenter is located in the area, and Tabor et al. (1982) mapped a fault that cuts across the Thorp terrace just south of the project area. Site-specific seismic studies of this area would be advisable before final location of turbines.

Areas prone to seismically-induced landslides would probably correspond to Landslide Hazard Zones 1 and 2. A seismic event of significant local intensity might function as a trigger mechanism for landslides and/or rock falls to occur in areas of the project site delineated by these two landslide hazard zones. Therefore, turbines, roads, or structures located within Landslide Hazard Zones 1 and 2 might be subject to increased risks from seismically-induced landslides.

Soils susceptible to liquefaction during larger seismic events may be present in areas of the site underlain by shallow, saturated cohesionless soils, such as portions of wetland areas and young stream deposits. Specific areas of liquefaction-prone soils in the streambeds and wetland areas are likely of limited extent and thickness because most of the sediments are coarse-grained consisting of sand, gravel, and cobbles. Turbine and associated building locations do not correspond to locations with young stream deposits or potential wetland features, however some proposed roads traverse streambeds and potential wetland areas. If portions of these areas are underlain by liquefiable soils, unmitigated development of the proposed roads could increase the risk of damage to the roads as a result of loss of soil shear strength during an earthquake.

Significant ground motion caused by an earthquake of sufficient intensity could result in damage to turbines, associated buildings, and roads. If such damage occurred, the consequences would be limited to project facilities and would not extend to off-site areas. Because the intensity of a specific seismic event is the result of numerous factors (**Section 3.1.1.5**), site-specific studies would be necessary to identify areas that would be more susceptible to damaging ground motion.

3.1.3 Impacts of the Alternatives

3.1.3.1 Alternative 1: Wild Horse Site

Impacts from Alternative 1 to earth resources in the area would be similar to those described for the proposed action. Similar to the proposed action, changes to the local topography are expected to be minimal and would be limited to the footprint of the project facilities and roads. The project would alter the landscape with minor cuts and fills for roadways and leveling for wind turbine foundations. These alterations would result in a minimal long-term impact to existing topography, surface geology and drainage patterns, and would not cause any significant change to those conditions. Impacts to the topography of areas adjacent to the facility would be negligible, because the proposed facilities would be constructed at or near existing grade.

Impacts to local geologic resources would be limited to redistribution of rock and soil excavated during wind turbine foundation construction. Earth materials disturbed during excavation activities are not considered significant geologic resources, and therefore, impacts to local geologic resources would be negligible. It is anticipated that impacts on area soils would be limited to areas disturbed by the project construction activities. As discussed in **Section 3.1.2**, erosion and landslide impacts are expected to be insignificant with implementation of standard erosion control measures that are proposed or required management practices. Development of Alternative 1 would have no influence on the level of seismic hazard applicable to the project vicinity.

3.1.3.2 Alternative 2: Springwood Ranch Site

Impacts from Alternative 2 to earth resources in the Springwood Ranch area would be similar in nature to those described for the proposed action, but would be less extensive due to the smaller number of turbines and smaller project footprint for this alternative.

Construction activity on the site would cause a temporary increase in erosion rates. The turbine layout for Alternative 2 would generally locate turbines on topographic plateaus and would avoid areas of the site with steep slopes and landslide features. Moderate erosion hazard zones were mapped along the steeper portions of the on-site terraces where slopes between 15 and 45 percent were identified; some of this hazard zone is scattered throughout the site. Low to moderate erosion hazards were identified for portions of the Yakima River bluff on the north and northeastern end of the site. These areas are underlain by bedrock and are generally more resistant to erosion. Given the use of standard erosion control and stormwater management BMPs, as assumed for the proposed action, erosion impacts would be localized and temporary, and therefore insignificant.

Areas with a high landslide potential were identified on portions of the bluffs along the Yakima River, while moderate-to-low landslide hazards were identified along the side slopes of the on-site terraces, portions of the Yakima River Valley slopes, and slopes along Taneum Creek near the confluence with the Yakima River. The conceptual plan for Alternative 2 suggests that approximately 10 to 15 turbines could be located near these areas. If construction occurred in these locations, there would likely be a higher risk of triggering landslides on the adjacent slopes. Setbacks from the top of the adjacent slope and/or engineered protective measures might be needed to address the landslide risk.

Seismic hazards for Alternative 2 would be low, as the Springwood Ranch site is located in an area of relatively low to moderate historical seismicity. Portions of the site with moderate to high landslide hazards might be prone to seismically-induced landslides. The Yakima River and Taneum Creek floodplains might be underlain by soils susceptible to liquefaction during an earthquake. No turbines would be located within the floodplain. Development of Alternative 2 would not increase the seismic hazard for any existing uses on the site or adjacent lands.

3.1.3.3 No Action Alternative

The no action alternative would result in continued use of the project area by current and future landowners, including agricultural uses, rangeland used for grazing, and rural residential use. Ongoing impacts relative to the erosion, landslide and seismic hazards addressed in **Section 3.1.1.5** could generally continue, or they could increase in response to future human activity within the area. Most of the land in the project area is currently zoned agricultural, with a 20-acre minimum parcel size. The entire project area and the adjacent lands are within a large area designated as rural in the Kittitas County Comprehensive Plan. Maximum density of housing is 1 or 2 dwelling units per 20 acres, depending on zoning; therefore, long-term future development and land conversion could result in as many as about 400 developed parcels across the Desert Claim project area. It is likely that the future pace of development would be similar to what has occurred in recent decades, as described in **Section 3.7.1.1**.

Under this alternative, agricultural or construction activity could potentially occur in all erosion hazard and landslide hazard zones. As a result, the erosion risks could be increased from existing conditions and localized areas of significant erosion could occur. Similarly, future development in higher landslide hazard zone areas could trigger landslide activity. However, because the parcel sizes would generally be 20 or more acres, it is possible that sufficient room would be available to construct residences on the lower hazard zones or implement appropriate mitigation measures, such as slope setbacks or retaining walls. Future development in the project area would be subject to some risk of damage from seismically-induced landslides or soil liquefaction, as discussed previously.

3.1.4 Cumulative Impacts

Cumulative impacts for all elements of the environment are addressed in **Chapter 4**.

3.1.5 Mitigation Measures

A number of measures are available to mitigate the potential project impacts relative to erosion and landslide hazards, as discussed in **Section 3.1.2**. Some of these measures are incorporated in the project description, as documented in **Section 2.2**, some would be required as conditions of permits needed for the project, and others are additional measures that could be implemented. These measures are described below, along with actions that could be taken to protect project facilities from potential seismic hazards. These measures would be applicable to Alternative 1 or 2 as well as the proposed action.

3.1.5.1 Erosion Hazards

Proper control of surface water runoff would be important in alleviating potential erosion hazards and subsequent potential slope stability hazards from the proposed action. To mitigate and reduce the sheet and channel erosion hazard potential in the project area, BMPs outlined in the Washington Department of Ecology (WDOE) *Stormwater Management Manual for Eastern Washington* would be implemented. As per WDOE guidelines, the following erosion BMPs would be needed to meet the terms of the construction stormwater discharge permit and would be implemented during construction:

- Source control measures are practices that are used to reduce erosion risks before they occur. These measures typically involve soil cover practices and drainage control. In general, it is more effective and efficient, both physically and economically, to employ source control methods to prevent erosion rather than to establish repairs to erosion features or to trap sediment once it is in motion. Source-control BMP mitigation measures for the project area for cleared areas during summertime construction should include, at a minimum, the proper placement of 1.5 tons/acre of straw mulch (tacked down) on exposed ground surfaces. Prior to the onset of winter, the exposed subgrade should be seeded, covered with plastic sheeting, or otherwise protected. In addition, exposed construction slopes should be trackwalked (up and down) in order to roughen the ground surface and reduce runoff velocities. Surface water runoff should be directed away from exposed subgrades or into approved temporary stormwater conveyance systems, such as tightlined drains or rock-lined swales.
- Stockpiled soils to be used as backfill material should be stored in such a manner to minimize sheet, rill or gully erosion. Protective measures may include, but are not necessarily limited to, covering the stockpiled soils with plastic sheeting, the use of low stockpiles in flat areas to reduce the risk of sediment transport from the area, or the use of silt fences around the perimeter of the stockpiles to trap eroded sediment.
- Temporary sedimentation traps or ponds should be installed to provide sediment transport control during construction. These facilities are designed to slow the water flow in order for sediment to settle out of the water column prior to the material entering surface water features. Discharge points for stormwater release, including emergency overflow outfalls, should be provided with an energy dissipater to reduce the risk of erosion.
- Rock check dams are often utilized to reduce water velocities and trap transported sediment. Rock check dams should be established along roadways during the earthwork phase of construction. In addition, rock check dams should be used within drainage ditches constructed along sloping ground to reduce the water energy and the subsequent risk of channel incision.
- Silt fences are temporary structures utilized to trap sediment transported from sheet erosion while allowing some conveyance of water through the filter fabric. Silt fences are not designed for concentrated flows but are most effective in retaining sediment transported from sheet flow in relatively small catchment areas. Silt fences should be established along wetlands, stream and river corridors, open space areas, and other sensitive areas located in or adjacent to construction zones to reduce the risk of sediment transport into these features.
- All construction runoff must be collected and treated by sediment ponds, turf-covered sand filters, temporary filtration, or other approved methods before release to any surface waters. Surface discharge should not exceed 5 nephelometric turbidity units (NTU) above background in the receiving water and be free of construction waste or its influences.

- Clean water entering construction areas should not be allowed to mix with construction water. All intercepted clean water should either be routed around construction areas to discharge into the original receiving waters or discharge separately into stormwater facilities. Energy dissipaters may be required at discharge points depending on the site conditions.
- A temporary erosion and sediment control plan (TESCP) should be established for the development during the design phase. A TESCP inspector should be on-site during construction to assist in maintaining the integrity of the erosion control structures and to provide further site-specific erosion recommendations, as necessary. The TESCP inspector should be independent of the contractor and have the authority to stop work if necessary to facilitate implementation of erosion control measures during construction.
- TESCP measures should be in place and operating properly prior to beginning major clearing and earthwork activities.
- Disturbed areas beyond the permanent footprint of project elements would be revegetated, using an appropriate seed mix, by the close of the construction period.

In addition to the above BMPs, the following erosion mitigation measures should also be considered during the design and construction of the project.

- Surface water and domestic discharge, either during or after construction, should not be directed onto sloping areas or randomly daylight on the project area. All devices used to collect surface runoff should be directed into tightlined systems that discharge into approved stormwater control facilities such as infiltration or detention ponds. Uncontrolled discharge on slopes would promote erosion and, subsequently, slope instability hazards.
- Clearing, excavation and grading should be limited to the minimum areas necessary for construction and original vegetation should be retained as much as possible, including buffer strips between construction disturbance zones and potential receiving waters.
- A geotechnical engineer should review the grading, erosion, and drainage plans prior to final plan design to further assist in mitigating erosion hazards during and after development. Additional erosion mitigation measures might be offered at that time to address site-specific issues.

3.1.5.2 Landslide Hazards

Construction of the proposed wind energy facility would not increase the existing landslide hazards, provided appropriate mitigation measures were implemented. To mitigate potential landslide hazards as a result of construction, the following setback distances for structures, infiltration systems, and detention ponds should be incorporated into the design plans, where appropriate. The setback distances are based on professional experience and standard practice with slopes of similar gradient, geology, and ground water conditions as those observed on the project area. As a result, the setback distances in this technical report are more stringent than those recommended in the 1997 *Uniform Building Code* (UBC). However, as mentioned below, the enclosed setback distances could be reduced in some instances depending on detailed design plans and additional, site-specific geologic hazard studies.

- Landslide Hazard Zone 1 is considered to possess a high risk of landslide hazard under existing conditions. The past landslide activity in the project area may have been seismically induced or it may have been caused by some other factor or event; the specific triggering mechanism for this slide is not clear. The risks of landslide hazard in this area are considered to remain high regardless of any future construction activities, and would persist with or without the Desert

Claim project. Therefore, a minimum setback distance of 125 feet should be maintained for turbines, underground cables, and roads proposed on lands within Landslide Hazard Zone 1. Based on the modified project configuration, three turbines and associated project access road and underground cables would be located within the setback area of Landslide Hazard Zone 1 in Section 9. Using micro-siting, it might be possible to relocate these turbines outside of the buffer. Site-specific geotechnical studies designed to evaluate landslide hazards would be required if these turbines were not or could not be relocated. Based on such studies, engineering measures would need to be applied to protect the stability and integrity of project facilities constructed within the buffer area. With such measures, the landslide hazard area would continue to be highly localized and would not be extended to off-site areas beyond the project area boundary.

- Landslide Hazard Zone 2 is considered to possess a moderate risk of slope instability under existing conditions. A minimum setback distance of 50 feet from the top or toe of these slopes should be maintained for structures. This setback distance might be reduced provided proper grading and drainage control measures were implemented as approved by a geotechnical engineer. Site-specific studies might be required to reduce this setback distance and might include performing additional subsurface explorations and slope stability computer modeling.

In addition to the above setback distances, the mitigation measures outlined below should be implemented.

- Stormwater from the construction site should be collected and tightlined away from the top of Landslide Hazard Zones 1 and 2. Uncontrolled discharge in these areas could cause erosion, oversteepening of the slope, and subsequent slope instability hazards. All stormwater runoff should be directed into tightlined systems that discharge into approved stormwater facilities. Erosion control measures as outlined above would also apply for all discharge points.
- No fill, topsoil, or other debris should be placed over the top of areas within Landslide Hazard Zone 1. Uncontrolled material placed on steep sloping ground is susceptible to movement. Any fill planned for slopes steeper than 5H:1V (Horizontal:Vertical) should be benched and compacted into the hillside as per the geotechnical engineer's recommendations. Site-specific studies might be required where filling is planned in Landslide Hazard Zone 2. Depending on the proposed slope gradients, the use of retaining or erosion control structures might be required in these areas.
- No cuts should be made on or at the toe of areas within Landslide Hazard Zone 1 unless approved by the geotechnical engineer. The geotechnical engineer should review any proposed cuts into Landslide Hazard Zone 2 areas to evaluate the risk of slope instability and provide specific mitigation recommendations designed to minimize landslide hazard potential.
- No vegetation should be removed from areas within Landslide Hazard Zone 1, with the exception of dead or diseased trees, unless approved by the geotechnical engineer. Vegetation removed from Landslide Hazard Zone 2 areas should be limited to the immediate vicinity of construction. The removal of vegetation might reduce the protective canopy and increase the risk of landslides unless otherwise mitigated.
- A geotechnical engineer should be given the opportunity to review all grading, erosion, and drainage control plans prior to construction to assist in reducing the landslide risks from and to the development.

3.1.5.3 Seismic Hazards

Appropriate 1997 UBC guidelines would be followed for siting and design of the proposed Desert Claim Wind Power Project. Following this guidance, turbines and buildings should be designed to be able to sustain some damage from ground motion during the design seismic event without causing life safety concerns. A Washington State-licensed engineer would select the appropriate design for each turbine location during the design phase of the project.

The provisions for seismic hazards in the 1997 UBC will continue to be updated in the future, and it is possible that the 1997 UBC will be replaced by the *International Building Code* 2000 (IBC 2000). The IBC 2000 requires seismic design to evaluate ground motions for a longer earthquake recurrence interval (lower probability event) than currently used in the 1997 UBC. Kittitas County may choose to adopt the seismic provisions of the IBC 2000 code as part of the County's building codes.

Avoidance is the primary mitigation measure for turbines or buildings sited in zones of potential surface rupture or seismically induced landsliding to prevent damage to proposed structures in case of a seismic event. Site-specific studies are recommended to determine the risk of fault rupture and seismicity of the eastern Thorp Gravel terrace and of seismically-induced landslide potential of the northern property in Section 9.

Development along slopes prone to seismically induced landslides should follow the appropriate mitigation measures outlined for Landslide Hazard Zones 1 and 2 as described above.

3.1.6 Significant Unavoidable Adverse Impacts

Unavoidable erosion impacts as a result of construction of the Desert Claim Wind Power Project would include some increase in soil loss during construction. Provided the mitigation measures offered in **Section 3.1.5.1** were properly followed, however, it is anticipated that erosion and sediment transport would be contained within the construction areas, and the resulting impacts would be insignificant. The risk of landslide activity in Landslide Hazard Zone 1 would remain high, but localized, regardless of whether the project were constructed. Construction of the project would not increase the existing landslide hazards on or immediately adjacent to the project area, however, provided that the mitigation measures presented in **Section 3.1.5.2** were implemented. With those mitigation measures, potential impacts associated with landslide hazards would be insignificant. Development of the project would have no influence on the level of seismic hazard applicable to the project vicinity. Based on project design features and standard measures for erosion control and stormwater management, no significant unavoidable adverse impacts to earth resources are expected.